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Response of *Sorghum vulgare* L. Cultivars to Gamma Irradiation, a Preliminary Approach

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Abstract

The seeds of four *Sorghum vulgare* L. cultivars (*Asian*, *Indian*, *Mycho*, *Summer graze*) exposed to various doses of gamma irradiation (15 krad, 20 krad, 25 krad, 30 krad) were critically examined for percent emergence, plumule and radical growth, fresh and dry weight and moisture contents. Irradiation doses were instrumental in creating significant variability for all traits except percent emergence, indicating that *Sorghum vulgare* L. cultivars did not perform uniformly across different gamma rays treatments. The cultivars varied significantly ($P < 0.05$) for all characters. Similarly, doses × cultivars effects were highly significant for radical growth, percent emergence, biomass as well as moisture contents, indicating greater instability of performance for mentioned characters across different irradiation treatments. Mutagenic treatments shifted mean values towards negative direction for almost all traits except moisture contents. Mutagenic effectiveness was found to be dependent upon dose and cultivars concerned. The present study categorically showed that the applied doses of gamma irradiation were unable to enhance percent emergence and seedling growth. Inter cultivar genetic variations were observed among the cultivars.

Key words: gamma rays, sorghum cultivars, mutation breeding.

Introduction

Mutation breeding is the process of exposing seeds to chemicals or radiation in order to generate mutants with desirable traits to be bred with other cultivars. Plants created using mutagenesis are sometimes called mutagenic plants or mutagenic seeds. From 1930–2004 more than 2250 mutagenic plant varieties have been released that have been derived either as direct mutants (70%) or from their progenies (30%). Crop plants account for 75% of released mutagenic species with the remaining 25% ornamentals or decorative plants (Ahloowalia *et al*., 2004). However, it is unclear how many of these varieties are currently used in agricultural production around the world, as these seeds are not always identified or labeled as being mutagenic or having a mutagenic provenance. There are different kinds of mutagenic breeding such as using chemical mutagens like ethyl methane sulfonate (EMS) and dimethyl sulfide, radiation and transposons are used to generate mutants. Mutation breeding is a very effective technique to produce traits in crops such as larger seeds, new colors or sweeter fruits that either cannot be found in nature or have been lost during evolution. The biological effect of gamma-rays is based on the interaction with atoms or molecules in the cell, particularly water, to produce free radicals which can damage different important compounds of plant cells. However, gamma rays accelerate the softening of fruits, causing the breakdown of middle lamella in cell wall (Tarroum *et al*., 2011). They also influence the plastid development and their function such as starch-sugar inter-conversion. Although, gamma radiation is a mutational tool with diverse applications in agriculture, industry and medicine, its potential exploitation in agriculture is limited mainly because of lack of information awareness on optimal dose of irradiation which differs from one crop to another crop and from one application to another application. Radiation mediated morphological, structural and/or functional changes in a plant are governed by the intensity and duration of the gamma irradiation (Tarroum *et al*., 2011). *Sorghum vulgare* L. is an important crop being cultivated for grain and fodder production. Sorghum cultivation in Pakistan is facing constraints that are limiting its expansion in terms of area and sustainable stable yield. High concentration of cattle in the country resulting in high demand for seed concentrate necessitates that new adaptable varieties of sorghum are developed for wider cultivation (Larik *et al*., 2009). Many workers had studied the effects of gamma rays on various plants (Moussa 2011; Sherif *et al*., 2011; Tarroum *et al*., 2011; Marcu *et al*., 2013; Maamoun *et al*., 2014; Santosa *et al*., 2014; Zanzibar & Sudraja, 2016). Doses of gamma irradiation positively affected growth and seed yield of *Abelmoschus esculentus* L. (Hegazi and Hamideldin, 2010). Dubey *et al*. (2007) reported increase in plant height and branches per plant of *Abelmoschus esculentus*L L. irradiated by different doses of gamma rays. It has been indicated that the effect of interaction between doses of gamma rays and okra genotypes was highly significant in the number of pods per plant and seeds per pod (Ullah, 2014). The present study was designed to compare relative effectiveness of gamma rays for inducing improvement in primary attributes of *Sorghum vulgare* L. cultivars having different histories of selection. The study provides a guideline for other workers in selection of appropriate doses of gamma irradiation for testing in field conditions.

Materials and Method

Seeds of *Sorghum vulgare* L. cultivars (*Asian*, *Indian*, *Mycho* and *Summer graze*) were obtained from open market (chowk e yadgar, Peshawar). Cobalt 60 source was used to treat sorghum seeds at the Radiation Technology Department, Nuclear Institute for Agriculture (NIFA), Peshawar, Pakistan. The radiator carried plaque source rack (1× 1m^2) containing CoS43HH source types from the rest position to the irradiation position in the irradiation chamber and a transport system for rotating the tote boxes to ensure a dose uniformity ratio of approximately unity. The seeds of sorghum cultivars were subjected to 15, 20, 25 and 30 krads doses of gamma irradiation. Four (4) samples of dry sorghum cultivars seeds each treated at a position of 71 cm from the floor and 110 cm from the gamma irradiation source in the irradiation chamber. A dosimeter was attached to each sorghum sample subjected to gamma irradiation. Seeds viability was checked prior gamma irradiation treatment by putting some seeds in a petri dish with filter paper soaked with water. Non radiated seeds were used as control. The glass ware were properly washed and sterilized at 65^{0}C for 24 hours in the oven prior to starting the experiment. Seeds were placed equidistantly on two folded whatman filter paper as seed bed in petri dishes of equal sizes. Each treatment was replicated five times with 100 seeds in each replicate. Equal volume of tape water was added to all petri dishes. The petri dishes were incubated at 25 ^{0}C for 72 hours, data for germination percentage (%), plumule, radical growth (cm) and fresh weight was collected. Dry weight (gm) and moisture contents (%) were determined after the seedlings were dried in the oven at 65 ^{0}C for 72 hours following (Hussain, 1989). Fisher analysis of variance technique and LSD test at 0.05 % probability was applied on the data to compare the differences among doses, cultivars and their interactions (Steel & Torrie, 1984).

Results and Discussion

Effects on plumule growth (cm): The gamma radiation doses and sorghum cultivars induced significant ($p<0.05\%$) variations in plumule growth. However, the effect of doses × cultivars on plumule growth was highly non-significant (Table 1).

Table 1. Mean-square values and significance tests for plumule and radicle growth, germination %, fresh and dry weight and moisture contents of four *Sorghum vulgare* L. cultivars evaluated with variable doses of gamma radiation.

Source	D.F.	Plumule Growth	Radicle Growth	Germination Percentage	Fresh Weight	Dry Weight	Moisture Contents
Doses (D)	4	0.0000^S	0.0000^S	******	0.0000^S	0.0000^S	0.0002^S
Cultivars (C)	4	0.0105^S	0.0000^S	0.0000^S	0.0000^S	0.0000^S	0.0003^S
D × C	3	0.1055^{NS}	0.0116^S	0.0002^S	0.0000^S	0.0000^S	0.0010^S
Error	12						
Total	76						

S = Significant NS = Non Significant D.F. = Degree of Freedom

The control seeds recorded the highest plumule growth value (5.69cm) followed by a dose of 15 krad (3.33) gamma irradiation (Table 2). Moreover, variations between control and applied doses were highly significant ($p<0.05\%$). However, plumule growth values recorded from 20 krad, 25 krad and 30 krad were highly non-significant among each other. Among treatments, the dose of 20 krad caused maximum inhibition of plumule growth (0.94cm) (Table 2; Fig. 1). The cultivar *Mycho* showed the highest plumule growth value (2.96cm). The same cultivar (*Myco*) showed the significant variations with genotypes *Asian* and *Indian* for subject parameter. However, the cultivars *Myco* and *Summer graze* exhibited a non-significant variation upon comparing (Fig. 4; Table 2).

Growth inhibition induced through gamma irradiation may be attributed to cell cycle arrest in the G2/M phase during somatic cell division and/or to a variety of damages in the entire genome (Preuss & Britt, 2003). Processes like auxin destruction, changes of the ascorbic acid contents and physiological and biochemical disturbances could induce the inhibition of plant germination and development (Shah *et al.*, 2008). Chaudhuri (2002) reported that when radiation is sufficient to reduce the rooting percentage, the root lengths do not exceed a few millimeters in length. Due to metabolic disorders in the seeds after gamma irradiation, the seeds are unable to germinate or to survive more than a few days. Plant survival to maturity depends on the nature and extent of chromosomal damage. The frequency of chromosomal damage with increasing dosage may be responsible for reduction in plant development (Kiong *et al*., 2008). The present study agree to the observed reduction in shoot length in plants raised from gamma irradiated seeds by various workers (Shah *et al*., 2008; Borzouei *et al*., 2010; Kabori *et al*., 2010; Tabassum *et al*., 2011; Peykarestan & Seify, 2012).

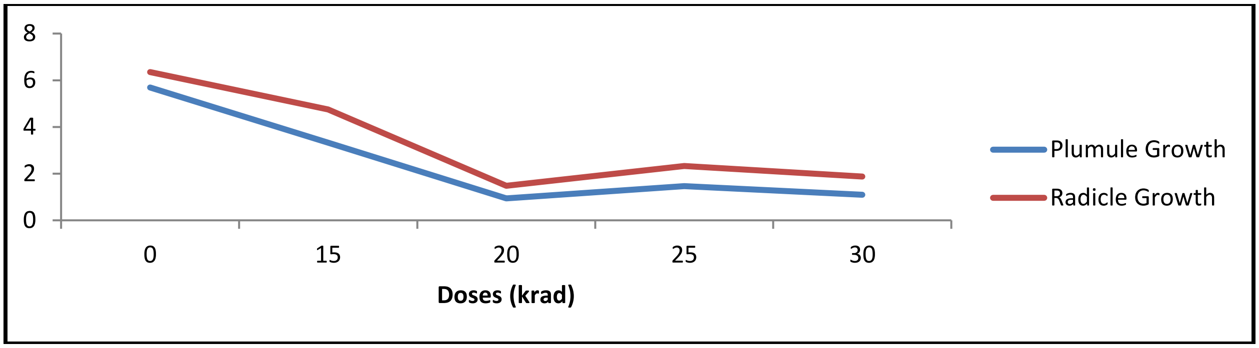

Fig 1. Effect of gamma irradiation on plumule and radical growth of *Sorghum vulgare* L.

Table 2. Effect of gamma irradiation (krad) on plumule growth (cm) of *Sorghum vulgare* L. cultivars.

Doses (krad)	***Asian***	***Indian***	***Mycho***	***Summer graze***	**Doses Means**
Control	5.63	3.93	6.35	6.85	5.69[a]
15	3.08	3.08	4.30	2.87	3.33[b]
20	0.45	1.00	1.13	1.17	0.94[c]
25	1.16	1.36	1.64	1.69	1.46[c]
30	0.71	1.09	1.38	1.20	1.09[c]
Cultivars Means	2.21[bc]	2.09[c]	2.96[a]	2.76[ab]	

Lsd value at 0.05 % level of significance for Doses = 0.6621 and Cultivars = 0.5922. Values bearing similar letters in rows and columns are statistically non-significant at 0.05 % level of significance.

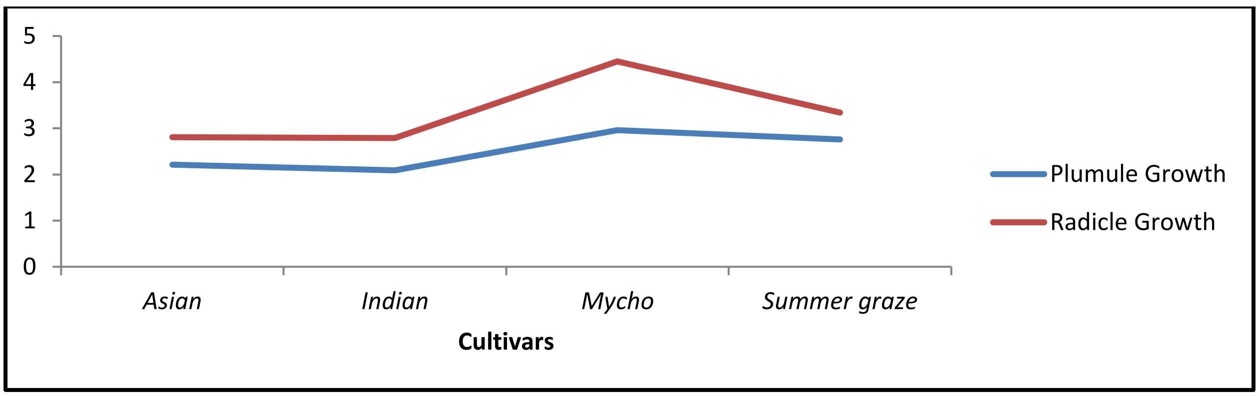

Fig 4. The varietal differences among selected *Sorghum vulgare* L. cultivars in terms of plumule and radical growth (cm).

Effect of various gamma irradiations on radical growth (cm) of sorghum cultivars: Radical growth exhibited significant variations ($p < 0.05\%$) for doses, cultivar and their interaction (doses × cultivars) (Table 1).

The non-irradiated (control) seeds recorded maximum (6.35cm) radical growth (Table 3). Furthermore, variations between control and irradiation doses were highly significant ($p<0.05\%$). Among treatments, 20 krad irradiation dose recorded the lowest radical growth value (1.48) as affected by various gamma irradiations. The cultivar *Mycho* showed highest radical growth value (4.45 cm) exhibiting highly significant variations when compared with genotypes *Summer graze* (3.34cm), *Asian* (2.81cm) and *Indian* (2.79 cm) respectively. However, variations among cultivars *Asian*, *Indian* and *Summer graze* were found as non-significant (Table 3; Fig. 4). The study related to interaction (doses × cultivars) showed that a dose of 20 krad is inhibitory for radical growth of the selected cultivars. On the contrary, zero gamma treatment is stimulatory for the studied genotypes (Table 3).

The recorded data clearly showed the injurious nature of the applied gamma irradiation doses (Fig. 1). The reduction in radical growth may be attributed to the altered physiology of the embryo by gamma rays or may be meristematic cells damaged by the irradiation doses resulting in reduced radical activity. Among the cultivars, increased radical growth of *Mycho* shows its comparative resistivity to gamma irradiation. Gamma irradiation was reported to induce oxidative stress with over production of reactive oxygen species such as superoxide radicals, hydroxyl radicals and hydrogen peroxides which react rapidly with almost all structural and functional organic molecules including proteins, lipids and nucleic acids causing disturbance of cellular metabolism (Al-Rumaih & Al-Rumaih, 2008). Reactive oxygen species can react with nearly all cell constituents. And due to lipid peroxidation, the membrane loses its stability and its permeability is enhanced leading to damages of the cell structure and disturbances of normal physiological functions (Moghaddam *et al*., 2011). Massive doses of ionizing radiation have been shown to induce physiological changes in plants such as enhancement of respiration, increase in ethylene production and induction of enzyme activities (particularly for phenolic metabolisms and accumulation of specific protein species). These effects are considered a consequence of both the direct interactions between the ionizing radiation and the macromolecular structures and the indirect action of ROS generated by water radiolysis (Marcu *et al*., 2013) preventing plants from normal growth. The present observations are parallel to the findings of Cheema & Atta, (2003), Borzouei *et al.* (2010) and Peykarestan & Seify, (2012) who reported reduction in radicle or root length in rice, wheat and redbean, respectively raised from gamma irradiated seeds.

Table 3. Effect of gamma irradiation (krad) on radical growth (cm) of *Sorghum vulgare* L. cultivars.

Doses (krad)	*Asian*	*Indian*	*Mycho*	*Summer graze*	Doses Means
Control	5.76^{bc}	4.54^{cde}	7.59^{a}	7.51^{a}	6.35^{a}
15	4.87^{cd}	3.77^{def}	7.02^{ab}	3.32^{d-g}	4.75^{b}
20	0.92^{j}	1.57^{ij}	1.55^{ij}	1.88^{g-j}	1.48^{d}
25	1.29^{j}	2.49^{f-j}	3.22^{e-h}	2.32^{f-j}	2.33^{c}
30	1.20^{j}	1.57^{ij}	3.04^{e-i}	1.67^{hij}	1.87^{cd}
Cultivars Means	2.81^{b}	2.79^{b}	4.45^{a}	3.34^{b}	

Lsd value at 0.05 % level of significance for Doses = 0.8139, Cultivars = 0.7280 and Doses x Cultivars interaction = 1.628. Values bearing similar letters in rows and columns are statistically non-significant at 0.05 % level of significance**.**

Impact of gamma irradiations on percent (%) emergence of various sorghum cultivars: Germination percentage confirmed significant ($p<0.05\%$) interaction effects between doses and cultivars. In similar way, selected genotypes recorded significant variations ($p<0.05\%$) for the subject parameter. However, variations among gamma irradiation doses were non-significant (Table 1).

Seeds germination test declared *Mycho* as an efficient germinating cultivar (84.80) as compared to *Asian* (76.00), *Indian* (71.20) and *Summer graze* (58.80) (Table 4; Fig. 6). The percent emergence value of cultivar *Myco* varied significantly in contrast to other genotypes. The doses × cultivars effects on percent emergence were highly significant and inconsistent. Genotypes like *Asian*, *Indian* and *Mycho* showed marked increase in percent emergence over control under a dose of 25 krad. Whereas for cultivar *Summer graze*, the same dose (25 Krad) brought marked reduction in percent emergence compared to zero treatment.

It has been reported that gamma rays can affect seed germination, morphology, anatomy, and physicochemical characteristics of plants, depending on irradiation level (Maamoun *et al*., 2014). The inhibitory nature of gamma rays is confirmed by many authors while studying on maize, sorghum, abelmoschus, pinus and cicer plants (Irfaq & Nawab, 2001; Kumar & Mishra 2004; Thapa, 2004; Khan *et al*., 2005; Larik *et al*., 2009; Marcu *et al*., 2013; Ambavane *et al*., 2015; Wanga *et al*., 2020). On the contrary, improvement in seed germination by gamma radiation was also observed in plants like *Tectona grandis*, *Acacia leucophloea*, *Albizia lebbeck*, *Ziziphus mauritiana*, *Pterocarpus santalinus* and *Terminalia arjuna* (Selvaraju & Raja, 2001; Akshatha & Chandrashekar, 2013; Akshatha *et al*., 2013; Zanzibar & Sudrajat, 2016). In the present study we have obtained non-significant results of gamma rays on germination of sorghum cultivars (Fig. 3). Non-significant effect of doses on germination showed greater stability of sorghum cultivars towards gamma irradiation.

Table 4. Effect of gamma irradiation (krad) on germination percentage (%) of *Sorghum vulgare* L. cultivars.

Doses (krad)	*Asian*	*Indian*	*Mycho*	*Summer graze*	Doses means
Control	66.00^{e-f}	72.00^{c-g}	86.00^{abc}	66.00^{e-h}	72.50
15	78.00^{a-f}	60.00^{gh}	84.00^{abc}	68.00^{d-h}	72.50
20	82.00^{a-d}	64.00^{fgh}	80.00^{a-e}	64.00^{fgh}	72.50
25	90.00^{ab}	84.00^{abc}	92.00^{a}	40.00^{i}	76.50
30	64.00^{fgh}	76.00^{b-f}	82.00^{a-d}	56.00^{h}	69.50
Cultivars means	76.00^{b}	71.20^{b}	84.80^{a}	58.80^{c}	

Lsd value at 0.05 % level of significance for Cultivars = 6.964 and Doses x Cultivars interaction = 15.57. Values bearing similar letters in rows and columns are statistically non-significant at 0.05 % level of significance.

Influence of gamma irradiations on fresh weight (gram) of *Sorghum vulgare* L: The influence of doses, cultivars and doses × cultivars was highly significant (p<0.05%) on fresh weight (Table 1).

Plants grown from non-irradiated plants showed significant increase in fresh weight (0.61). However, among the applied doses, some are stimulatory while others are inhibitory for fresh weight. Dose of 20 krad of gamma irradiation caused maximum reduction in fresh weight (0.25 g) as compared to other treatments (Table 5; Fig. 2). The comparison of values regarding fresh weight confirmed non-significant variations between cultivars *Mycho* (0.51 g) *and Asian* (0.44 g). In similar way, non-significant changes between *Indian* and *Summer graze* showed same tendencies of both cultivars towards gamma rays (Table 5; Fig. 5). The effect of interaction between doses and cultivars showed significant inconsistent variations for fresh weight. Plants rose from non-irradiated seeds of cultivars *Mycho, Indian* and *Summer graze* showed maximum fresh weight value as compared to other gamma irradiation doses. On the contrary, dose of 15 krad was found stimulatory for cultivar *Asian* (Table 5).

In certain plants, gamma irradiation had negative and hazardous effects on morphology and growth compared to control (Sarduie-Nasab *et al*. 2010; Hanafy & Akladious, 2018). Preussa & Britta (2003) stated that the gamma radiations contribute in cell cycle arrest during cell division that caused decrease in growth rate resulting in lower fresh weight. The reduction in fresh weight seedlings might be attributed to the decrease in seedling growth due to radiation stress (Hanafy & Akladious, 2018). The reported enhanced shoot fresh weight (El-Sherif *et al*., 2011; Latif *et al*., 2011; Tabasum *et al*., 2011) due to gamma irradiation in different plants negates the present findings. However, decreased fresh weight of plants under gamma irradiation (Vanhoudt *et al*., 2010; Peykarestan & Seify, 2012) have also been reported which confirmed the present work.

Table 5. Effect of gamma irradiation (krad) on fresh weight (g) of four *Sorghum vulgare* L. cultivars.

Doses (krad)	***Asian***	***Indian***	***Mycho***	***Summer graze***	**Doses means**
Control	0.51[cde]	0.47[def]	0.78[a]	0.67[abc]	0.61[a]
15	0.53[bcd]	0.33[f-i]	0.52[cde]	0.38[d-h]	0.44[b]
20	0.38[d-h]	0.27[g-j]	0.12[j]	0.24[hij]	0.25[d]
25	0.36[e-i]	0.38[d-h]	0.70[ab]	0.19[ij]	0.41[bc]
30	0.42[d-g]	0.29[ghi]	0.42[d-g]	0.19[ij]	0.33[cd]
Cultivars means	0.44[a]	0.35[b]	0.51[a]	0.33[b]	

Lsd value at 0.05 % level of significance for Doses = 0.08450, Cultivars = 0.0558 and Doses x Cultivars interaction = 0.1690. Values bearing similar letters in rows and columns are statistically non-significant at 0.05 % level of significance.

Dry weight (g) of different sorghum cultivars as affected by gamma irradiations: Doses, cultivars and doses × cultivars interaction produced highly significant (p<0.05%) effects on dry weight of sorghum cultivars (Table 1).

The applied gamma irradiation doses brought a significant decrease in dry weight compared to zero treatment (Table 6). The doses of 15 krad and 25 krad gamma rays induced non-significant changes in dry weight. In the same way, response of sorghum to 20 krad and 30 krad gamma rays were statistically same for subjected parameter. The cultivars varied significantly for dry weight confirming inter-cultivar variations (Table 6; Fig. 5). The effect of doses × cultivars interaction on dry weight of sorghum was highly significant. The performance of selected genotypes for dry weight was very random under different gamma irradiation doses

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The study indicated that gamma irradiation can reduce the dry matter of sorghum (Fig. 2). This decrease was due to genetic changes in plants from gamma irradiation which can affect enzyme synthesis in plants. The mutations resulted in decrease of enzyme activity (Li *et al*., 2015), thereby reducing the dry matter (Scully *et al*., 2016; Delastra *et al*., 2021). Lehninger (1982) confirmed the fact that mutations can inhibit production and physiology of several enzymes thereby affecting various pathways responsible for synthesis of various organic substances resulting in low dry biomass. Previous reports regarding seedling dry weight **(**Borzouei *et al*., 2010; Jagajanantham *et al*., 2012) under gamma irradiation are in complete accordance to our study, thus confirming the present finding

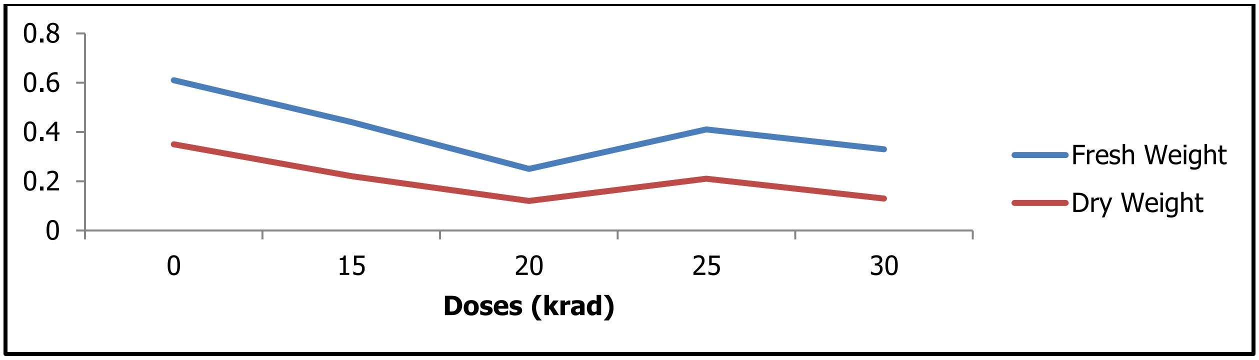

Fig 2. Effect of gamma irradiation on fresh and dry weight (gm) of *Sorghum vulagare* L.

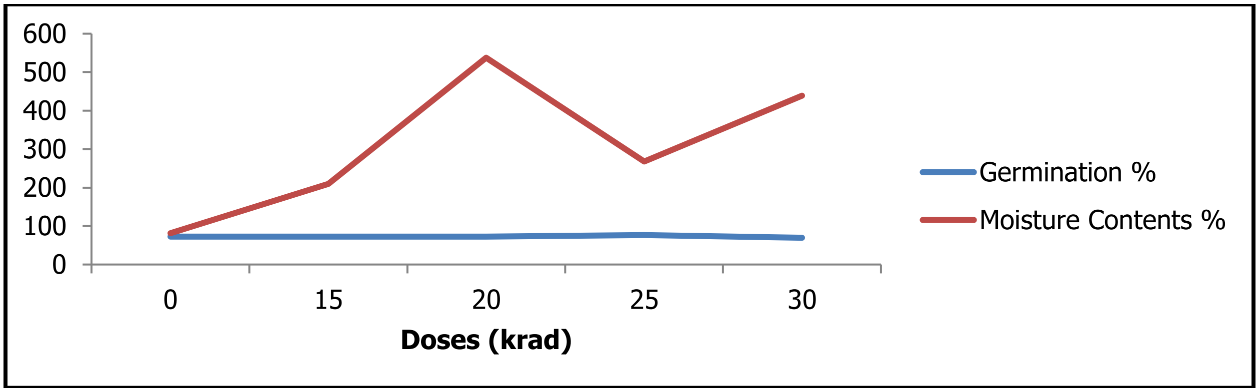

Fig 3. Effect of gamma irradiation on germination (%) and moisture contents (%) of *Sorghum vulgare* L.

Table 6. Effect of gamma irradiation (krad) on dry weight (g) of *Sorghum vulgare* L. cultivars.

	Asian	***Indian***	***Mycho***	***Summer graze***	**Doses means**
Control	0.26^{cde}	0.11^{f-i}	0.58^{a}	0.43^{b}	0.35^{a}
15	0.31^{bcd}	0.04^{hi}	0.35^{bc}	0.17^{d-h}	0.22^{b}
20	0.18^{d-h}	0.19^{d-g}	0.06^{ghi}	0.06^{ghi}	0.12^{c}
25	0.16^{e-i}	0.19^{d-g}	0.44^{ab}	0.03^{i}	0.21^{b}
30	0.24^{c-f}	0.07^{ghi}	0.18^{d-g}	0.02^{i}	0.13^{c}
Cultivars means	0.23^{b}	0.12^{c}	0.32^{a}	0.15^{c}	

Lsd value at 0.05 % level of significance for Doses = 0.07181, Cultivars = 0.06423 and Doses x Cultivars interaction = 0.1436. Values bearing similar letters in rows and columns are statistically non-significant at 0.05 % level of significance.

Effects of gamma rays on moisture contents (%) of sorghum cultivars: Doses, cultivars and doses × cultivars interaction instigated highly significant changes in moisture contents (%) of sorghum (Table 1). Unlike other parameters, gamma irradiation brought significant increase in moisture content (%) of sorghum as compared to control treatment (Table 7). The highest moisture content (537.62 %) value was recorded under a dose of 20 krad followed by 30, 25 and 15 krad of gamma irradiation as 439.04, 267.58 and 209.76 %. The cultivars *Asian* and *Mycho* showed non-significant moisture content values. Similarly, moisture content values recorded from cultivars *Indian* and *Summer graze* were non-significant variations. The doses × cultivars interaction enhanced moisture contents of cultivars *Mycho* and *Summer graze* under different irradiation doses (Fig. 3). On the other hand, the effect of doses × cultivars interaction on moisture contents of cultivars *Asian* and *Indian* were inconsistent and random. The exposure of a biological system to ionizing radiation activates a number of physical and chemical steps between the initial absorption of energy and the final biological injury. One of the most important targets is the water molecule. The ionized water molecule and the radicals are produced due to the primary reactions of excitation and ionization. These radicals can damage or modify important components of plant cells and affect certain physiological and biochemical processes that might be vital for organism survival (Marcu *et al*., 2013). The given logic is seemed to be operating in the present case also. Ionization brought scarcity of water thereby compelled sorghum to absorb more water (Fig. 3). Among the cultivars, *Indian* with significantly higher and *Asian* with the lower moisture contents was the prominent cultivars (Fig. 6). The stimulation of moisture contents due to gamma irradiation in the present study is in contrast to the reported negative effects of gamma irradiation on moisture contents of *Pisum sativum* (Navena, 2002) and *Lathyrus sativus* (Tripathi & Kumar, 2010). Unlike present findings, negative effects of gamma irradiation on the moisture contents of pea (Tripathi & Kumar, 2010) have been reported which contradicts the present findings.

Table 7. Effect of gamma irradiation (krad) on moisture contents (%) of four *Sorghum vulgare* L. cultivars.

Doses (krad)	*Asian*	*Indian*	*Mycho*	*Summer graze*	Doses means
Control	104.11^{de}	127.14^{de}	40.21^{e}	54.06^{e}	81.38^{c}
15	91.56^{de}	287.04^{cde}	334.02^{cde}	126.40^{de}	209.76^{bc}
20	113.22^{de}	1135.12^{a}	415.00^{b-e}	487.12^{bcd}	537.62^{a}
25	148.74^{de}	119.38^{de}	61.53^{e}	740.66^{ab}	267.58^{bc}
30	145.62^{de}	666.97^{bc}	166.92^{de}	776.66^{ab}	439.04^{ab}
Cultivars means	120.65^{b}	467.13^{a}	203.54^{b}	436.98^{a}	

Lsd value at 0.05 % level of significance for Doses = 202.2, Cultivars = 180.8 and Doses x Cultivars interaction = 404.3.
Values bearing similar letters in rows and columns are statistically non-significant at 0.05 % level of significance.

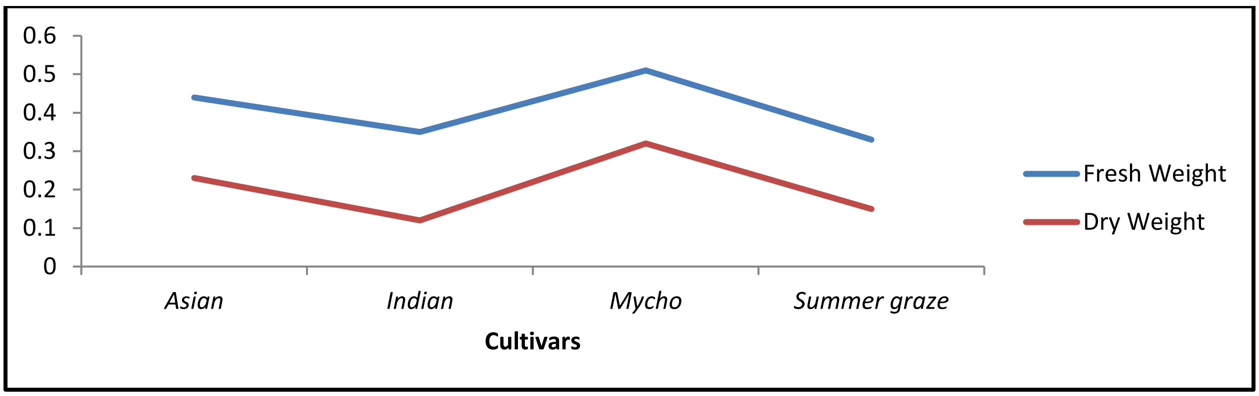

Fig 5. The varietal differences among selected *Sorghum vulgare* L. cultivars in terms of fresh and dry weight (g).

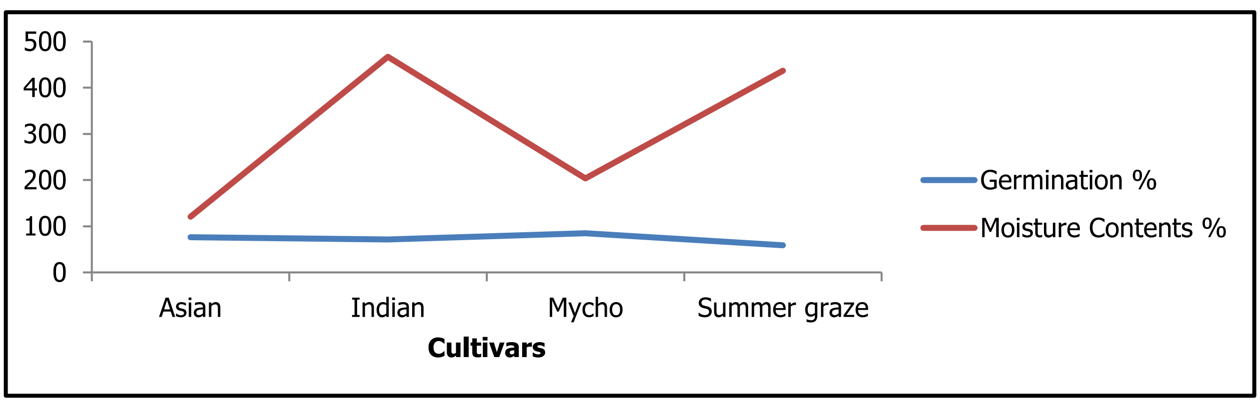

Fig 6. The varietal differences among selected *Sorghum vulgare* L. cultivars in terms of germination and moisture contents (%).

Conclusion

From the studied facts, it is clearly visible that gamma irradiation is stimulatory for moisture contents of *Sorghum vulgare* L. But at the same time, gamma rays failed to enhance seedling growth and biomass yield of sorghum cultivars over control treatment. Germination showed non-significant responses under gamma radiation treatments. Among the cultivars, *Mycho* with maximum seedling growth and biomass was a prominent cultivar. The cultivar *Indian* showed its superiority only in one parameter (moisture contents (%)) over the rest of the cultivars. The doses × cultivars interaction affected all the studied attributes significantly except plumule growth revealing dose dependent response of cultivars under gamma rays treatment.

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