Journal of Stress Physiology & Biochemistry, Vol. 16, No. 2, 2020, pp. 102-113 ISSN 1997-0838

ORIGINAL ARTICLE

OPEN ACCESS

Assessment of Induced Variability of Yield Contributing Traits in M1 Gamma Irradiated Germplasm of wheat (*Triticum aestivum* L.)

Amir Hasan Khan[1], Tabinda Nowsheen[1], Muhammad Abdul Aziz[2], Sharif Ullah[1], Khan Sher[1], Ateeur Rahman[1], Ahmad Hassan Khan[1]

1 Shaheed Benazir Bhuto University Sheringal, District Dir (Upper) Khyber Pakhtunkhwa, Pakistan

2 Kohat University of Science and Technology, Kohat-26000, Pakistan

*E-Mail: ***amirhasankust@gmail.com**

Received February 17, 2020

Sowing of radiated Germplasam of two-selected virus free wheat cultivars namely Pirsabak-98 and Fisalabad-2000, were conducted in the department of Botany, Shaheed Benazir Bhutto University Sheringal during crop season November 2016 to study the impact of different doses of gamma radiation. Both cultivars were purchased from Tarnab Farm Peshawar and later on irradiated to 5, 10, 20 Krad at NIFA. (Nuclear institute for food and agriculture Peshawar). It was observed that inverse relationship was created in doses of 5, 10, 15 Krad against number of parameters like number spikelet per plant, number of spike per plant, spike length per plant, grain number per plant, 1000 seeds fresh weight, 1000 grain dry weight. Similarly the stated parameter means values gradually and continuously decreases with increasing of gamma irradiation concentration in both the hybrids pirsabak-98 and Fisalabas-2000 of wheat. It was also evaluated that high concentration of doses cause restrictive in the mean figure of all parameters which reflect that both cultivars pirsabak-98 and Fisalabad-2000 were sensitive high intensity of gamma radiation. Moreover there were also found a small number of mutant genotypes in Fisalabad-2000 at 15 krad due to genetic changeability similarly at 5 krad dose in both cultivar found pink color plant and sterile plant. As far as the effect gamma irradiation through of analysis for all the parameters were highly significant while due to the interaction doses and cultivar effects for the length of the spike was insignificant. Similarly the mean values for length of spike per plant, fresh weight of grain, and dry weigh of grain and number of grain per plant varietal effects were concluded as highly significant however the effects. Likewise in-significant outcome were obtained in the mean value due cultivar effect for fresh weight of 1000 seeds

Key words: Gamma radiation , Doses, Wheat cultivars, Mutant, Genotypes, Parameters

Pakistan is at ninth number among the countries producing the wheat crop all over the crop and Pakistan is a net importer in world market (Anon, 2015). The production of the crop in Khyber Pakhtunkhwa is about 1.0718 million tons while the demand has been reported to be 2.6860 million tons. (Anon, 2008a). About one third population of the world is depended on wheat and used as a staple food by one third of the world population. In Pakistan, the vital crop is being cultivated by about 80% farmers and growing up at an area of total of about 9 million hectares (ha). (Abd-El-Haleem, 1998; Adams *et al*., 2002; Shewry, 2009). Being the main food grain in the country, it covers a very large segment of the cultivated land. It has been reported that about 10 % value added in agriculture and 2.1 % to Gross Domestic Product (GDP). The crop is a major grain crop for the whole world and it is considered at the central position in both agriculture as well as economy (Khan and Zeb, 2007). The nutritional value of the crop then it gives us about 78.10% carbohydrate, 14.70% protein, 2.10% fat, 2.10% minerals and a considerable amount of vitamins and minerals (zinc, iron). The crop is also a good source of minerals which are essential components in human diet and health requirements (Adams *et al*., 2002; Fraley, 2003; Shewry *et al*., 2006; Topping, 2007). Gamma rays are most energetic rays these rays are considered to having the highest penetrating power as compared to other radiations. (Kovacs and Keresztes, 2002). These are the type of the ionizing radiation being interacting with molecules or atoms for the production of free radicals. These are the rays which modify the morphology, anatomy, biochemistry and physiology of plants is being affected by the ray with various degrees (Kim *et al*., 2004; Wi *et al*., 2005). induced mutations mostly occur in the genome of an organism thus just one of the two or additional alleles of a locus is affected, resulting in the need for breeders to ensure homo zygosity through self-pollination before the trait will be properly expressed (Micke, 1999). Being an important tool, induced mutation are used an important tool when breeders required them for bringing the plant breeding and to work on functional genomics to increase the frequency of mutations, and consequently broadening the genetic base of germ plasma. Mutagenesis causes small but stable genetic changes within individuals. (Weil and Monde, 2007). Artificial mutation helps to induce genetic variation of gene loci controlling efficiently significant character and/ or removal of unwanted genes as of breeding lines (Alcantara *et al*., 1996). Sen and joshi (1958) found a number of valuable high yielding mutants at low dose of gamma irradiation similarly Khan and Verma (2015). reported significant increase in grain weight at 15 Krad dose of gamma irradiation. Thus, now Pakistan researchers have launched wheat mutant through induce mutation program to increase wheat production to stabilize the country economy to curb the current rising demand for wheat. Therefore, the aim of the present study was to examine the effect of gamma rays on some important quantitative traits in wheat, which led to effective radiation dose affecting the architecture of radiation doses in the upper mountain ranges of sheringal. Moreover, this study is also concern to create significant mutants of wheat for increasing yield of wheat.

MATERIALS AND METHODS

Field experiment carried out in the month of November 2016. On two different cultivars of *Triticum aestivum* L., named viz. Pirsabak-98 and Faisalabad-2000 concerning were subjected to check the effects of gamma radiations on their growth parameters in region of Shaheed Benazir Bhuto University Sheringal Khyber Pakhtunkhwa Pakistan. Healthy seeds of two cultivars were purchased from Tarnab Farm Peshawar. later on radiated with 5, 10, and 15 Krad doses of gamma radiations from Cobalt-60 gamma source operating at NIFA. (nuclear institute for food and agriculture Peshawar) . Data was collected on the targeted parameters like, plant height (cm), number of leaves per plant, number of tillers per plant , spike length (cm), spike number plant-1 , number of spikelet per plant, number of roots per plant, number of grain per plant, fresh weight of the 1000 grain (gm). And dry weight of the 1000 grain (gm). Also other parameters like days taken to heading, germination percentage, number of roots per plant and plant survive percentage at defined stage of growth to find out the outcome of the trial doses

of gamma radiation. The design of the experiment split plot and plot size was set as 110 x83.40=916.71 keeping three replications and 4 treatments. Each replication divided into 4-sub plot. Row to row distance was 20 cm whereas plant to plant spaced as 10 cm. 50 seeds per row in every sub plot were sown about 4 to 5 cm depth of soil. The land for growing of seeds ploughed and prepared. For better wheat growth Nitrogen was given once and phosphorus penta oxide fertilizer three time in concentrated field at varying times.. Hoeing was don regularly to remove the weeds. The experimental field was irrigated periodically to avoid the crop from stress. From each sub plot maximum of ten plants randomly selected for every one treatment the chosen plants had tagged from each one subplot for examining the gamma rays effect on varied morphological traits.

The data were recorded on the subsequent parameters in M1 generation.

Spike length plant^{-1}(cm)

The decided plants from each sub plots harvested at full maturity and then the Spike of primary stem was cut and its length measured by lime.

Spike Number plant^{-1}

Spike number plant^{-1} calculated from selected plant at maturity from each sub plot.

Spikelet Number plant^{-1}

The number of spikelet per plant calculated by taking the average of spikelet from the spike of selected plants

Number of grain plant^{-1}

The grain number spike^{-1} was calculated by taking the average of seeds from the spike of the selected plants

1000 grain Fresh weight (gm).

Fresh 1000-grains were collected and counted from the grain yield of each experimental unit and were weight to record 1000-grain weight.

1000 grain dry weight (gm).

Dry 1000-grain counted from the selected plants and then the average weight of seeds was recorded in grams.

Statistical analysis:

Statistical analyzed of each parameter of the data were used statistic software Statistix 8.1. Tukey's least significant difference test applied for comparison between the hybrid mean, treatment mean, and interaction among treatment and cultivars

RESULTS AND DISCUSSION

Two types of cultivars Pirsabak-98 and Faisalabad-2000 of wheat were used to review the effects of gamma rays through dose of 5, 10 and 15Krad on yield component along with morphological characteristics. The statistics as highlighted in the material method were applied on the data of different parameters in M1 generation.

Spikelet number per plant

The analysis of variance in Table 1a showed the differences in the mean values due to irradiation doses statistically found as highly significant for the number of spikelet plant^{-1}. The variation in the mean values of cultivars recorded as highly significant. However, the variation in the suggest values for interaction among doses and cultivars is found as highly significant.

Furthermore, one can conclude from Table 1.b and Figure 1 that the difference in the computed values due to gamma rays doses was particularly highly significant. The mean values for both cultivars based on gamma irradiation doses were range 117.74-128.74. The variation in the mean values inside the cultivars statistically found as highly significant. The variation in the suggested values ranged 102.79, 145.84 respectively Pirsabak-98 and Faisalabad-2000. In addition the interaction between doses of gamma irradiation and cultivars concluded as insignificant while the mean observed from 96.97-106.66 for Pirsabak-98 and 138.50-150.80 for Faisalabad-2000.

In present investigation it is found that the number of spikelet per plant decrease with increase of gamma rays intensity. Number of spikelet per plant is inversely proportional to the increase of gamma radiation concentration. The highest mean value were noted in control (106.66, 150.80) for both the cultivar respectively -98 and Faisalabad-2000 while the lowest mean value were recorded under the influence of 15 Krad (96.96) for Pirsabak-98 and (138.50) for Faisalabad-2000. A gradual decrease observed in the mean number with the increase of gamma irradiation concentration. Percent decrease in the spikelet number spike^{-1} under the

influence of 15 Krad dose as compared to control was computed as 9.09, 8.16% respectively -98 and Faisalabad-2000.

The present investigation also show co-linearity with the result of Galal *et al*., (1975), who also reported adverse effects of gamma irradiation on number of spikelet per spike. Khan *et al*., (2003), who observed the regular decreases in number of spikelet with increasing gamma irradiation. At the other Irfaq and Nawab (2003), reported significant decrease in number of spikelet per spike with increasing of gamma radiation intensity.

Spike number per plant

The observation of variance represented in Table 2a regarding number of spike plant^{-1} statistically found significant and varietal effects observes significant. The interaction inside the cultivars with gamma doses noted as significant

From the Table 2b and Figure 2 the mean figure for spike number plant^{-1} differed highly significantly under the power of different gamma irradiation doses. The calculated values for doses of gamma irradiation ranged 65.17-68.00. The variation recorded in the mean table due to dose for spike number plant^{-1} 51.33 for Pirsabak-98 and 81.25 for Faisalabad-2000. The interaction among cultivars and doses was statistically as non significant and obtained effect obtained between 49.67 to 52.66 and 80.00 to 83.33 respectively Pirsabak-98 and Faisalabad-2000. In the present study it was found that as the radiation intensity increase spike number plant-1 decrease in all case except at 15 Krad dose somewhere the both cultivars illustrate some progress as weigh against to control.

The highest mean figure observed at 15 Krad (83.33) and while the lowest mean values recorded at 10 Krad (49.67). Although both cultivars reflected response at 15 Krad but Faisalabad-2000 showed nicely respond over control. Maximum percent increase (4%) for Faisalabad-2000. Maximum decrease in the spike number plant^{-1} under the power of 10 Krad doses as compared to control (2.99, 1.23%) respectively Pirsabak-98 and Faisalabad-2000.

The present study decided with the investigation of Irfaq and Nawab (2003) reported the effect on different doses of radiation on the number of tillers per plant except at 100 GY which somewhat decrease the characters. Similarly many other worker reported such as Ghafoor and siddiqui (1976) , Davies (1970) and (Din *et al*., 2004), however khamankar (1989) reported adverse effects of gamma rays on the average spike number per plant which was agreed with previous reports Hassan (1986), Millado *et al*., (1989)

length of Spike per plant (cm)

For the parameter like spike number plant^{-1} in Table 3a reflected that the suggested values due to irradiation doses are significant. And however due to cultivars effects it's been observed as highly significant. Even though difference in denote values due to relations between doses and cultivars is also significant.

From Table 3b and Figure 3 in both cultivars in response to increase in the irradiation doses concentration a continues decrease was recorded. The mean values against the different radiation doses ranged 8.54-11.07. The difference recorded for spike length was in the range of 9.90 for Pirsabak-98 and 9.52 for Fislabad-2000. Furthermore, the interaction among gamma irradiation doses and cultivars found as non significant. The mean values for two cultivars for spike length per plant ranged between 8.52-11.61 and 8.55-10.54 for Pirsabak-98 and Faisalabad-2000 respectively.

Maximum percent decrease 26.62, 18.62 % was found under the influence of 15 Krad dose for Pirsabak-98 and Faisalabad-2000 respectively over their control. Similarly it was the evident from Table 3b that the spike length gradually decreases with increase of radiation concentration. The highest mean values recorded in control (11.61, 10.54) for Pirsabak-98 and Faisalabad-2000 respectively. While the lowest mean values noted at 15 Krad dose (8.25).

The present study were agreement with Khalil *et al*. (1986), Larik *et al*. (1980) who statement that the gamma irradiation induce significantly decrease in spike length over the control. Molle (1965) find out the gamma radiation effect on spike length is inversely proportional to the increase of gamma rays intensity. Irfaq and Nawab (2003) studded the spike length continuously decrease with increase of gamma irradiation intensity as compare to control.

Grain number per plant

The assessment of variance as highlighted in Table 4a the difference in the recorded values due to gamma dose is highly significant and cultivars effects statistically observed as highly significant. The interaction between cultivars and doses observed as highly significant

From Table 4b and Figure 4 it was concluded that the mean figure for number of grain plant^{-1} were significantly different as increase the gamma rays intensity number of grain per plant decrease. The mean for number of grain plant^{-1} due to different gamma irradiation dosage ranged between 204.96-262.95. The difference observed in mean values due cultivars effects ranged 237.21 and 247.63 respectively for Pirsabak-98 and Faisalabad-2000. Furthermore the interaction between cultivars and gamma irradiation were observed highly significant. The mean standard for two cultivars for grain number plant^{-1} was sort between 197-93-253.23 for Pirsabak-98 while 211.98-279.17 for Faisalabad-2000.

Maximum percent decrease found at 15 Krad dose of gamma radiation for both cultivars. Pirsabak-98 and Faisalabad-2000 (21.87, 24.02%) over the control. Number of grain per plant decreased with increases of gamma rays concentration. Number of grain per plant is inversely comparative to the increase of gamma irradiation intensity. No increase observed in the number of grain per plant over control under the power of gamma rays. The highest number of grain per plant was obtained from control (253.66, 279.16) while the lowest mean values were observed at 15 Krad dose (197.93, 211.98) for Pirsabak-98 and Faisalabad-2000, respectively.

The present investigation agreed the finding of Khan *et al*., (2003), Irfaq and Nawab (2003). Who reported the gamma rays effect on number grain per plant which decrease with increase of gamma irradiation, Galal *et al*., (1975) who find out continues decrease in the trait with increase of gamma irradiation intensity Yildirum *et al*., (1989) observed that spike number, spike length and number of grain was lower as compare to control.

1000-grains fresh weight (g)

The observed variance represented in Table 5a showed that the divergence in the mean values due to gamma doses is highly significant while the varietal effects under influence of different gamma irradiation doses statistically found insignificant. The interaction between cultivars and doses was observed as insignificant.

Table 5b and Figure 5 shows that the variation in the observed mean values were different due to gamma radiation doses is insignificant. The denoted values for gamma rays are 32.20 to 45.80 for 1000 grain weight. The variation observed in mean number due to cultivars for 1000 seeds mass is highly significant and values ranged from 38.20 to 41.82. The result of between gamma irradiation doses and cultivars obtained as insignificant. The mean values for 1000 seeds weight (gm) ranged between 33.58-46.47 and 30.81-45.12 for Pirsabak-98 and Faisalabad-2000 respectively. In the present investigation, a simultaneous decrease in the mean figure for 1000-grain fresh weight was noted due to increase in the intensity of gamma irradiation except of 15 Krad dose where both cultivars showed some improvement over the control. Although both cultivars reflected good response at 15 Krad but Pirsabak-98 observed nicely as compare to Faisalabad-2000.

The maximum percent increase in the 1000-grain weight was 27.74% for Faisalabad -2000 and 31.71% for Pirsabak-98 under the influence of 15 Krad dose. The highest mean values as compare to control were observed at 15 Krad dose (46.47) while the lowest mean values was found at 10 Krad dose (30.81).

The present study coincide with those of Dumanovic and Denic (1967), Masayuki (1970), Galal *et al*., (1975), who observed irradiation doses with increase of intensity negatively effect on 1000 seeds weight (gm). Irfaq and Nawab (2001), Khalil *et al*., (1986), who reported adverse effects on average grain weight. Similarly (Animasaun *et al*.,2004), find out increase in the 100 grain weight at 80 GY of irradiation doses as it observed at 15 Krad dose in the present investigation. Khan and Verma (2015). Studied that the gamma rays doses negatively affect the grain weight in all condition except at 15 Krad dose where seeds weight show some improvement as compare to control as it was reported in the present study.

1000-grains dry weight (g)

The analysis of variation in Table 6a showed that the variation in mean values in response of radiation doses were significant and varietal effects found highly significant. Moreover, the interaction among cultivars and doses had been document as highly significant.

One can see from Table 6b and Figure 6 that the differentiation in the mean values due to gamma irradiation is insignificant. The divergence in the mean values for the irradiation doses ranged between 31.43 to 43.24.The variation noted in mean number due to dehydrate seeds weight per plant is highly significant values were inside the cultivars of 41.07 for Pirsabak-98 and 36.57 for Faisalabad-2000.The interaction amid cultivars and gamma doses had also found insignificant. The recorded means figure ranged among 32.8-45.33 for . Pirsabak-98 while 30.05-41.15 for Faisalabad-2000.

In the present study gradual decrease in the mean values for dry weight (gm) was observed due to increase in the gamma irradiation strength except of 15 Krad dose. while both cultivars showed some improvement as evaluate to control (Table 4.8) The highest percent increase in the dry weight (gm) was 27.61% for Pirsabak-98 and 26.97% for Faisalabad -2000 under the influence of 15 Krad dose. The highest mean values as compare to control were observed at 15 Krad dose (45.33) while the lowest mean values was found at 10 Krad dose 30.05 (Table 4.8).

Present investigation is disagreeing with Asmanhan and Twaty (2006) such type of disagreement may be due to agro-climatic situation or difference in genetic material.

Table 1a: Analysis of variation for the spikelet number plant^{-1} in wheat hybrids as outcome of gamma irradiation

Source	D.F	S.S	M.S	F value	Prob	Sig
Replications.	2.00	204.51	1.02			
Cultivars.	1.00	11117.20	11117.20	261.25	0.00	**
Error Rep*Cultivars.	2.00	85.10	42.60			
Treatment.	3.00	401.00	133.70	8.64	0.00	**
Cultivars*Treatments.	3.00	7.40	2.50	0.16	0.02	*
Total	12.00	185.60	15.50			

Table 1b Effects of gamma irradiation on the spikelet number plant^{-1} in Wheat hybrids.

Radiation Dose Krs	**Persabak**	**Fisalabad**	**Mean**
(T0) 00	106.67 c	150.80 a	128.74 A
(T1) 05	104.27 c	148.35 a	126.31 A
(T2) 10	103.26 cd	145.68 a	124.47 A
(T3) 15	96.97 d	138.50 b	117.74 B
Mean	102.79 B	145.84 A	

Mean with the similar alphabetic are not significantly dissimilar according to Tukey's teast significant difference at 5% probability level.

Table 2a. Analysis of variation for the spike number plant^{-1} in wheat hybrids as outcome of gamma irradiation

Source	D.F	S.S	M.S	F value	Prob	Sig
Replications.	2.00	196.75	98.38			
Cultivars.	1.00	160.17	160.17	1.40	0.036	*
Error Rep*Cultivars.	2.00	228.58	114.29			
Treatment.	3.00	110.83	36.94	0.34	0.050	*
Cultivars*Treatments.	3.00	412.83	137.61	1.26	0.033	*
Total	12.00	1315.33	109.61			

Table 2b: Effects of gamma irradiation on the spike number plant^{-1} in Wheat hybrids.

Radiation Dose Krs	Persabak	Fisalabad	Mean
(T0) 00	52.66 b	81.00 a	66.00 A
(T1) 05	50.33 b	80.67 a	65.50 A
(T2) 10	49.67 b	80.00 a	64.84 A
(T3) 15	53.67 b	83.33 a	68.00 B
Mean	51.58 B	81.25 A	

Mean with the similar alphabetic are not significantly dissimilar according to Tukey's teast significant difference at 5% probability level.

Table 3a. Analysis of variation for the length of spike plant^{-1} in wheat hybrids as outcome of gamma irradiation

Source	D.F	S.S	M.S	F value	Prob	Sig
Replications.	2.00	1.95	0.98			
Cultivars.	1.00	0.81	0.81	2.23	0.027	*
Error Rep*Cultivars.	2.00	0.73	0.36			
Treatment.	3.00	23.80	7.93	30.12	0.00	**
Cultivars*Treatments.	3.00	1.87	0.62	2.36	0.12	NS
Total	12.00	3.16	0.26			

Table 3b Effects of gamma irradiation on the length of spike plant^{-1} in Wheat hybrids.

Radiation Dose Krs	Persabak	Fisalabad	Mean
(T0) 00	11.61a	10.54a	11.07A
(T1) 05	10.60a	9.83a	10.22A
(T2) 10	8.87b	9.17a	9.02C
(T3) 15	8.52b	8.55a	8.54C
Mean	9.90B	9.52A	

Mean with the similar alphabetic are not significantly dissimilar according to Tukey's teast significant difference at 5% probability level.

Table 4a. Analysis of variation for the number of grain plant^{-1} in wheat hybrids as outcome of gamma irradiation

Source	D.F	S.S	M.S	F value	Prob	Sig
Replications.	2.00	356.60	178.32			
Cultivars.	1.00	715.60	715.59	11.73	0.003	**
Error Rep*Cultivars.	2.00	122.00	61.01			
Treatment.	3.00	13309.40	4436.48	55.55	0.00	**
Cultivars*Treatments.	3.00	2538.20	846.05	10.59	0.00	**
Total	12.00	958.40	79.86			

Table 4b Effects of gamma irradiation on the number of grain plant^{-1} in Wheat hybrids.

Radiation Dose Krs	Persabak	Fisalabad	Mean
(T0) 00	253.34 a	279.17 a	266.25 A
(T1) 05	251.93 b	271.93 a	261.87 A
(T2) 10	249.9 b	227.40 c	238.65 B
(T3) 15	197.93 d	212.12 d	205.03 C
Mean	237.21 A	247.63 A	

Mean with the similar alphabetic are not significantly dissimilar according to Tukey's least significant difference at 5% probability level.

Table 5a. Analysis of variation for the 1000-grain fresh weight in wheat hybrids as outcome of gamma irradiation

Source	D.F	S.S	M.S	F value	Prob	Sig
Replications.	2.00	49.65	24.83			
Cultivars.	1.00	78.55	78.55	6.25	0.13	NS
Error Rep*Cultivars.	2.00	25.14	12.57			
Treatment.	3.00	607.27	202.42	25.09	0.00	**
Cultivars*Treatments.	3.00	16.56	5.52	0.68	0.00	**
Total	12.00	96.83	8.07			

Table 5b Effects of gamma irradiation on the 1000-grain fresh weight in Wheat hybrids.

Radiation Dose Krs	**Persabak**	**Fisalabad**	**Mean**
(T0) 00	45.33 a	39.76 abc	42.55 AB
(T1) 05	41.91 ab	37.12 bc	39.52 B
(T2) 10	33.58 cd	30.81 d	32.20 C
(T3) 15	46.47 a	45.12 a	45.80 A
Mean	41.82 A	38.20 A	

Mean with the similar alphabetic are not significantly dissimilar according to Tukey's teast significant difference at 5% probability level.

Table 6a. Analysis of variation for the 1000-grain dry weight in wheat hybrids as outcome of gamma irradiation

Source	D.F	S.S	M.S	F value	Prob	Sig
Replications.	2.00	35.50	17.75			
Cultivars.	1.00	121.37	121.37	14.65	0.005	**
Error Rep*Cultivars.	2.00	16.57	8.28			
Treatment.	3.00	498.30	166.10	33.96	0.00	**
Cultivars*Treatments.	3.00	7.89	2.63	0.54	0.007	**
Total	12.00	58.69	4.89			

Table 6b Effects of gamma irradiation on the 1000-grain dry weight in Wheat hybrids.

Radiation Dose Krs	**Persabak**	**Fisalabad**	**Mean**
(T0) 00	44.51 ab	39.10 bc	41.81 A
(T1) 05	41.63 abc	35.99 cd	38.81 B
(T2) 10	32.81 de	30.05 e	31.43 C
(T3) 15	45.33 a	41.15 abc	43.24 A
Mean	41.07 A	36.57 A	

Mean with the similar alphabetic are not significantly dissimilar according to Tukey's teast significant difference at 5% probability level.

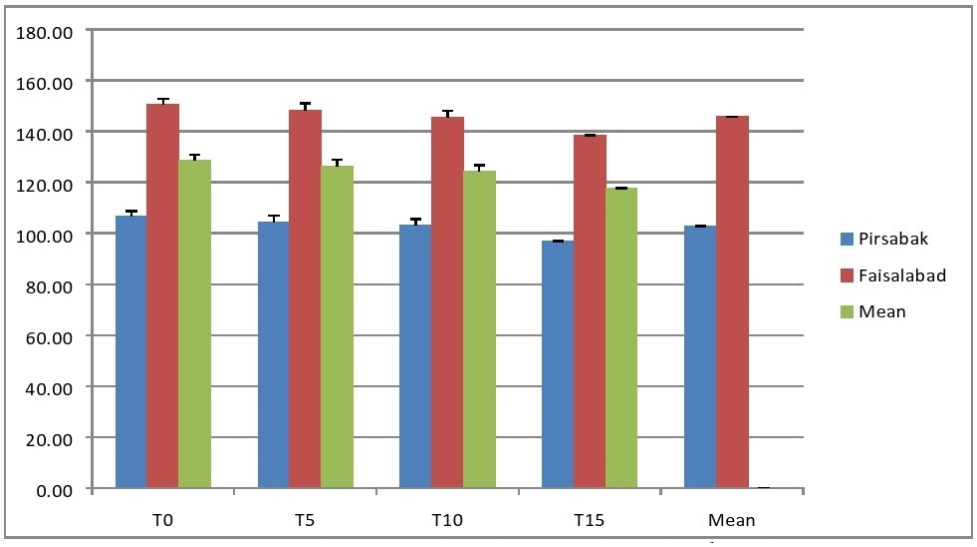

Figure 1: Effects of gamma irradiation on the spiklet number plant^{-1} in wheat hybrids.

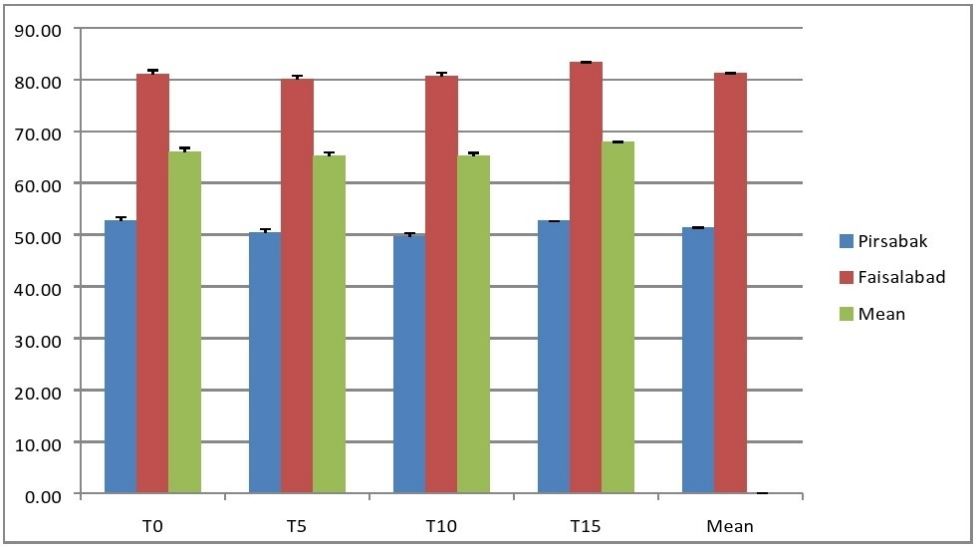

Figure 2: Effects of gamma irradiation on the spike number plant^{-1} in wheat hybrids.

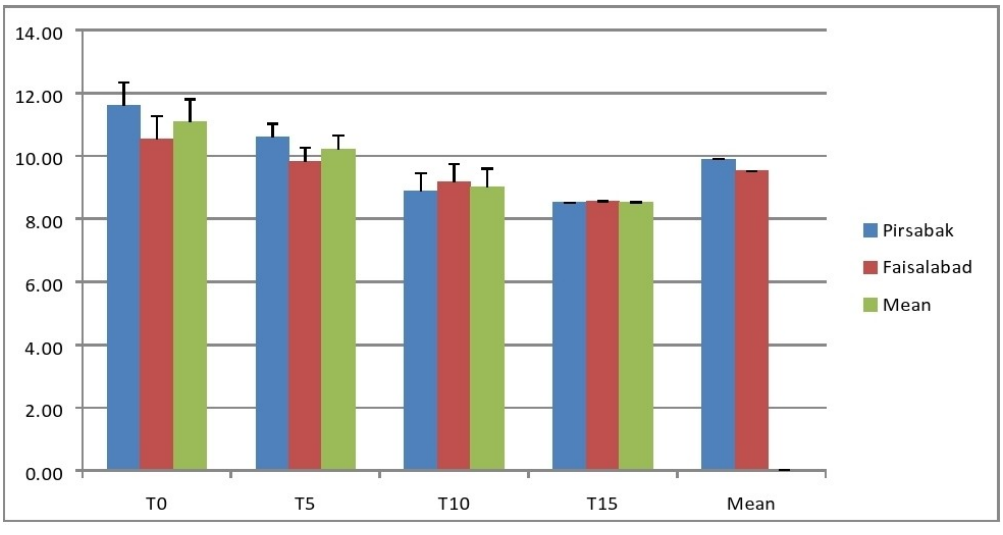

Figure 3: Effects of gamma irradiation on the length of spike plant^{-1} in wheat hybrids.

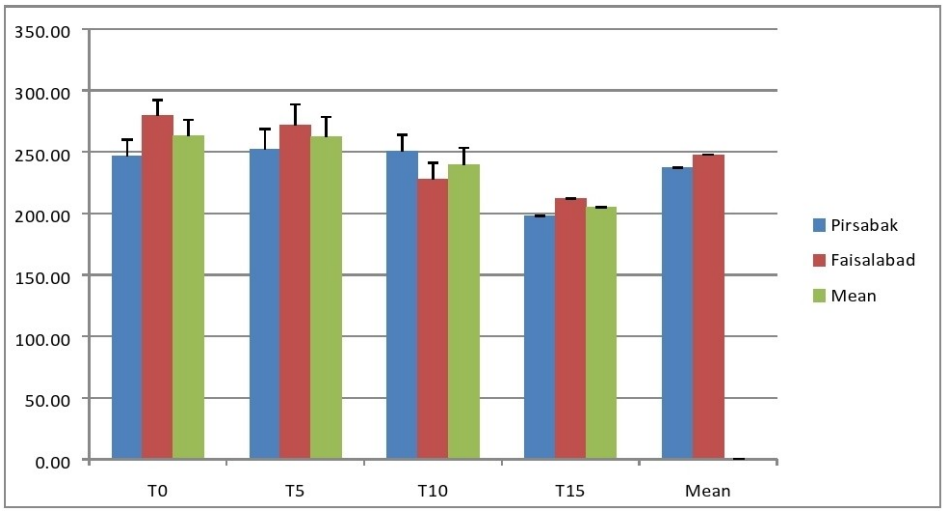

Figure 4: Effects of gamma irradiation on the grain number plant^{-1} in wheat hybrids.

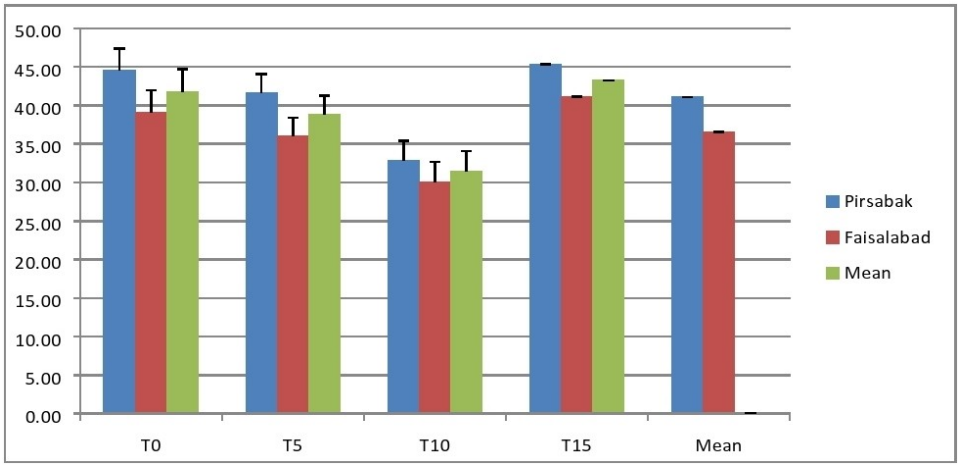

Figure 5: Effects of gamma irradiation on 1000-grain fresh weight in wheat hybrids.

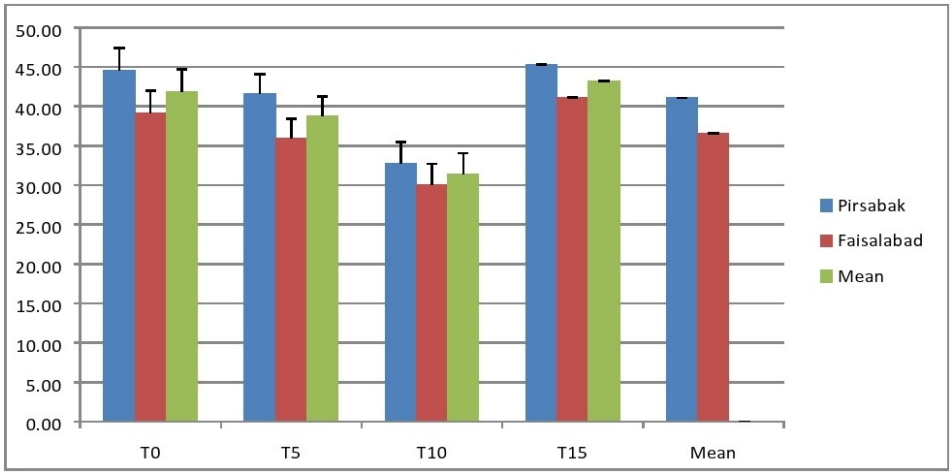

Figure 6: Effects of gamma irradiation on 1000-grain dry weight in wheat hybrids.

CONCLUSION

All parameters yield decrease with increasing of gamma irradiation intensity as the damaging effect of high concentration of gamma radiation dose due to additional climatic condition and ecological factor such as top soil texture, humidity, soil chemistry, temperature, light intensity particularly due to high altitude. Both cultivars predicted as sensitive to high concentration of gamma radiation which leading to a decrease in the mean values of the majority of the parameters. Valuable mutant can achieved at 15 krad dose. 15 krad dose have capability to stimulate maximum frequency of mutation in wheat variety of Pirsabak-98 and Faisalabad-2000 by exposing it to gamma radiation.

CONFLICT OF INTERESTS

The authors declare that they have no competing interests.

AUTHOR'S CONTRIBUTIONS.

Muhammad Abdul Aziz and Taninda Nowsheen indicated the language and grammatical mistakes. Amir Hasan Khan wrote the draft manuscript. Sharif Ullah, Ateeur Rahman and Ahmad Hassan Khan helped in the compilation of data. Khan Sher supervised all the stages. All the authors read and approved the Manuscript.

ETHICAL STATEMENT

The study does not report any experiment related to human and animals, so there is no ethical concern in the study.

ACKNOWLEDGMENT

The authors extend their high appreciation and acknowledgement towards the local communities by providing moral support to the authors.

REFERENCES

Abd-El-Haleem SHM, Reham MA, Mohamed SMS, Abdel-Aal ESM, Sosulski FW, Hucl P, (1998). Origins, characteristics and potentials of ancient wheats. *Cereal Foods World*, **43**: 708–715.

Adams, M.L., Lombi, E., Zhao, F.J. and McGrath, S.P., (2002). Evidence of low selenium concentrations in UK bread-making wheat grain. *J. Sci. Food Agric.*, **82(10)**, 1160-1165.

Alcantara, T.P., Bosland, P.W. and Smith, D.W., (1996). Ethyl methanesulfonate-induced seed mutagenesis of *Capsicum annuum*. *J. Hered*., **87(3)**, 239-241.

Anon. (2008a). Bureau of Statistics, Crop Reporting Services, Government of Khyber Pakhtunkhwa, Pakistan.

Anon. (2015). Economy Suvery of Pakistan. 2013-14. Economic Advisory Wing, Finance Division, Govt. of Pakistan Islamabad, Pakistan.

Asmanhan, A. M and N, Al- Twaty. (2006). Effect of gamma irradiation and sodium azide on some economic traits in tomato. *Saudi jounal of biological sciences* **13(1)** 44-49

Davies, C.R., (1970). Effects of gamma irradiation on growth and yield of agricultural crops-11. Spring sown baley and other cereal. *Radiation Bot*., **10**; 19-27.

Din, R., Qasim, M. and Ahmad, K., (2004). Radio sensitivity of various wheat genotypes in M1 generation. *Int. J. Agri. Biol*, **6**, 898-900.

Dumanovic, J. and Denic, M., (1967). Variation induced in some quantitative properties of wheat by radiation with gamma rays. *Arh Plojopr. Nauk*, **20**, 98-108.

Fraley RT, (2003). Improving the nutritional quality of plants. In: Vasil IK (ed) Plant biotechnology 2002 and beyond. Kluwer, Dordrecht, pp 61–67.

Galal Jr, S., Ibrahim, A.F., Abdel-Hamid, A.M. and Mahmoud, I.M., (1975). Morphogenetical studies on the M 2-and M 3-populations of wheat (*Triticum aestivum* ssp. vulgare L.) after seed irradiation with gamma rays. *Z, Naturforsch, B,* **74(3)**, pp.189-198.

Ghafoor. A. and Siddiqui, K.A., (1976). Effect of gamma rays and fast neutrons treatments on tiller number and plant height in wheat. *Pak. J. Bot*. **8**: 1-7

Hassan, S., (1986). Gamma irradiation induced genetic variation in genetic parameters of wheat and triticale. *Sarhad J. Agric*. **2**: 173-179.

Irfaq, M. and Nawab, K., (2001). Effect of gamma irradiation on some morphological characteristics

of three wheat (*Triticum aestivum* L.) cultivars. *J. Biol. Sci*, **1(10)**, 935-945.

Irfaq, M. and Nawab, K., (2003). A study to determine the proper dose of gamma radiation for inducing beneficial genetic variability in bread wheat (*Triticum aestivum* L.). *Asian J Plant Sci*, **2**, 999-1003.

Khah, M.A. and Verma, R.C., (2015). Assessment of the effects of gamma radiations on various morphological and agronomic traits of common wheat (*Triticum aestivum* L.) var. WH-147. *J. Exp. Biol*., **5(7)**, 6-11.

Khalil, S.K., Rehman, S., Afridi, K. and Jan, M.T., (1986). Damage induced by gamma radiation in morphological and chemical characteristics of barley. *Sarhad J. Agric*. **2(1)**, 45-52.

Khamankar, Y.G., (1989). Gamma ray irradiation and selection for yield components in bread wheat. *PKV Res. J,* **13(1)**, 1-5.

Khan, M.M., Din, R., Qasim, M., Jehan, S. and Iqbal, M.M., (2003). Induced mutability studies for yield and yield related characters in three wheat (*Triticum aestivum* L.) cultivars. *Asian J Plant Sci Res,* **2(17-24)**, 1183-1187.

Khan, I. and Zeb, A., (2007). Nutritional composition of Pakistani wheat cultivars. *J. Zhejiang Univ. Sci.* **8(8)**, 555-559.

Kim, J.H., Baek, M.H., Chung, B.Y., Wi, S.G. and Kim, J.S., (2004). Alterations in the photosynthetic pigments and antioxidant machineries of red pepper (*Capsicum annuum* L.) seedlings from gamma-irradiated seeds. *J Plant Biol,* **47(4)**, 314-321.

Kovacs, E. and Keresztes, A. (2002). Effect of gamma and UV-B/C radiation on plant cells. *Micron,* **33(2)**, 199-210.

Larik, A.S., Siddiqui, K.A. and Soomoro, A.H., (1980). Estimates of genetic variability in mutated population of *Triticum aestivum*. *Pak. J. Bot*., **12(1)**, 31-41.

Micke, A. (1999). Mutation breeding of grain legumes. Plant Breeding and Genetics section, Joint FAO/IAEA Division, Vienna, Austria.

Millado, Z., Trajilo, M.A. and Mendozoz, F.R., (1989). Effect of different doses of gamma rays Co60 on four quantitative characters in wheat (*T. aestivum* L.). *Agro. Sci B*, **8**, 41-65.

Molle, K.G., (1965). The influence of seed treatment with gamma radiation on plant yield. *Appl. Radiat. Isot.* **16(7)**, 397-404.

Sen, B. and Joshi M.C. (1958) Effects of ionizing radiation on wheat. *Arch Biochem Biophys*. **76(1),** 188-195

Shewry PR, (2009). The HEALTHGRAIN programme opens new opportunities for improving wheat for nutrition and health. *Nutrition Bulletin*, **34(2),** 225–231.

Shewry, P.R., Powers, S., Field, J.M., Fido, R.J., Jones, H.D., Arnold, G.M., West, J., Lazzeri, P.A., Barcelo, P., Barro, F. and Tatham, A.S., (2006). Comparative field performance over 3 years and two sites of transgenic wheat lines expressing HMW subunit transgenes. *Theor, Appl, Genet*, **113(1)**, 128-136.

Topping, D., (2007). Cereal complex carbohydrates and their contribution to human health. *J, Cereal Sci.*, **46(3)**, 220-229.

Weil, C.F. and Monde, R.A., (2007). Getting the point—mutations in maize. *Crop science*, **47(Supplement-1)**, S-60.

Wi, S.G., Chung, B.Y., Kim, J.H., Baek, M.H., Yang, D.H., Lee, J.W. and Kim, J.S., (2005). Ultrastructural changes of cell organelles in Arabidopsis stems after gamma irradation. *J Plant Biol.*, **48(2)**, 195-200.

Yildirum, M.B., M.I. Cagirgan and I. Turgut, (1987) Selection application in mutant barley population. *Turkiye Tahul Simpozyumu*, 6-9 Ekim 1987*,* Bursa, pp: 473-481