Pak. J. Biotechnol. Vol. 12 (1) 63-72 (2015)
www.pjbt.org
ISSN Print: 1812- 1837
ISSN online: 2312-7791

EVALUATION OF SOME LOCAL WHEAT LANDRACES TREATED WITH DIFFERENT DOSES OF GAMMA RAYS IN SAUDI ARABIA

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Article received 9.3.2015, Revised 17.5.2015, Accepted 21.5.2015

ABSTRACT

Radiation-induced mutagenesis is playing a vital role in the development of improved crop varieties including wheat worldwide. Gamma irradiations ($^{\gamma}$) in mutation breeding are a quicker method in creation of genetic variability to improve many complex characters in cereals. M3 mutation generation of six wheat landraces Halba Al-qassim, Missani, Samrra Najran, Samma, Nukrat Zahran and Mabyat Alnamas originated from 3 different doses of gamma rays (50^{γ}, 100^{γ} and 150^{γ}Gy) were evaluated along with control under pot-house experiment at Al-Mozahimiyah Research Station, King Abdul Aziz City for Science and Technology, Riyadh, Saudi Arabia. The effects of different doses of gamma rays were studied for various yield associated traits. The results obtained from the present study showed that the varieties significantly and variably differed in their response for various traits at different gamma rays doses. The traits number of seeds per spike, weight of seeds per spike and plant height (with and without awns) showed reduction with higher gamma irradiation (150 Gy) doses as compared to low doses. Some of the traits showed improvement due to the induced mutations could be used in future wheat breeding.

INTRODUCTION

Wheat crop productivity is highly affected due to drought, high temperature, soil erosion and several other environmental stresses throughout the different regions of the world including Saudi Arabia.It is expected that the productivity of the major food crops in the world is to be decline in the future due to the environmental stresses, continued reduction of arable land, increased global warming trends, climate change and reduction of water resources (Lobell *et al.*, 2011). About 20% of the irrigated soils in the world are heavily affected due to salinity and drought. The improvement of potential yield and yield associated traits has been the prime objectives of the breeding programme. Wheat yields can be only be improved through breeding techniques viz., hybridization, mutations and biotechnological approaches (Lagoda 2008; Maluszynski, 2000; Konzak, 1987; Borojevic, 1991; Maluszynski, *et al.*, 1995; Albokari, 2014). In Saudi Arabia, due to severe drought spell and other many other climatic changing issues, the optimum yields are not being achieved since last few years. Therefore, wheat crop demands an urgent need to improve the yield gap in the country either by improving the yield potential or increasing the area under cultivation (Reynolds and Rebetzke, 2011; Caldwell *et al.*, 2004; Abderrahman *et al.*, 2008; Ahmed *et al.*,2014). The induced mutations has become an essential approach to create variability and improve the yield potential of wheat (Borzouei *et al.*, 2010; Rakszegi *et al.*, 2010; Sial *et al.*, 2013; Ahmed *et al.*, 2014; Safdar *et al.*, 2013). Among these all breeding approaches, induced-mutagenesis through gamma irradiation have played a significant role in improving the several complex traits in wheat and many other cereals. Gamma rays have been proved as very effective in breaking the closely tight-linkages of genes of many complex quantitative traits. The efficacy of mutation for variability in plant growth, development, and function depends upon the dose of gamma irradiation (Singh et al., 2012). Some researchers have obtained high rate of variability on low doses others have contrary opinion (Baldık *et al.*, 2011). It has been reported that more than 3200 improved varieties of 200 plant species have been officially release by mutation through direct or indirect use of physical (gamma rays, x-rays, fast neutrons, ion beams etc.) and chemical mutagens (ethyl methane sulphonate, sodium azide etc.) in more than 70 countries of the world (IAEA-2014). Such mutant varieties includes cereal crops, ornamental plants, pulses and oil crops have been released on the basis of high yield potential, wide adaptability, resistance/tolerance to biotic and abiotic factors and high quality. FAO/IAEA report has also reported that these varieties are being cultivated over millions of hectares land and have got

massive positive impact on economy of these countries. Several researchers have investigated the effects of gamma radiation on morphological and physiological traits of wheat seedlings (Borzouei *et al.,* 2010; Jain, 2012; Kurowska, 2014; Sial *et al.,* 2008). The present research studies were therefore conducted to determine the effects of different doses of gamma rays on some morphological traits of mutant lines as compared to controls (non-irradiated). The knowledge obtained through this research will be helpful for the breeders while making selection of potentially improved wheat mutant germplasm.

MATERIALS AND METHODS

To investigate the effects of various doses of gamma rays on various plant growth and yield associated traits, the experiment was conducted at Al-Muzahimiyah Research Station of King Abdul Aziz City for Science and Technology (KACST), Riyadh, Saudi Arabia during wheat season 2013. The mutant population (M3) of six wheat landraces viz., Halba Al-qassim, Missani, Samrra Najran, Samma, Nukrat Zahran and Mabyat Alnamas originated from 3 different doses of gamma rays (50^{γ}, 100^{γ} and 150^{γ}Gy) were evaluated along with control (no or zero gamma irradiation dose) under Pot-house experiment. The experiment was conducted using three replications in randomized complete block design (RCBD) in factorial. Each genotype was sown with four rows, 2m long and 30cm distance between the rows.The cultural practices were adopted uniformly in all the plots throughout the growing period as and when required.The effects of gamma irradiations were studied for various yield associated traits likewise number of leaves per plant, leaf length (cm), number of tillers, spike length with awns (cm), spike length without awns (cm), plant height with awns (cm), spike length without awns (cm), seeds per spike and main spike yield (g). Data were statistically analyzed through statistical software Statistis-8.10 using analysis of variance (ANOVA) as suggested by Steel & Torrie 1980 and Gomez and Gomez 1984. The means were compared using standard error and least significant difference (Lsd) according to Duncan's multiple range test (D'MRt).

RESULTS AND DISCUSSION

The mean square obtained from the results showed significant ($P< 0.05$) differences among genotypes and treatments for various observed traits. The mean performance of different parameters is given here as under:

Leaf length (cm): The variety Mabyat Alnamas showed highly significant ($P< 0.05$) increase (20.6, 21.0 and 20.7cm respectively) in leaf length at 3 treatments (Control, 50Gy, 100Gy respectively); whereas, the variety Samrra Najran showed also highly significantly increase in leaf length at all mutant population viz., 50Gy, 100Gy and 150Gy3 gamma rays doses (20.1 respectively), except control (Table 1). Three varieties Halba Al-qassim, Missani and Samrra Najran produced significantly higher leaf length (20.9, 20.6 and 20.1 respectively) at higher gamma rays (150Gy) dose. The overall comparison of treatment showed that the leaf was significantly increased at higher doses (150Gy and 100Gy), as compared to low dose and control (Fig. 1).

Table- 1: Overall mean performance of Leaf length (cm) of wheat mutants and control at different doses of gamma rays

Genotypes	Leaf length (cm)				Overall mean
	(Control γ0)	(50 γ Gy)	(100 γ Gy)	(150 γ Gy)	
Halba Al-qassim	12.1E	12.6D	13.4C	20.9A	12.88E
Missani	17.8B	18.4B	19.4A	20.6A	19.10C
Samrra Najran	19.0B	20.1A	20.1A	20.1A	20.06B
Samma	13.8D	12.8D	12.7C	15.3B	13.04E
NukratZahran	16.1C	15.5C	15.5B	13.3C	15.79D
MabyatAlnamas	20.6A	21.0A	20.7A	12.6C	20.99A
Overall mean	**16.68B**	**16.87AB**	**17.09AB**	**17.09AB**	--
Standard Error	0.2864				0.7996
LSD (0.05)	0.7356				2.5978

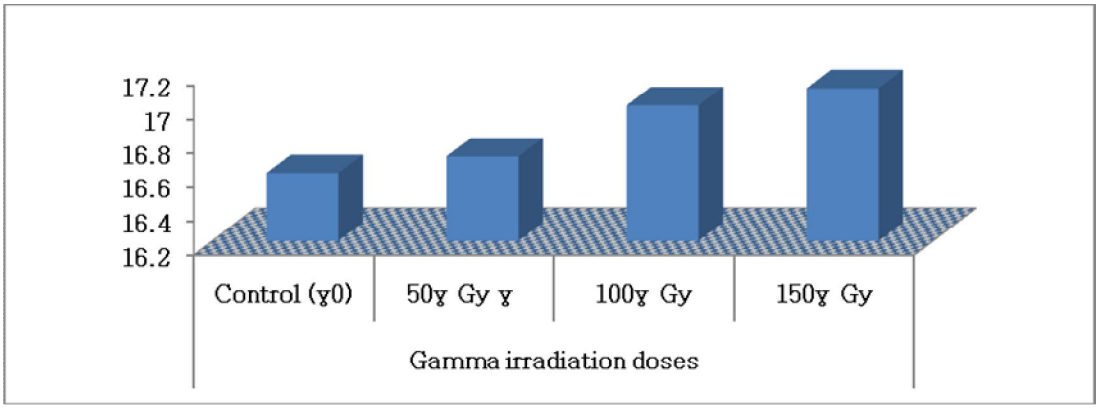

Figure -1: Effect of different doses of gamma rays on Leaf length (cm)

Number of leaves per plant: Genotypes different response for the trait number of leaves. Halba Al-qassim showed highly significant (P< 0.05) increase number of leaves at Control, 50Gy and 100Gy (3.97, 3.80 and 3.90 respectively). The variety Samma also showed significant increase in their number of leaves over all the treatments. Nukrat Zahran showed significantly the lowest number of leaves in all the cases at control as well as in mutated population. The overall mean comparison of treatment showed that the number of leaves were significantly increased in control and decreased at lower (50Gy) gamma rays dose (Fig. 2).

Table -2: Overall mean performance for Number of leaves wheat mutants and control at different doses of gamma rays

Genotypes	Number of leaves (Control γ0)	(50 γ Gy)	(100 γ Gy)	(150 γ Gy)	Overall mean
Halba Al-qassim	3.97A	3.80A	3.90A	3.75AB	3.85 A
Missani	3.45C	3.42B	3.40B	3.32C	3.40 AB
Samrra Najran	3.62BC	3.22B	3.40B	3.35C	3.40 AB
Samma	3.85AB	3.77A	3.80A	3.90A	3.83 A
NukratZahran	2.94D	2.83C	2.91C	2.94D	2.90 B
MabyatAlnamas	3.43C	3.31B	3.22B	3.50BC	3.41AB
Overall mean	3.55A	3.40B	3.44AB	3.47AB	--
Standard Error	0.0520				0.1674
LSD (0.05)	0.1335				0.5440

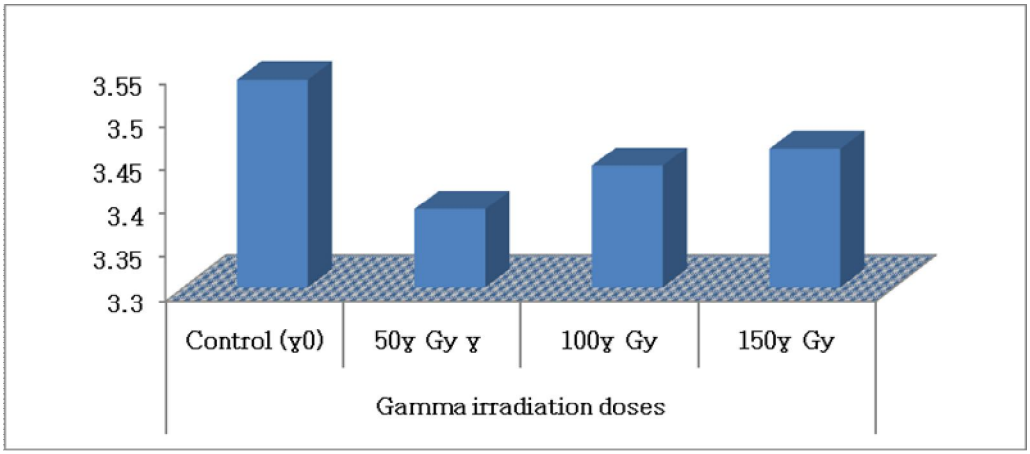

Figure -2: Effect of different doses of gamma rays on Number of leaves

Number of tillers per plant: Different response was observed among genotypes for the trait number of tillers per plant (Table 3). Genotypes Samrra Najran and Mabyat Alnamas produced significantly more number of tillers per plant (3.05 and 2.86 respectively) while Missani (2.25) and Nukrat Zahran (1.91) produced lowest number of tillers at control. Missani and Samrra Najran (3.17 and 3.05 respectively) had higher and Halba Al-qassim had low number of tillers at 50Gy. The variety Nukrat Zahran again could produce lower number of tillers per plat in all the mutated population as well as control. The overall mean of all genotypes showed significant decrease in tiller number at control and increase at low (50Gy) gamma rays dose (Fig 3). The changes due to the induced mutations could be in both directions either increase or reduction in the magnitude of the trait (Albokari, 2014; Irfaq and Nawab, 2001).

Table -3: Overall mean performance for Number of tillers wheat mutants and control at different doses of gamma rays

Genotypes	Number of tillers				Overall mean
	(Control γ0)	(50 γ Gy)	(100 γ Gy)	(150 γ Gy)	
Halba Al-qassim	2.40BC	2.25C	2.52B	2.17CD	2.3375 A
Missani	2.25C	3.17A	2.80B	2.87AB	2.7750 A
Samrra Najran	3.05A	3.05A	2.80B	3.30A	3.0500 A
Samma	2.45BC	2.62ABC	2.30BC	2.55BC	2.4813 A
NukratZahran	1.91C	2.44BC	1.77C	1.91D	2.0625 A
MabyatAlnamas	2.86AB	2.93AB	3.38A	3.15A	3.1438 A
Overall mean	2.5042 A	2.7542 A	2.6250 A	2.6833 A	--
Standard Error	0.1085				0.3954
LSD (0.05)	0.2787				1.2846

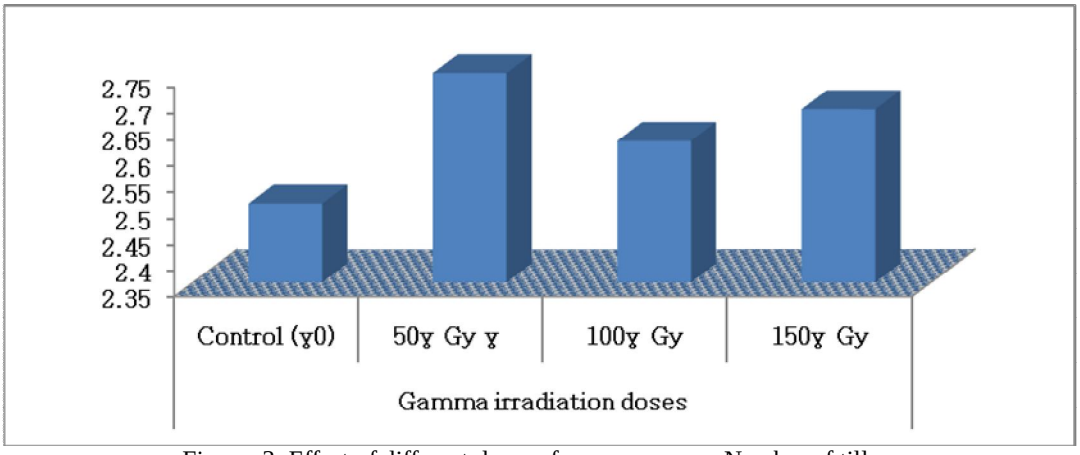

Figure- 3: Effect of different doses of gamma rays on Number of tillers

Plant height (with awns) cm: The highly significant difference for the trait plant height (with awns) of wheat genotypes was observed both in treatments and control (Table 4). Two genotypes Halba Al-qassim and Samma showed overall increase in this trait (ranged from 75.4-79.1cm and 74.2-79.0cm respectively) as compared to all other contesting varieties. Missani and Samrra Najran dwarf type plant height. The trait plant height (with awns) showed significant increase in overall mean at control and linear decrease with the increase of gamma rays doses (Fig.4).

Table-4: Overall mean performance for Plant height (with awns) cm wheat mutants and control at different doses of gamma rays

Genotypes	Plant height (with awns) cm				Overall mean
	(Control γ0)	(50 γ Gy)	(100 γ Gy)	(150 γ Gy)	
Halba Al-qassim	75.7A	78.4A	79.1A	75.4A	77.166 A
Missani	49.4C	51.2B	50.7C	47.7BC	49.772 B
Samrra Najran	50.6BC	49.1B	46.8D	45.3C	47.984 B
Samma	79.0A	76.8A	74.2B	74.2A	76.103 A
NukratZahran	53.7B	51.9B	52.5C	48.5B	51.781 B
MabyatAlnamas	52.7BC	51.1B	51.6C	49.2B	51.063 B
Overall mean	60.194 A	59.794 A	59.179 A	56.746 B	--
Standard Error	0.4486				5.3477
LSD (0.05)	1.1522				17.374

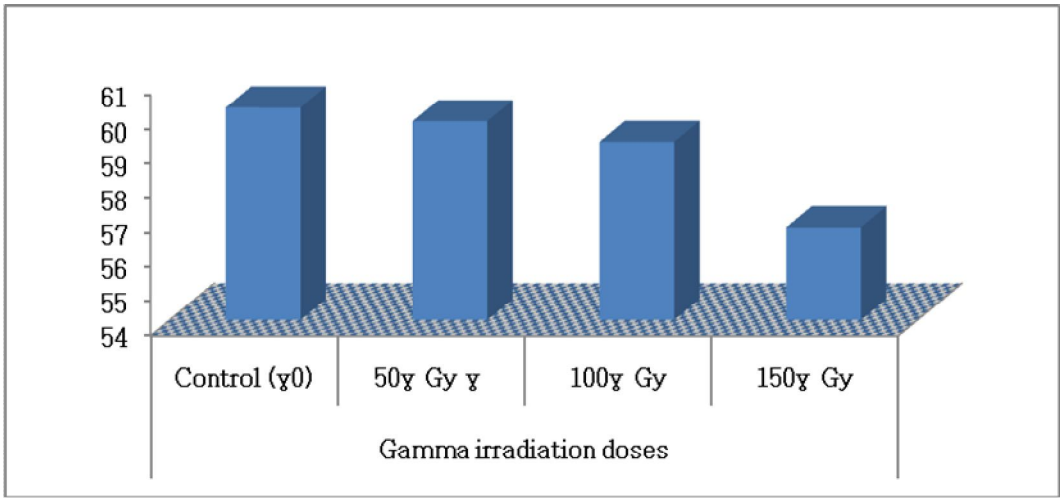

Figure -4: Effect of different doses of gamma rays on Plant height (with awns) cm

Plant height (without awns) cm: The result showed similar trend for plant height (without awns) cm as it was observed in plant height (with awns) among all genotypes and treatments; (Table 5), however there was some comparatively difference for the awn size The trait plant height (without awns) also showed linear reduction with the increase of gamma rays dose (Fig.5).

Table- 5: Overall mean performance for Plant height (without awns) cm wheat mutants and control at different doses of gamma rays

Genotypes	Plant height (without awns) cm				Overall mean
	(Control γ0)	(50 γ Gy)	(100 γ Gy)	(150 γ Gy)	
Halba Al-qassim	70.7A	73.5A	74.2A	70.7A	72.297 A
Missani	42.8C	44.4B	44.0C	41.4BC	43.203 B
Samrra Najran	44.1BC	42.7B	40.3D	38.6C	41.462 B
Samma	74.0A	71.7A	69.0B	69.2A	71.022 A
NukratZahran	47.7B	45.9B	46.7C	42.9B	45.931 B
MabyatAlnamas	45.4BC	44.5B	44.7C	42.6B	44.125 B
Overall mean	54.115 A	53.800 A	53.190 A	50.923 B	--
Standard Error	0.4454				5.3004
LSD (0.05)	1.1438				17.221

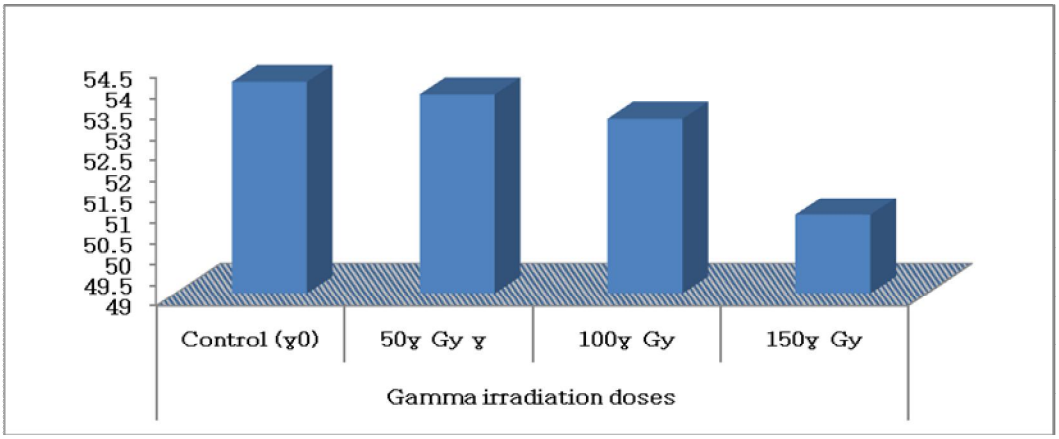

Figure- 5: Effect of different doses of gamma rays on Plant height (without awns) cm

Spike length (with awns): The varieties showed highly significant difference among each other for the trait spike length (with awns) in treatments and control (Table 6). Genotype Mabyat Alnamas produced spikes with significantly higher length ranged from 15.0cm to 15.4cm in all 3 treatments and control. Two varieties Samma (13.0 to 13.5cm) and Nukrat Zahran (12.4 to 12.7cm) could produce smaller spikes than other varieties. Three varieties Mabyat Alnamas, Missani and Samrra Najran showed significantly longer spikes (15.0 and 15.3cm) at higher gamma(150 Gy) rays dose (Table 6) . The overall mean of spike length (with awns) reduced at lower gamma rays dose; while it was increased at control (Figure 6).

Table -6: Overall mean performance for Spike length (with awns) cm wheat mutants and control at different doses of gamma rays

Genotypes	Spike length (with awns) cm				Overall mean
	(Control γ0)	(50 γ Gy)	(100 γ Gy)	(150 γ Gy)	
Halba Al-qassim	13.1CD	12.7B	13.1CD	12.7B	12.872 C
Missani	14.9AB	15.2A	14.9AB	15.3A	14.925 AB
Samrra Najran	14.5B	15.0A	14.5B	15.0A	14.863 AB
Samma	13.5C	13.0B	13.5C	13.0B	13.359 BC
NukratZahran	12.7D	12.4B	12.7D	12.4B	12.709 C
MabyatAlnamas	15.4A	15.0A	15.4A	15.1A	15.491 A
Overall mean	14.056 A	13.963 A	14.104 A	14.023 A	---
Standard Error	0.1357				0.5400
LSD (0.05)	0.3485				1.7544

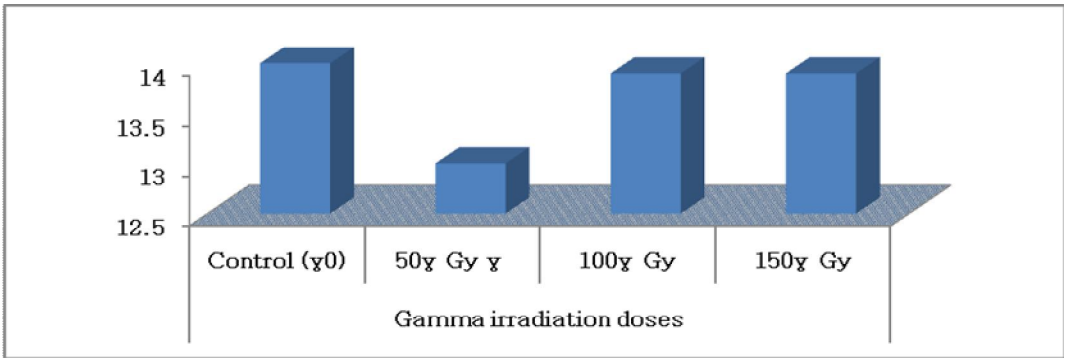

Figure 6: Effect of different doses of gamma rays on Spike length (with awns) cm

Spike length (without awns): Almost similar trend in the average of the trait spike length (without awns) was observed among genotypes and treatments as it was observed in spike length (with awns). Mabyat Alnamas produced spikes with higher length ranged from 8.28cm to 8.51cm in all 3 treatments and control (Table 7). The overall mean of spike length (without awns)

reduced at lower gamma rays dose and also contro; while it was increased with higher gamma rays (150Gy) dose (Figure 7).

Table 7: Overall mean performance for Spike length (without awns) cm wheat mutants and control at different doses of gamma rays

Genotypes	Spike length (without awns) cm				Overall mean
	(Control γ0)	(50 γ Gy)	(100 γ Gy)	(150 γ Gy)	
Halba Al-qassim	7.51CD	7.70B	8.20A	8.13AB	7.8875 A
Missani	7.37D	8.06AB	8.07AB	8.60A	8.0281 A
Samrra Najran	8.08BC	8.35A	7.56BC	7.98B	7.9969 A
Samma	8.85A	8.02AB	8.02AB	7.95B	8.2125 A
NukratZahran	7.02D	6.55C	7.06C	6.52C	6.8344 A
MabyatAlnamas	8.28AB	8.32A	8.51A	8.43AB	8.5094 A
Overall mean	7.8771 A	7.86 A	7.93 A	7.97A	--
Standard Error	0.1135				0.5489
LSD (0.05)	0.2914				1.7833

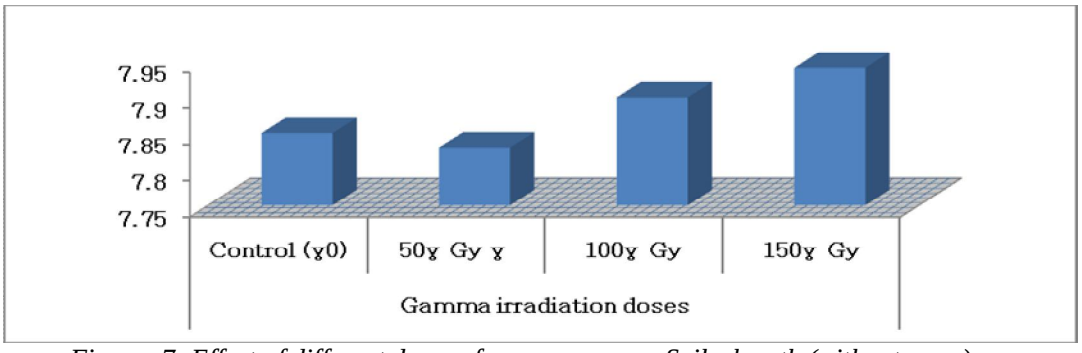

Figure -7: Effect of different doses of gamma rays on Spike length (without awns) cm

Seeds per spike: The number of seeds per spike was significantly increased (33.8) in variety Mabyat Alnamas, followed by Samma (32.1), Nukrat Zahran (30.9), while it was decreased (26.4) in Mssani at control (Table 8). The non-sgnificant difference was observed in all the varieties at low dose of gamma ray (50 Gy). Mabyat Alnamas and Halba Al-qassim produced higher number of spikes at 100Gy, whereas Mabyat Alnamas, Missani, Samrra Najran and Samma produced more seeds per spike at 150Gy. On average, The higher gamma rays doe (150Gy) showed reduction seeds number; however other two treatments (100 and 150Gy) and control were not significantly different with each other (Figure 8). The results have shown that the yield can be improved through increasing the number of seeds per spike (Morad *et al.*, 2011).

Table- 8: Overall mean performance for Seeds per spike wheat mutants and control at different doses of gamma rays

Genotypes	Seeds per spike				Overall mean
	(Control γ0)	(50 γ Gy)	(100 γ Gy)	(150 γ Gy)	
Halba Al-qassim	31.3AB	28.7A	32.3AB	26.1C	29.631 A
Missani	26.4C	31.3A	30.0B	30.0AB	29.469 A
Samrra Najran	30.2B	32.0A	28.7B	29.2ABC	30.050 A
Samma	32.1AB	31.3A	30.6B	29.6ABC	30.931 A
NukratZahran	30.9AB	29.6A	30.3B	27.1BC	29.906 A
MabyatAlnamas	33.8A	31.6A	34.2A	31.7A	32.825 A
Overall mean	30.85A	30.82 A	31.12 A	29.06 B	--
Standard Error	0.6692				3.1290
LSD (0.05)	1.7187				10.166

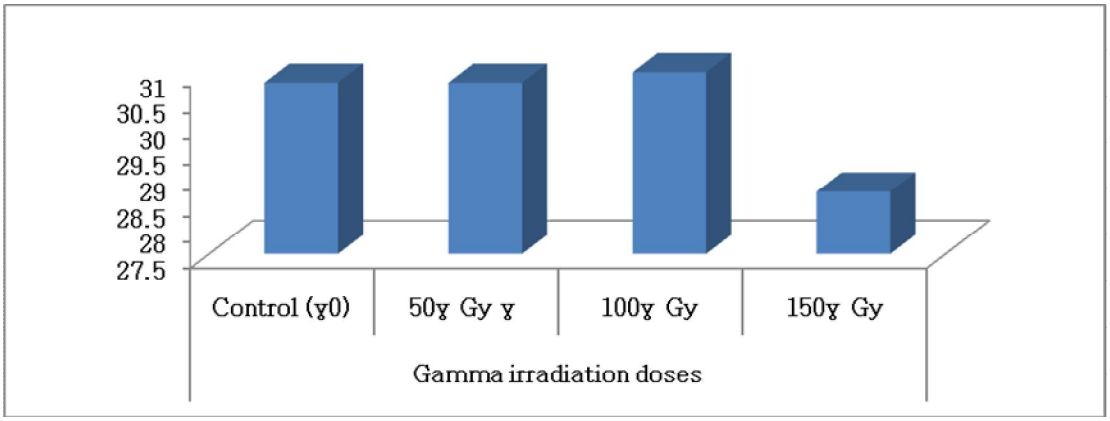

Figure -8: Effect of different doses of gamma rays on Seeds per spike

Weight of seeds /spike (g): The variety Mabyat Alnamas showed significant increase in weight of seeds per spike at all the treatments and control (Table 9). At control, three varieties Mabyat Alnamas, Nukrat Zahran and Samrra Najran produced significantly high weight of seeds per spike (1.38, 1.22 and 1.208). Similarly, Mabyat Alnamas, Samrra Najran, Missani and Nukrat Zahran had higher seed weight at 50Gy, while only Mabyat Alnamas had high seed weight at 100Gy. Three varieties (Mabyat Alnamas, Samrra Najran, Missani) gave highest number of seeds than other varieties at 150Gy gamm rays. The higher dose (150Gy) comparatively showed reduction in seeds weight than other all treatments (Figure 9).

Table -9: Overall mean performance for Seeds per spike (g) wheat mutants and control at different doses of gamma rays

Genotypes	Weight of seeds /spike (g)				Overall mean
	(Control γ0)	(50 γ Gy)	(100 γ Gy)	(150 γ Gy)	
Halba Al-qassim	0.95C	0.89B	0.98C	0.81C	0.9121 A
Missani	0.99C	1.20A	1.17B	1.23A	1.1522 A
Samrra Najran	1.20B	1.25A	1.19B	1.25A	1.2261 A
Samma	1.09BC	0.99B	0.97C	0.90BC	0.9924 A
NukratZahran	1.22B	1.17A	1.18B	1.05B	1.1796 A
MabyatAlnamas	1.38A	1.32A	1.40A	1.34A	1.3656 A
Overall mean	1.1466 A	1.1422 A	1.1566 A	1.1065 A	--
Standard Error	0.0291				0.1458
LSD (0.05)	0.0747				0.4736

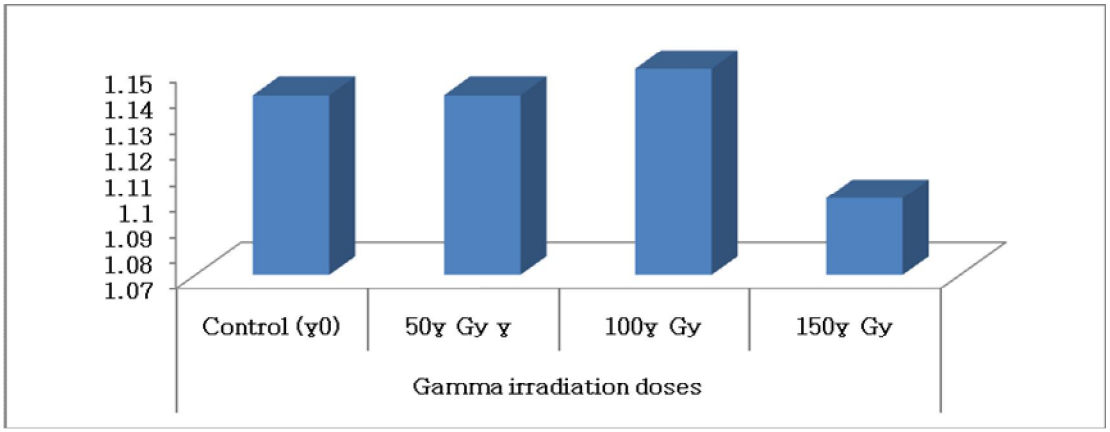

Figure -9: Effect of different doses of gamma rays on Weight of seeds /spike (g)

CONCLUSION

The results obtained from the present study showed that the varieties significantly and variably differed in their response for various traits at different gamma rays doses. It is concluded that the traits like number of seeds per spike, weight of seeds per spike and plant height (with and without) showed reduction with higher gamma irradiation (150 Gy) doses as compared to low doses. However, spike length showed some increase at higher dose and decrease at lower doses. These findings suggested that the variability could be induced through the use of gamma irradiations. The information generated through this research will be helpful for the selection of desired mutants from the mutation generation. The selected mutant progenies will be further evaluated in future mutation breeding programme.

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