Zagazig J. Agric. Res., Vol. 44 No. (6B) 2017 2431-2444

Field Crop Science

http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

PERFORMANCE AND BREEDING PARAMETERS FOR YIELD AND ITS ATTRIBUTES IN M_2 GENERATION OF THREE BREAD WHEAT CULTIVARS AS INFLUENCED BY GAMMA AND LASER RAY

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Received: 19/10/2017 ; Accepted: 05/11/2017

ABSTRACT: The present investigation was carried out at the Experimental Farm, Plant Research Department, Nuclear Research Center, Atomic Energy Authority, Inchas, Egypt during 2011/2012 and 2012/2013 seasons. Preliminary experiment was investigated to identify the proper dose radiation, seeds of the three cultivars (Sids 12, Sakha 94 and Gemmeiza 9) had been exposed to gamma irradiation doses of 0.0, 150, 200, 250, 300, 350, 400, 450 and 500 gray. Based on mean value of epicotyl length (cm), three gamma ray doses were selected *i.e.*, 250 (Gy_1), 300 (Gy_2) and 350 Gy (Gy_3) for both Sids 12 and Gemmeiza 9 cultivars as well as 350 (Gy_1), 400 (Gy_2) and 450 Gy (Gy_3) for Sakha 94 cultivar. LASER treatments were 1, 1.5 and 2 hr., in addition to the control. The maximum values for both spike length and No. of fertile spikelets/spike were observed by Gemmeiza 9 which attained the lowest No. of sterile spikelets/spike (2.44). Furthermore, wheat cv. Sids 12 was the shortest height (75.19 cm) and gave the greatest No. of grains/spike (71.66) and the highest 1000-grain weight (41.27 g), while Gemmeiza 9 was the tallest (82.20 cm) and produced the greatest No. of spikes/plant (9.05) and grain yield/plant (14.79 g). Gamma irradiation dose (Gy_1) resulted in a decrease in plant height (79.75 cm) and No. of sterile spikelets/spike (2.40) rather than the control. Grain yield/plant, No. of spikes/plant and spike length recorded significant increase due to gamma ray treatments at the lowest dose (Gy_1) valued 14.42 g, 8.46 and 13.88 cm, respectively but both characters decreased with the highest dose (Gy_3). LASER exposure periods at 1 hr., resulted in a significant increase in plant height and No. of fertile spikelets/spike, but significantly reduced No. of sterile spikelets/spike rather than 1.5 and 2 hr. Both 1.5 hr., and 2 hr., LASER exhibited significant increase in grain yield/plant valued 15.78 g and 15.57 g, respectively, rather than the control (13.67 g). Interaction of cultivar × mutagen treatments was significant for all studied wheat characters, except No. of fertile spikelets/ spike. Under gamma ray, GCV and PCV estimates were high for No. of spikes/plant only, with higher estimates of ECV for that character and grain yield/ plant. Whereas, it was relatively low for plant height, spike length, No. of fertile spikelets/spike and No. of sterile spikelets/spike. Heritability in broad sense was high (≥75%) for plant height, spike length, No. of sterile spikelets/spike, No. of spikes/plant, No. of grains/spike, and 1000-grain weight. Estimates of broad sense heritability coupled with genetic advance and were low for No. of fertile spikelets/spike and grain yield/plant. Estimates of GCV and PCV under LAZER ray were high for No. of grains/ spike, 1000-grain weight and grain yield/plant, whereas, it was low for plant height, spike length and No. of spikes/plant. These findings indicate the importance of previous results in wheat breeding programs for improving yield.

Key words: Wheat, mutation, laser, induction, gama ray, genetic parameters.

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INTRODUCTION

Recently the use of physical methods for plant growth stimulation is getting more popular due to the less harmful influence on the environment. Govindaraj *et al.* (2017) stated that, physical factors can be used to get positive biological changes in crop plants without affecting the ecology. Energy treatment is an innovative area of research to improve physiological and biochemical changes, which reflect the plant growth and ultimately improve the yield and quality of the produce.

The increase in variation of quantitative characters for a given generation can depend on the genotype, trait, mutagen used and the precision in selection techniques. Desirable mutant individuals can be isolated using good selection procedures. So, selected high grain yield/plant and other desirable traits in the M_2 populations to produce significant yield superiority families in M_3's over their original and better parents has been obtained by Al-Naggar *et al.* (2015).

Many new mutants are selected which are not observed in the parental M_2 families. The expected response to selection can be measured by determining the parameter like mean, variation, standard deviation, heritability and genetic advance (El-Degwy and Hathout, 2014; El-Naggar and Soliman, 2015).

In continuous, estimates of genetic components are important for determining breeding strategies for improving economic characters. AL-Azab (2013) registered highest estimates of PCV, GCV, σ^2 P and σ^2 g for grain yield/plant and spikes/plant. The irradiated cultivar Sids-4 (1) recorded the highest estimates of PCV and σ^2p and highest GCV and σ^2 g for grain yield and the most important yield components, and Maryout-5 and Sakha-93 came in the second rank. Heritability estimates in the broad sense in M_2 generation, were higher for five traits (plant height, spikes/plant, grains/spike, 100 grain weight and grain yield/plant), while the opposite was true for spike length trait. The average predicted genetic gained from selection was high for all studied traits, except spike length.

The helium (He-Ne) LASER irradiation improved morphological parameters, so Chen and Han (2014) used He-Ne LASER applied under field conditions to increase the yield of wheat crop Laxani *et al.* (2013) irradiated tetraploid wheat populations by physical and chemical mutagens, recorded highest PCV and GCV for all characters except for plant height, spike length and number of spikelets/spike. Moreover, all characters exhibited high heritability value except spike length. Kumari *et al.* (2014) evaluated wheat variety RAJ-4037 under 9 different doses of gamma rays (5, 10, 15, 20, 25, 30, 35 and 40 KR) including control during M_1 and M_2 generations. Higher doses of gamma rays reduced the germination (%), shoot length and seedling height in M_1 generation. Higher magnitude of each GCV and PCV was recorded for number of tillers plant while plant height and test weight show high heritability. Moderate to low genetic advance was observed for plant height in M_2 generation. Added to that, some mutants were identified as the best progeny for grain yield/plant and test weight among all the progeny of different families.

The present investigation aims to: Investigate the effect of different doses of gamma ray and LASER beams on some agronomic traits of Sids 12, Sakha 94 and Gemmeiza 9 wheat cultivars, induction of genetic variability to perform selection of some mutants with some useful quantity and quality and study genetic variability through compute genotypic and phenotypic coefficient of variability, heritability and genetic gain.

MATERIALS AND METHODS

The present investigation was carried out at the Experimental Farm, Plant Research Department, Nuclear Research Center, Atomic Energy Authority, Inchas, Egypt during 2011/2012 and 2012/2013.

Seeds of the three wheat cultivars Sids 12, Sakha 94 and Gemmieza 9 (Table 1) were obtained from Wheat Research Section, Field Crops Research Institute, Agricultural Research Center (ARC), Giza, Egypt.

Table 1. Name and pedigree of the studied wheat cultivars

Name	Pedigree
Sids 12	BUC//7C/ALD/5/MAYA74/ON//1160-147/3/BB/GLL/4/CHAT"S"/6/ MAYA/VUL//CMH74A.6304/*SX.SD70964-SD-1SD-1SD-0SD.
Sakha 94	Opata/Rayon//KauZ.CMBW90Y3180-0T0PM-3Y-010M-010Y-10M-15Y-0Y-0AP-0S.
Gemmeiza 9	Ald"S"/Huac "S"//CMH 74A.630/5XCGM4583-5GM-IGM-0GM.

Preliminary Experiment

The main objective of this experiment was to detect the relative sensitivity of the three cultivars to different gamma ray doses to identify the proper dose radiation for useful mutation induction. In 2011, dry seeds of each cultivar (Sids 12, Sakha 94 and Gemmeiza 9) had been exposed to gamma irradiation at the doses of 0.0, 150, 200, 250, 300, 350, 400, 450 and 500 gray. Irradiated and non irradiated (control) seeds of each cultivar were sown on 9th November at room temperature. Three replicates were sown for each treatment. Each replicate includes one Petri-dish containing 25 seeds. The experiment carried out in a randomized complete block design. After seven days, length of epicotyl (cm) of seedling and reduction (%) was estimated.

Irradiation treatments were achieved by radioactive Cobalt-^{60} (co^{60}) gamma rays from Gamma Unit which delivered 7.5 k Gy (7500 Gy) per hour. Exposure times were equivalent to achieve the previous doses.

Field Experiments

Two field experiments *i.e.,* gamma ray and LASER ray were separately conducted. The experimental design was split plot design with randomized complet blocks arrangement in three replicates, cultivars were put in the main plot and treatments were put in the sub plot.

Gamma Ray Experiment

M_1 generation (2011/2012 season)

According to the previous preliminary experiment, seeds of two wheat (*Triticum aestivum* L.) cultivars (Sids 12 and Gemmeiza 9) were irradiated with 250, 300 and 350 Gy, while Sakha 94 seeds were irradiated with 350, 400 and 450 Gy of gamma rays and sown in the field on 25th November 2011. Individual seed was sown in a three meter long at 10 cm space between plants and 30 cm between rows in plots (each plot contains 5 rows) to obtain M_1 generation. The soil was sandy loam in texture and the recommended cultural practices for wheat production at Inchas, Sharkia Governorate were followed.

M_2 generation (2012/2013 season)

Seeds of the M_1 generation were sown on 27th November, 2012 in plots. Each plot contains 5 rows; each row was three meter in length and 30 cm in width and spaces within plants were 10 cm. One percent selection intensity was practiced in the same season.

LASER ray experiment

Seeds of the three wheat cultivars *i.e.*, Sids 12, Sakha 94 and Gemmeiza 9 were exposed to LASER ray at different times of exposure 1, 1.5 and 2 hr. The helium-neon LASER (He-Ne) at the wave length of 632.8 nm in the red portion of the visible spectrum and power density of Mw^{-2} was applied. Treated seeds were sown immediately after irradiation in the field experiment in rows with the same system used in gamma rays experiment in the same time of sowing, in addition to the control.

One percent selection intensity was practiced in the same season. The selection was done in the two experiments *i.e.,* gamma ray and LASER ray depended on plant height, spike length, number of spikes/plant and seed index.

Data were recorded on 5 individual guarded plants in each replicate for plant height; spike characteristics *i.e.,* spike length, number of fertile spikelets/spike and number of sterile spikelets/spike as well as grain yield and its components *i.e.,* number of spikes/plant, number of grains/spike and 1000-grain weight.

Statistical Analysis

Data were statistically analyzed, and mean values were compared by using the least significant difference test (LSD) at 5% level (Steel *et al.,* 1997). Genotypic (GCV), phenotypic (PCV) and environmental (ECV) coefficient of variations were estimated according to Burton (1952). Heritability in broad sense (H_b %) and genetic advance as (%) of population mean (G.s%) were computed according to Hanson *et al.* (1956) following to Singh and Chaudhary (1985).

RESULTS AND DISCUSSION

Preliminary Experiment

Mean values of epicotyl length (cm) of seedling for three wheat cultivars as affected by different gamma rays doses and percentage of reduction as compared to control (0 dose) are presented in Table 2. Epicotyl length decreased dramatically with increasing gamma ray dose. Therefore, reduction (%) of epicotyl length was increased with each increase in gamma ray dose.

The growth reduction resulting from 250, 300, 350, 400, 450 and 500 Gy doses were above 30% in both cultivars of Sids 12 and Gemmeiza 9. However, the growth reduction resulting from 350, 400, 450 and 500 Gy doses was above 30% in Sakha 94 cv.

Accordingly, in the present investigation three gamma ray doses were selected *i.e.*, 250, 300 and 350 Gy for both Sids 12 and Gemmeiza 9 cultivars as well as 350, 400 and 450 Gy for Sakha 94 cultivar. In this respect, Konzak and Mikaleson (1995) advised that the selected doses of sparsely ionizing radiation, *i.e.*, gamma rays for mutation breeding of cereals are those which cause 30-50% reduction in seedling growth laboratory tests.

Mean Performance of M_2 Generation as Influenced by Gamma Ray

Plant height and spike characteristics

Results presented in Table 3 show mean performance of plant height and spike characteristics as influenced by gamma irradiation on M_2 generation for Sids 12, Sakha 94 and Gemmeiza 9 wheat cultivars. Subjected wheat cultivars to gamma irradiation doses resulted significant variation for all studied characters in all cases. This result revealed the great influence of the gamma ray irradiation doses on genetic structure of wheat cultivars.

Regarding wheat cultivars, as presented in Table 3, Gemmeiza 9 produced the tallest plants (82.20 cm), otherwise Sids 12 was the shortest (75.19 cm) one, as well as, Sakha 94 was intermediate between them (78.56 cm).

Concerning spike characteristics, significant differences were detected between bread wheat cultivars for spike length, No. of fertile spikelets/spike and No. of sterile spikelets/ spike. The maximum and the minimum values for such characters were 14.26 cm (Gemmeiza 9) and 11.68 cm (Sakha 94) for spike length; 20.35 (Gemmeiza 9) and 18.52 (Sakha 94) for No. of fertile spikelets/spike and 2.96 (Sakha 94) and 2.44 (Gemmeiza 9) for No. of sterile spikelets/ spike. Sakin (2002) and El-Degwy and Hathout (2014) recorded significant differences between mutations after gamma ray treatments in plant height and spike characteristics.

Concerning the effect of gamma ray irradiation treatments (Table 3), a decrease in plant height was observed due to Gy_2 treatment with value of (80.16 cm) followed by Gy_1 then Gy_3 treatments with values of (79.75 cm) and (72.52 cm), respectively, rather than the control (82.16 cm). In this respect, Singh and Balyan (2009) found that, three progenies out of thirteen derived from Kharchia 65 wheat cultivar under four gamma treatments (0, 20, 30 and 40 KR) showed reduction in plant height.

As presented in Table 3, significant increase in spike length was observed due to Gy_1 treatment valued (13.88 cm) followed by Gy_2 treatment with value of (13.53 cm). While, Gy_3 treatment had insignificant decrease in spike length as compared to the control.

Whereas, significant increase was observed in No. of fertile spikelets/spike due to both Gy_2 and Gy_1 treatments valued (20.21) and (20.04), respectively when compared to the control (19.30). Gy_3 treatment caused insignificant decrease in No. of fertile spikelets/spike when compared with the control. On the other hand, significant increase was observed in No. of sterile spikelets/spike due to the highest gamma

Table 2. Mean values of epicotyl length (cm) of seedling for three wheat cultivars as affected by different gamma ray doses and percentage of reduction as compared to control (0 dose)

Cultivar	Sids12		Sakha 94		Gemmeiza 9	
Dose (Gy)	Epicotyl length (cm.)	Reduction (%)	Epicotyl length (cm.)	Reduction (%)	Epicotyl length (cm.)	Reduction (%)
Control (0)	4.38	-	5.12	-	4.18	-
150	2.44	44.29	4.78	6.64	3.74	10.52
200	3.01	31.27	4.43	13.47	4.18	-
250	2.72	37.90	4.23	17.38	2.42	42.10
300	2.42	44.74	3.73	27.14	1.99	52.39
350	2.16	50.68	3.15	38.47	1.36	67.46
400	0.95	78.31	2.16	57.81	1.15	72.48
450	1.32	69.86	1.75	65.82	0.74	82.29
500	1.04	76.25	1.11	78.32	0.81	80.62
$LSD_{0.05}$	0.738		1.067		0.932	

The percent decrease values were calculated by dividing the difference between the highest and lowest value over the highest value multiplied by hundred.

Table 3. Mean performance of plant height and spike characteristics for Sids 12, Sakha 94 and Gemmeiza 9 wheat cvs. as influenced by gamma irradiation treatments and their interaction in M_2 generation (2012/2013 season)

Main effects and interaction	Plant height (cm)	Spike length (cm)	No. of fertile spikelets/spike	No. of sterile spikelets/spike
(A) Cultivar				
Sids 12	75.19	13.10	20.09	2.75
Sakha 94	78.56	11.68	18.52	2.96
Gemmeiza 9	82.20	14.26	20.35	2.44
F. test	*	*	*	*
$LSD_{0.05}$	3.409	0.434	0.2583	0.0546
(B) Gamma irradiation treatment				
Control	82.16	12.40	19.30	2.66
Gy_1	79.75	13.88	20. 04	2.40
Gy_2	80.16	13.53	20.21	2.79
Gy_3	72.52	12.25	19.06	3.02
F. test	*	*	*	*
$LSD_{0.05}$	3.272	1.137	0.279	0.067
Interaction				
A × B	*	NS	*	*

Irradiation treatments were 250, 300 and 350 Gy of Gy_1, Gy_2, Gy_3 for both Sids 12 and Gemmeiza 9 cultivars as well as 350, 400 and 450 Gy of Gy_1,Gy_2,Gy_3 for Sakha 94 cultivar referenced to results of radio sensitivity test experiment.* , Significant at 0.05 level of probability and NS, refers to Not significant.

ray dose Gy_3 valued (3.02) followed by Gy_2 (2.79). Otherwise, the lowest gamma ray dose Gy_1 treatment caused significant decrease in No. of sterile spikelets/spike (2.40) rather than the control (2.66). In this respect, high degree of genetic variation was registered between wheat genotypes under gamma ray irradiation for plant height (Jamil and Khan, 2002). Whereas, Rybinski *et al.* (2003) detected great differences between three gamma ray treatments *i.e.,* 150, 200 and 250 Gy for spike length, number of spikelets/ spike and number of fertile spikes/ spike in barley.

Interaction between cultivars × gamma ray irradiation were found to be significant in all studied wheat characters except spike length, where it was insignificant. This means that wheat cultivars did not differ in their response to gamma ray irradiation treatments in respect to spike length. Similar results were obtained by El-Degwy and Hathout (2014)

Grain yield and its components

Results presented in Table 4 show mean performance for yield and its components as influenced by gamma irradiation on M_2 generation for Sids 12, Sakha 94 and Gemmeiza 9 wheat cultivars. Subjected wheat cultivars to gamma ray irradiation doses resulted in a significant variation for all studied characters in all cases, revealing the great effect of the gamma ray irradiation doses on genetic structure of wheat cultivars.

Regarding wheat cultivars (Table 4), Gemmeiza 9 produced the greatest number of spikes/ plant (9.05) and grain yield/plant (14.79 g), whereas Sids 12 was the lowest one in number of spikes/plant (5.27) and Sakha 94 in grain yield/plant (11.26 g). The other wheat cultivars exhibited different magnitudes of both characters.

Sids 12 produced the highest number of grains/spike (71.66.) and 1000-grain weight (41.27 g), while Sakha 94 was the lowest one in No. of grains/spike (46.17) and Gemmeiza 9 was the lowest in 1000-grain weight (34.72 g) among the studied wheat cultivars. Nazarenko (2016) found that the most informative parameters for mutagenic depression in M_1 generation due to gamma-rays and chemical mutagens were yield parameters as plant height, grain weight per spike, 100-grain weight. Insensitive and most sensitive for mutagen actions varieties have been developed. Whereas, Laghari *et al.* (2012) showed that mutant MASR-3, MASR-9, MASR-14 and MASR-64 produced higher 1000-grain weight (45.2, 47.7, 45.7 and 45.0 g, respectively). While the highest number of grains/spike was recorded in MASR-64 (79.9), MASR-6 (71.8) and MASR-8 (68.0), and higher grain yield (5420 kg/ha, 5380 kg/ha) was produced by mutant MASR-64 and MASR-6, respectively.

Regarding the effect of gamma ray irradiation treatments (Table 4), significant increase in number of grains/spike was observed due to gamma ray irradiation treatments at Gy_2 with value of (58.28) followed by Gy_3 treatment valued (56.48), but such number of grains/spike was decreased under the lowest dose Gy_1 treatment valued (54.70) rather than the control (55.18). However, 1000-grain weight was significantly increased due to gamma ray irradiation treatments at Gy_3 with value of (39.83 g) followed by Gy_2 valued (38.58 g). This result could be due to stimulation effect of gamma ray on 1000-grain weight. In contrast, such character decreased with the lowest effect at Gy_1 (35.57 g) rather than the control (36.67 g).

Furthermore, significant increase was observed in both grain yield/plant and number of spikes/plant due to gamma ray irradiation treatments at the lowest dose Gy_1 with values of (14.42 g) and (8.46) followed by Gy_2 (13.53 g) and (8.03). But both characters decreased with the highest dose Gy_3 with value of (10.50 g) and (5.12) rather than the control (11.79 g) and (6.61), respectively. Response of genotypes to irradiation doses suggests that the effect is essentially at physiological than at genetic level and that role of growth hormones could be crucial (Singh and Datta, 2010). These results reveal that Gy_1 and Gy_2 treatments caused activation in physiological process which reflected on increasing wheat grain yield, but high dose of gamma ray "Gy_3" caused inhibition effect. The obtained results indicated that mutant induced with gamma ray provided new useful germplasms for wheat genetics and breeding. The obtained results are hold true by RAPD analysis, where highest genetic diversity was detected among bread wheat mutants.

Table 4. Mean performance for yield and its components for Sids 12, Sakha 94 and Gemmeiza 9 wheat cvs. as influenced by gamma irradiation treatments and their interaction in M_2 generation (2012/2013 season)

Main effects and interaction	No. of spikes/plant	No. of grains/ spike	1000-grain weight (g)	Grain yield/plant (g)
(A) Cultivar				
Sids 12	5.27	71.66	41.27	11.62
Sakha 94	6.84	46.17	37.14	11.26
Gemmeiza 9	9.05	51.18	34.72	14.79
F.test	*	*	*	*
LSD $_{0.05}$	0.788	2.480	2.46	1.252
(B) Gamma irradiation treatment				
Control	6.61	55.18	36.67	11.79
Gy_1	8.46	54.70	35.57	14.42
Gy_2	8.03	58.28	38.58	13.53
Gy_3	5.12	56.48	39.83	10.50
F. test	*	N.S	*	*
LSD $_{0.05}$	1.803	-	1.754	1.250
Interaction				
A × B	*	NS	*	*

Irradiation treatments were 250, 300 and 350 Gy of Gy_1, Gy_2, Gy_3 for both Sids 12 and Gemmeiza 9 cultivars as well as 350, 400 and 450 Gy of Gy_1, Gy_2, Gy_3 for Sakha 94 cultivar referenced to results of radio sensitivity test experiment. *, Significant at 0.05 level of probability and NS, refers to Not significant.

Interaction of cultivars × gamma ray treatments was found to be significant in all studied wheat characters, except No of grains/spike (Table 4). Therefore, wheat cultivars had differential response to gamma ray irradiation treatments. These results are in agreement with those reported by Jamil and Khan (2002) who registered significant differences among 5, 10, 15, 20 and 25 Kr doses of gamma radiation on wheat cultivar Bakhtawar-92. The most beneficial dose was 20 Kr on plant height, number of grains/spike and grain yield. However, Singh and Balyan (2009) indicated that, out of thirteen mutant progeny from Kharchia 65 cv., three progenies namely 368, 446-7 and 621 were superiority over control population for number of tillers/plant, number of spikelets/spike and biological yield.

Mean Performance of M_2 generation as Influenced by LASER Irradiation Treatments

Plant height and spike characteristics

It is interest to mention that, the LASER offers a pure ecological source of energy that ensures high yield, hence the LASER started to be used as a bio stimulator in plant production. Results presented in Table 5 show performance of plant height and spike characteristics for Sids 12, Sakha 94 and Gemmeiza 9 wheat cvs. as influenced by LASER irradiation treatments in M_2 generation.

Regarding wheat cultivars as given in Table 5, Sids 12 produced the shortest plants (76.96 cm), otherwise Gemmeiza 9 was the tallest (89.26 cm) one, whereas, Sakha 94 located in

Table 5. Mean performance of plant height and spike characteristics for Sids12, Sakha 94 and Gemmeiza 9 wheat cvs. as influenced by LASER irradiation treatments and their interaction in M_2 generation (2012/2013 season)

Main effects and interaction	Plant height (cm)	Spike length (cm)	No. of fertile spikelets/spike	No. of sterile spikelets/spike
(A) Cultivar				
Sids 12	76.96	13.79	19.00	3.29
Sakha 94	83.07	12.13	17.90	2.87
Gemmeiza 9	89.26	13.17	21.00	2.47
F.test	*	*	*	*
LSD $_{0.05}$	1.166	0.8701	1.619	0.0979
(B) LASER irradiation treatment				
Control	78.34	12.45	19.00	2.83
1 hr	85.75	13.15	23.30	2.45
1.5 hr	82.32	13.28	20.00	2.95
2 hr	81.93	13.26	20.00	3.22
F.test	*	*	*	*
LSD $_{0.05}$	1.947	0.5818	1.1570	0.1100
Interaction A × B	*	*	NS	*

*, Significant at 0.05 level of probability and NS, refers to Not significant

between them with value of (83.07 cm). In this respect, significant differences between mutant wheat genotypes in regard to plant height has been registered by El-Naggar and Soliman (2015).

Spike characteristics *i.e.,* spike length, No. of fertile spikelets/spike and No. of sterile spikelets/ spike exhibited significant differences between bread wheat cultivars. The maximum and the minimum values for such characters were 13.79 cm (Sids 12) and 12.13 cm (Sakha 94) for spike length; 21.00 (Gemmeiza 9) and 17.90 (Sakha 94) for No. of fertile spikelets/spike as well as 3.29 (Sids 12) and 2.47 (Gemmeiza 9) for No. of sterile spikelets/spike. In this regard, high degree of genetic variability was registered between wheat genotypes for plant height and spike length under LASER treatments by Rybinski (2001).

Regarding the effect of LASER irradiation treatments (Table 5), significant increase in plant height was observed due to LASER treatments compared to the control. The highest effect was observed at 1 hr., (85.75 cm) followed by 1.5 and 2 hr., with values of (82.32 cm) and (81.93 cm) in descending order, respectively.

All tested treatments caused significant increase in both spike length and No. of sterile spikelets/ spike rather than the control without significant differences between all LASER treatments for spike length (Table 5). Whereas, 1 hr., treatment resulted in pronounced effect on No. of fertile spikelets/spike with value of (23.30) compared to both 1 .5 and 2 hr., period which gave the same effect valued (20.00). In contrast, 1 hr., treatment significantly reduced No. of sterile spikelets/spike compared to the control, then it was increased from 2.95 to 3.22 with prolonged exposure periods from 1.5 to 2 hr., respectively. An increase in spike length and No. of fertile spikelets/spike after mutagen treatments has been also obtained by Drozd and Szajsner (1999).

Interaction between cultivar × LASER treatments was significant for plant height and spike characteristics, except for No. of fertile spikelets/ spike which was insignificant. Hereby, these cultivars had differential responses to LASER irradiation treatments. Similar results were recorded by Rybinski (2001) who registered high levels of reduction and stimulation of the M_1 plants after application of LASER light on Rudzik and Ramp cvs. for plant height, spike length and number of fertile spikelets/plant. Chen and Han (2014) showed that single He-Ne LASER irradiation yielded improved morphological parameters, while the combined He-Ne LASER and enhanced UV-B radiation group exhibited rehabilitation effects.

Grain yield and its components

Results presented in Table 6 show mean performance of yield and its components as influenced by LASER irradiation on M_2 generation of Sids 12, Sakha 94 and Gemmeiza 9 wheat cultivars. It can be seen that, subjecting wheat genotypes to LASER exposure periods resulted in a significant variability for all studied characters in all cases. This result revealed the great effect of the LASER on performance of wheat cultivars.

As presented in Table 6, concerning wheat cultivars, Sakha 94 produced the biggest number of spikes/plant (10.75), otherwise, Sids 12 gave the smallest (3.3) number as well as Gemmeiza 9 was located in between them with value of (9.25).

Wheat cultivar Sids 12 produced the highest No. of grains/spike (75.16) and 1000-grain weight (49.64 g), otherwise, Sakha 94 produced the lowest No. of grains/spike and 1000-grain weight with values of 56.42 and 38.68 g, respectively. Whereas, Gemmeiza 9 was located in between them with values of 60.97 and 41.66 g for the same studied characters, in the same respective order. Meanwhile, Gemmeiza 9 produced the heaviest grain yield/plant (18.00 g), otherwise Sids12 gave the lowest productivity (10.32 g), while Sakha 94 was moderate between them (14.59 g). In this regard, high level of genetic variability between wheat genotypes under LASER treatments has been recorded by Nenadic *et al.* (2008) who showed the impact of LASER treatment on dynamics of germination and wheat characters.

Concerning the effect of the LASER irradiation treatments (Table 6), an increase in No. of spikes/plant was observed due to exposure periods of LASER 1.5 and 2 hr., valued (8.47) and (8.37), but it showed insignificant decrease with 1 hr., with value of (7.08) compared to the control (7.26).

LASER irradiation treatments showed an increase in No. of grains/spike due to 1 hr., followed by 2 hr., with values of (65.78) and (64.20), respectively. Whereas, subjected wheat seeds to 1.5 hr., LASER did not significantly affect this character which similar to the control valued (63.03).

An increase in 1000-grain weight and grain yield/ plant was observed due to different times of exposure with highest effect by 1.5 hr., exposure followed by 1 hr., then 2 hr., with values of (45.07), (44.22) and (43.40 g), respectively rather than the control (40.56 g) for 1000-grain weight. Meanwhile grain yield/ plant showed significant increase with 1.5 and 2 hr., valued (15.78 g) and (15.57 g), respectively, but decreased significantly (11.94 g) at 1 hr., rather than the control (13.67 g).

Interaction of cultivar × LASER treatments was also significant for all studied wheat yield characters. Hereby, these cultivars had differential responses to LASER irradiation treatments. Kannan *et al.* (2007) used physical mutagens, LASER rays (0.5, 0.1 and 1.5 minutes) and UV rays (0, 20 and 30 minutes). They showed that mean values of plant height, number of tillers per plant, spike length, spikelets per spike, grains/spik, grain yield/plant and 100-grain weight were shifted in the negative direction. PBW 226 cv. was more sensitive to the mutagens than WH 542. The differential mutagenic sensitivity between the two cultivars was explained by the higher nuclear DNA content in PBW 226.

Genetic parameters of M_2 generation as influenced by gamma rays

As presented in Table 7, estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation PCV could be classified into three groups for the studied

Table 6. Mean performance of yield and its components for Sids 12, Sakha 94 and Gemmeiza 9 wheat cvs. as influenced by LASER irradiation treatments and their interaction in M_2 generation (2012/2013 season)

Main effects and interaction	No. of spikes/ plant	No. of grains/spike	1000-grain weight (g)	Grain yield/plant (g)
(A) Cultivar				
Sids 12	3.31	75.16	49.64	10.32
Sakha 94	10.75	56.42	38.68	14.59
Gemmeiza 9	9.25	60.97	41.66	18.00
F. test	*	*	*	*
LSD $_{0.05}$	0.709	3.336	0.953	1 .577
(B) LASER irradiation treatment				
Control	7.26	63.00	40.56	13.67
1 hr.	7.08	65.78	44.22	11.94
1.5 hr.	8.47	63.03	45.07	15.78
2 hr.	8.37	64.20	43.40	15.57
F. test	*	*	*	*
LSD $_{0.05}$	1.106	2.036	1.488	1.694
Interaction A × B	*	*	*	*

* , Significant at 0.05 level of probability

Table 7. Estimates of some genetic parameters for studied wheat traits of gamma ray experiment in M_2 generation (2012/2013 season)

Parameter / Character	GCV	PCV	ECV	H_b (%)	G.s (%)
Plant height (cm)	10.43	11.88	5.67	77.18	16.11
Spike length (cm)	19.44	20.67	6.39	88.53	5.55
No. of fertile spikelets/spike	8.76	12.34	8.69	50.38	2.42
No. of sterile spikelets/spike	20.64	20.86	3.01	97.93	1.36
No. of spikes/plant	76.19	79.36	22.09	92.26	15.25
No. of grains/spike	47.35	49.05	12.87	93.12	60.98
1000-grain weight (g)	28.26	29.34	7.88	92.77	22.88
Grain yield/plant (g)	27.61	36.60	24.03	56.90	5.36

GCV: Genotypic coefficient of variation
PCV: Phenotypic coefficient of variation
ECV: Environmental coefficient of variation
H_b (%) : Heritability in broad sense
G.s (%) : Genetic advance as (%) of population mean

characters. The first group was high and included No. of spikes/plant only. The second group was moderate and contained No. of grains/spike, 1000-grain weight and grain yield/ plant. Whereas, the third group was relatively low and included plant height, spike length, No. of fertile spikelets/spike and No. of sterile spikelets/ spike. Whereas higher estimates of environmental coefficient of variation (ECV) were observed for No. of spikes/plant and grain yield/plant. Thus, these characters are influenced by the environmental conditions. Whereas, moderate ECV estimate was recorded by No. of grains/ spike only and low by plant height, spike length, No. of fertile spikelets/spike and No. of sterile spikelets/spike and 1000-grain weight.

PCV was higher than its respective GCV for No. of fertile spikelets/spike and grain yield/ plant, agreed with moderate heritability estimates, indicating their influenced by the environmental fluctuations. While, narrow difference between PCV and GCV was detected for the other studied characters, which coupled with ECV estimates.

Heritability in broad sense was high (≥75%) for plant height, spike length, No. of sterile spikelets/spike, No. of spikes/plant, No. of grains/spike and 1000- grain weight/plant. Thus, selection was effective for improving the abovementioned characters. Genetic advance was high for No. of grains/spike, and moderate for plant height, No. of spikes/plant and 1000-grain weight. Otherwise, spike length, No. of fertile spikelets/spike, No. of sterile spikelets/ spike and grain yield/plant attained low genetic advance.

Estimates of broad sense heritability coupled with genetic advance and were low for No. of fertile spikelets/ spike and grain yield/plant. Therefore, these characters are affected by environmental circumstances and their improving in early generations through selection was ineffective.

The changes in heritability and genetic advance from character to another, reflect their influence by gamma ray doses on M_2 generation. These results agreed with Kusaksz and Dere (2010) who recorded that in certain gamma irradiated populations, heritability and phenotypic standard deviation values and genetic gains were higher than those of control population.

Genetic parameters of M_2 generation as influenced by LASER treatments

Some genetic parameters for studied wheat characters as influenced by LASER ray doses on M_2 generation are presented in Table 8. GCV and PCV estimates could be divided into three groups for the studied characters. The first group was high and included No. of grains/spike, 1000-grain weight and grain yield/plant. The second group was moderate and contained No. of fertile spikelets/spike and No. of sterile spikelets/spike. Whereas, the third group was low and included plant height, spike length and No. of spikes/plant. Also based on ECV estimates, it was high for No. of spikes/plant and grain yield/plant; moderate for spike length, No. of fertile spikelets/spike and No. of grains/spike, whereas, it was low for plant height, No. of sterile spikelets/spike and 1000-grain weight. PCV was higher than its respective GCV for spike length, No. of fertile spikeletes/spike and grain yield/plant, indicating their influenced by the environmental changes. While, narrow difference between PCV and GCV was detected for the other rest characters which coupled with ECV estimates. These results agreed with Laxani (2008) who found that the irradiated populations registered highest PCV and GCV for all characters except for plant height, spike length and No. of spikelets/ spike. Except spike length, all characters exhibited high heritability values. Laxani *et al.* (2013) developed segregating populations (F_2M_2) from wheat varieties DDK 025 and HD 4502 after subjecting to EMS and gamma -rays treatment. Gamma -rays irradiated populations recorded highest PCV and GCV for all the characters except for plant height, spike length and spikelets/ spike. Most of the characters exhibited high heritability except spike length in all segregating populations.

Heritability in broad sense was high (≥75%) for plant height, No. of sterile spikelets/ spike, No. of spikes/plant, No. of grains/spike, 1000-grain weight and grain yield/plant, with highest genetic advance for No. of grains/spike and moderately high for No. of spikes/ plant,1000-grain weight and grain yield/plant, indicating greater scope for selection and improvement of these characters in the desired direction.

Table 8. Estimates of some genetic parameters for studied wheat traits of LASER ray experiment in M_2 generation (2012/2013 season)

Parameter / Character	GCV	PCV	ECV	H_b (%)	G.s (%)
Plant height (cm)	8.12	8.57	2.74	89.74	8.57
Spike length (cm)	12.4	14.22	7.41	72.85	2.96
No. of fertile spikelets/spike	23.73	27.47	6.18	74.66	33.10
No. of sterile spikelets/spike	34.08	34.40	4.78	98.14	2.39
No.of spikes/plant	11.72	12.79	12.79	98.90	28.17
No. of grains/spike	52.85	53.22	6.22	98.63	73.05
1000-grain weight (g)	45.95	46.14	4.22	99.16	45.09
Grain yield/plant (g)	53.04	55.24	15.40	92.20	14.62

GCV: Genotypic coefficient of variation PCV: Phenotypic coefficient of variation
ECV: Environmental coefficient of variation H_b (%) : Heritability in broad sense
G.s (%) : Genetic advance as (%) of population mean

Estimates of broad sense heritability were moderate for spike length and No. of fertile spikelets/spike with low to moderate genetic advance for both characters in the same respective order. While plant height, spike length and No. of sterile spikelets/ spike recorded low values of genetic advance. These results are confirmed with the previous findings of El-Degwy and Hathout (2014) who found that all genetic parameters σ^2g, GCV, PCV, $h^2_{b.s}$ and genetic advance from selection were higher and folded several times in case of irradiated plants compared to the control for plant height and yield contributing characters.

It interest to mention that, genetic parameters in M_2 generation of the studied traits found to be differed from character to another , this could be due to the different genetic behavior of the character and their influenced by mutagen treatments.

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سلوك ومؤشرات التربية للمحصول ومساهماته في الجيل المطفر الثاني لثلاث أصناف من قمح الخبز وتأثرها باشعة جاما والليزر

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أجريت هذه الدراسة بالمزرعة التجريبية بقسم البحوث النباتية - مركز البحوث النووية - هيئة الطاقة الذرية - مصر، خلال موسمى 2011/2012 ، 2012/2013، تم إجراء تجربة تمهيدية لتحديد الجرعة المناسبة من أشعة جاما لإستحداث طفرات، حيث عرضت بذور الثلاثة أصناف (سدس 12، سخا 94 وجميزة 9) لقمح الخبز للتشعيع بجرعات 0، 150 ، 200 ، 250، 300 ، 350 ، 400 ، 450 ، 500 جراى)، وبناءاً على نتائج قياسات طول السويقة (سم) ونسبة النقص (%) تم تحديد ثلاث جرعات من أشعة جاما هى 250 (Gy_1)، 300 (Gy_2) ، 350 (Gy_3) لصنفي سدس 12 وجميزة 9 والجرعات 350 (Gy_1)، 400 (Gy_2) و450 (Gy_3) لصنف سخا 94، وكانت معاملات الليزر 0، 1 ، 1.5 ، 2 ساعة، أشارت نتائج التجارب الحقلية إلى أن تعريض أصناف القمح لأشعة جاما والليزر أدى إلى فروق معنوية فى كل الصفات المدروسة فى جميع الحالات، أعطى الصنف سدس 12 أقصر ارتفاع للنبات (75.9سم) واعلي عدد حبوب بالسنبلة (71.66)، وزن الألف حبة (41.27 جم)، بينما أعطى الصنف جميزة 9 أعلى ارتفاع للنبات (82.20 سم) وأعلي عدد سنابل للنبات (9.05) وأعلى محصول حبوب للنبات (14.79جم)، أدت الجرعة Gy_1 إلى نقص إرتفاع النبات (79.75 سم) وعدد السنيبلات العقيمة بالسنبلة (2.40) مقارنةً بالكنترول، ولوحظت زيادة معنوية فى كلٍ من محصول حبوب النبات، عدد سنابل النبات وطول السنبلة عند المعاملة بالجرعة Gy_1 بقيم (14.42 جم)، (8.46) ، (13.88 سم)، على التوالى، بينما نقصت كلتا الصفتين مع أعلى جرعة Gy_3 ، أدى التعريض لأشعة الليزر إلى زيادة معنوية فى إرتفاع النبات، عدد السنيبلات الخصبة بالسنبلة عند 1 ساعة ولكن نفس الجرعة أدت إلى نقصٍ معنوي فى عدد السنيبلات العقيمة بالسنبلة مقارنة بــ 1.5 ، 2 ساعة، وأدت كلٍ من معاملة التعريض 1.5 و 2 ساعة إلى زيادة معنوية فى محصول حبوب النبات (١٥,٧٨ جم)، (15.57 جم)، على التوالى مقارنةً بالكنترول (13.67 جم) كما كان التفاعل بين الأصناف والمطفرات معنوياً فى كل الصفات المدروسة، أظهرت تقديرات معامل الإختلاف الوراثى والمظهرى قيماً عالية عند المعاملة بأشعة جاما لعدد سنابل النبات فقط مع تقديرات عالية لمعامل الاختلاف البيئى لنفس الصفة ومحصول حبوب النبات، بينما كانت منخفضة نسبياً لارتفاع النبات، طول السنبلة، عدد السنيبلات الخصبة بالسنبلة وعدد السنيبلات العقيمة بالسنبلة، كما كانت تقديرات كفاءة التوريث بالمعنى العام عالية (≤ 75%) لإرتفاع النبات، طول السنبلة، عدد السنيبلات العقيمة بالسنبلة، عدد سنابل النبات، عدد حبوب السنبلة ووزن الألف حبة، وقد تلازمت تقديرات كفاءة التوريث بالمعنى العام بالتحسين المتوقع بالانتخاب وجاءت منخفضة لعدد السنيبلات الخصبة بالسنبلة ومحصول حبوب النبات، كانت تقديرات معامل الإختلاف الوراثى والمظهري تحت تأثير المعاملة بالليزر عالية لعدد حبوب السنبلة، وزن الألف حبة ومحصول حبوب النبات، في حين كانت منخفضة لارتفاع النبات، طول السنبلة وعدد سنابل النبات، وجاءت تقديرات كفاءة التوريث بالمعنى العام عالية (≤75%) لارتفاع النبات، عدد السنيبلات العقيمة بالسنبلة، عدد سنابل النبات، عدد حبوب السنبلة، وزن الألف حبة ومحصول حبوب النبات، ويشير ذلك إلى أهمية هذه النتائج في برامج تربية القمح لتحسين المحصول.

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