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Effect of Gamma Rays on Growth, Yield and Yield Components Eight Traits of Flax Genotypes *Linum usitatissimum* L

Saad Edan A. Al_Raheem [1]*, and Ahmed H. Anees

Department of Field Crops, College of Agriculture, Tikrit University, Tikrit, Iraq

**Corresponding E-mail*: saadedan91@gmail.com

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ABSTRACT
A field experiment was carried out at agricultural field in al-Alam district\Sallahiddin Governorate during 2020-2021 season to study the Creation of genetic variations in the flax crop as a result of gamma rays. The study factors included four levels of gamma rays, which were 0, 9, 18 and 27 Gy and six genotypes of the flax crop, which were Sakha1, Sakha2, Sakha3, Giza8, Syrian and Poloni, use a completely randomized block design with split plot system and was used three replications, traits studied were Duration to 50% flowering and Duration of days to maturity, Plant height, Leaves ratio, Number of vegetative branches, Number of capsules Number of seeds, 1000 seeds weight, Plant yield and seed yield**.**The results of the study indicated that gamma rays had a significant effect on all studied traits, comparison treatment gave a lower value from the number of days to flowering 50% of plants and days to maturity (110.24) and (155.05) days, respectively, while the plants irradiated with the level 9 Gy recorded a significant superiority in the percentage of leaves (21.46) %, while the non-irradiated plants outperformed in the rest of the studied traits. the genotype Sakha1 gave the highest average mean in characteristics of number of vegetative branches (3.63) branch plant^{-1}, number of capsules per plant (54.35) capsule plant^{-1}, individual plant yield (2.22) gm plant^{-1}, and seeds yield (433.63) kg ha^{-1}. As for the interaction, it was significant through the non-irradiated Sakha1 genotype, which gave the highest value of the characteristics of the number of capsules per plant, the number of seeds per capsule, individual plant yield and total seed yield (62.22) capsule plant^{-1} 9.96 seed capsule^{-1} (2.89) g plant^{-1} (578.60) kg ha^{-1}, respectively.

تاثير اشعة كاما في صفات النمو والحاصل ومكوناتة لثمان تراكيب وراثية في محصول الكتان *Linum usitatissimum* L

سعد عيدان عبدالله الرحيم واحمد هواس عبدالله انيس

قسم المحاصيل الحقلية – كلية الزراعة – جامعة تكريت

الخلاصة

نفذت تجربة حقلية في الموسم الزراعي (2020 - 2021) في حقل زراعي في منطقة العلم / في محافظة صلاح الدين، بهدف دراسة استحداث التغايرات الوراثية في محصول الكتان باستخدام اشعة كاما، حيث شملت عوامل الدراسة اربعة مستويات من اشعة كاما وهي 0 و9 و18 و27 Gy وستة تراكيب وراثية من محصول الكتان وهي سخا1 وسخا2 وسخا3 وجيزة8 وسوري وبولوني، باستخدام تصميم القطاعات العشوائية الكاملة بنظام الالواح المنشقة وبثلاثة مكررات، لدراسة صفات عدد الايام الى 50% ازهار وعدد الايام الى النضج وارتفاع النبات ونسبة الاوراق وعدد الافرع الخضرية وعدد الكبسولات بالنبات وعدد البذور بالكبسولة وحاصل النبات الفردي والحاصل الكلي. اشارت نتائج الدراسة الى ان اشعة كاما اثرت معنوياً في جميع الصفات المدروسة اذ اعطت معاملة المقارنة اوطا قيمة من عدد الايام الى ازهار 50% وعدد الايام الى النضج 110.24 و155.05 يوم على الترتيب، في حين سجلت النباتات المشعة بالمستوى9 Gy تفوق معنوي في نسبة الاوراق 21.46 %، بينما تفوقت النباتات غير المشعة في باقي الصفات المدروسة، واختلفت التراكيب الوراثية معنوياً في جميع الصفات المدروسة واعطى التركيب الوراثي سخا1 اعلى متوسط في صفات عدد الافرع الخضرية (3.63) فرع نبات-1 وعدد الكبسولات بالنبات (54.35) كبسولة نبات-1 والحاصل الفردي للنبات (2.22) غم نبات-1 والحاصل الكلي (433.63) كغم ه-1، اما التداخل فكان معنوياً من خلال التركيب الوراثي سخا1 غير المشعع اذ اعطى اعلى قيمة من صفات عدد الكبسولات بالنبات وعدد البذور في الكبسولة والحاصل الفردي للنبات والحاصل الكلي للبذور 62.22 كبسولة نبات-1 9.96 بذرة كبسولة-1 2.89 غم نبات-1 578.60 كغم ه-1 على الترتيب، وكذلك التركيب الوراثي سخا5 غير المشعع تفوق في صفات ارتفاع النبات ونسبة الاوراق و وزن 1000 بذرة 82.62 سم و23.51 % و7.18 غم على الترتيب.

الكلمات المفتاحية:

اشعة كاما، الكتان، التراكيب الوراثية، مكونات الحاصل، صفات النمو.

INTRODUCTION

Linum usitatissimum L is a dual-purpose crop that is grown for the purpose of obtaining oil or fiber or both, and its seeds are classified among the important functional foods due to their abundance of many nutrients compared to other vegetable oils, such as unsaturated fatty acids. Therefore, it is unique among oil seeds for its high oils content (30-45)%, which consist of 57% of the total fatty acids (Simmons *et al.*,, 2011). The cultivated area of flax in the world for the year (2019) reached about (128 (15. million hectares) only and produced about (501.14) million tons of seeds, (STATA FAO, 2019).In Iraq, the cultivated areas of this crop are almost It is non-existent, for many reasons. working to increase its linen productivity in the unity of the area is what the plant breeders seek, and that is through the introduction of the advanced technologies in the production, the selection for the desired traits after using mutations, where mutation causes genetic variation that gives the breeder the opportunity to intervene to select the useful genotype, One of the means of physical mutagenicity is the use of (gamma rays), and the effect of doses depends on the type and strain of the plant in the first place, as some plants are stimulated by low doses of gamma rays, while other plants are stimulated by high doses, (Youssef, 2018). Among the previous studies that dealt with physical mutagenesis are the study of Alka (2013), Bornare *et al.*, (2013) and Ali *et al.*, (2018) that they studied the effect of gamma rays on the field characteristics of flax crop. The main purpose of flax breeding is to develop promising varieties that would outperform the existing ones in yield and quality characteristics. Accordingly, plant breeders have focused their interests in finding new varieties with high yield specifications as well as good fiber properties, studies that dealt with the performance of genotypes are the study of El-Refaie *et al.*, (2012), Singh and Tewari (2014), Govind (2018), Ahmad and others (2021).

The overlap between genotypes and gamma rays allows the development of new varieties through the selection of the best overlapping treatments and their multiplication, which provides a great opportunity for plant breeders to obtain the appropriate genetic variations to achieve the goals, and that most plant breeding programs aim to develop high-yielding and well-adapted varieties and hybrids, It outperforms the cultivated genotypes in productive and qualitative traits (Anees *et al.*,, 2019). Among the previous studies related with the interaction between genotypes and gamma rays for different crops were the study of Bornare *et al.*,, (2013) and Zaid (2014), Banakar *et al.*,, (2015) and Kiwan, (2018). It is worth noting that the aim of the study is to identify the favourable mutation that can be effective and distinctive of promising varieties.

MATERIALS AND METHODS

A field experiment was conducted at agricultural farm in the Al-Alam area, northeast of Tikrit/Salahal-Din Governorate, according to the coordinates X(43.83574378) Y(43.83574378) The experiment included use four levels of gamma rays (0, 9, 18, 27) to irradiate the seeds of eight genotypes of flax crop. which were Sakha1, Sakha2, Sakha3, Sakha5, Sakha 6, Giza8, Syrian and Poloni, the details of which are shown in Table (1). Each duplicate divided into four main plots, and sub-plot it was divided into eight secondary panels for the genotypes used, Soil and plant services applied as demand were carried out. as Triple super phosphate fertilizer was added at an amount of 80 kg ha^{-1} in one dose at farrowing stage and nitrogen fertilizer was added as Urea (NH2) 2 CO (46%) nitrogen 200 kg ha^{-1} in two batches: the first one month after planting and the second before flowering stage (Hassan and Shaker, 2013), After preparing the experimental land by plowing, smoothing and leveling it, soil analyzed at the laboratory of soil science, was conducted in the laboratory of the Department of Soil and Water Resources, College of Agriculture, Tikrit University, etc as shown in table (2), Each experimental unit was designed with dimensions (2×1) m and a distance of (0.50) m among rows and another and the distance between one plant and another (0.10) m, within row and the experiment was applied using a randomized complete block design with split plot system with three replications.

The following characteristics were studied: **Duration to 50% flowering (day)**: The number of days taken from the date of the first irrigation until 50% of the plants flowering for each experimental unit was recorded**. Duration of days to maturity (day)**: The number of days taken from the first irrigation until the physiological maturity of the experimental unit plants was recorded. **Plant height (cm plant $^{-1}$)**: The height was measured in centimeters from the base to the end of the main stem (the top of the plant) and its average was obtained**. Leaves ratio** (%): It was measured from the weight of dry leaves divided by the weight of the dry matter at harvest to get its average as a percentage. **Number of vegetative branches (branch plant^{-1})**: The number of branches was calculated from the base of the main stem for each plant and their average was obtained. **Number of capsules (capsule plant^{-1})**: The total number of capsules was calculated from ten plants randomly selected for each experimental unit, and their average was obtained. **Number of per capsules (seed capsule $^{-1}$)**: The total number of seeds in ten capsules randomly selected for each plant of the ten randomly assigned plants from each experimental unit was calculated, and averaged. **1000 seeds weight (g)**: 1000 seeds were weighed in grams by using a sensitive balance after the seeds were randomly taken from each plant. **plant yield (g plant^{-1})**: The yield of the individual plant was recorded by weighing the seeds of each of the ten plants chosen randomly. **Seed yield (kg ha^{-1})**: The productivity of one hectare of seeds was estimated according to the following equation :Seed yield kg ha $^{-1}$ = plant yield (g) $\times$ 10/Space occupied by the plant (m ^{2}).

Table (1) origin, lineage and source of the genotypes used in the study

No	Genotype name	Origin	lineage	source
1	Sakha 1	Egyptian	I.1485 x Bombay	College of Agriculture, Cairo University
2	Sakha 2	Egyptian	Hera × 1.123	College of Agriculture, Cairo University
3	Sakha 3	Egyptian	(Belinka (2E) × 1.2096)	College of Agriculture, Cairo University
4	Sakha 4	Egyptian	(Belinka (R3) ×1.2569	College of Agriculture, Cairo University
5	Sakha 5	Egyptian	S.420 x bombay (I. USA)	College of Agriculture, Cairo University
6	Giza8	Egyptian	(Giza6 × Senta Catalina	College of Agriculture, Cairo University
7	Syrian	Syrian	Imported	College of Agriculture, Salah adin University
8	Thorshansity72	Poloni	Imported	College of Agriculture, Salah adin University

Table (2): Some physical and chemical properties of soil at the experiment site

Traits	Value
Soil (PH)	7.80
EC (mmm.cm^{-1})	2.12
Organic matter (g.kg^{-1})	12.3
Separation ratio (%)	
Sand	72
Green	17
Mud	13
Soil texture	sandy mixture
Potassium (mg.100g^{-1})	0.82
(ppm)	7.45
Nitrogen (%)	0.42

Statistical Analysis

The experiment was applied by using Completely Randomized Block Design (CRBD) with split-plot arrangement, with three replications. The main plots included gamma ray levels, which were 0, 9, 18, and 27 gray while the subplot included eight cultivars of flax, as listed in table 1. The difference among averages were tested according to the Duncan test with a probability level of 0.05.

RESULTS AND DISCUSSION

The analysis of variance for the studied traits showed its results in Table (3), as the gamma rays and genotypes achieved a highly significant difference for all the studied trait except days to maturity while the interaction between the study factors was significant at the 1% probability level for all traits except for days to maturity and plant height trait, which was significant at the 5% level, The reason for this may be due to the genetic difference of the traits and thus their different response to gamma ray levels, and these results are similar to what was obtained by: Alka (2013) and Naz *et al.*, (2019).

Table (4) shows that gamma rays significantly affected the duration of flowering by 50%, Days reached 120.54 days, and this may be attributed to the fact that gamma rays lead to a disturbance of the vital activities and metabolic activity of the plant, and this negative effect increased with the increase in rays, and this result is somewhat consistent with the results of Banakar *et al.,* (2015), Saha and Paul (2017), Ravichandran and Jayakumar (2018).

Table (3) analysis of variance for the studied traits

S.O.V	d.f	Duration to 50% flowering (day)	Duration of days to maturity (day)	Plant height (cm plant $^{-1}$)	Leaves ratio (%)	Number of vegetative branches (branch plant^{-1})	Number of capsules (capsule plant^{-1})	Number of seeds (seed capsule $^{-1}$)	Weighing 1000 seeds (g)	plant yield (gm plant1-)	Seed yield (kg H^{-1})
Blcoks	2	0.188	0.876	8.24	0.02	0.008	0.97	0.002	0.001	0.003	19.38
Irradiation (A)	3	** 373.86	** 211.78	** 257.43	** 14.107	** 3.57	** 479.75	** 6.57	** 3.84	** 0.62	** 24911.41
Error (a)	6	1.43	0.79	1.49	0.03	0.008	1.18	0.005	0.001	0.01	119.88
genotypes	7	** 25.83	** 23.08	** 343.29	** 5.57	** 0.102	** 262.17	** 1.27	** 3.308	** 0.67	** 23593.57
Irradiation X genotypes	21	** 15.804	** 15.76	* 4.56	** 1.83	** 0.29	** 133.19	** 0.61	** 0.32	** 0.13	** 5287.36
Error (b)	56	0.54	1.58	1.98	0.02	0.008	1.12	0.003	0.001	0.007	48.84

(**) and (*) are significant at 1% and 5% probability levels, respectively genotypes showed a significant effect in the character of duration to flowering 50%, as the genotypes differed among themselves for this trait, as the synthesis was earlier Giza 8 with an average of 114.11 days and did not differ significantly from the composition Sakha1 Which gave 114.25 days, while the Sakha5 genotype gave the highest number of days, 117.72 days. As a result, the variance of the genotypes with early maturation of genetic factors that affect this trait and the speed of growth as a result of cell division (Elayan *et al.*,, 2015). As for the binary interaction between gamma rays and the genotypes in this trait, the Giza 8 genotype was distinguished at the non-irradiated level 0 Gy by giving it the least number of days amounting to 106.91 days and a significant difference from the rest of the interactions, while the same structure at the level 27 Gy gave the highest number of days reached 122.47 days. This result may be attributed to the effect of high doses of gamma rays and the interaction of this effect with the genetic factors of the genotypes. Which gave 114.25 days, while the Sakha5 genotype gave the highest number of days, 117.72 days. As a result, the variance of the genotypes with early maturation of genetic factors that affect this trait and the speed of growth as a result of cell division (Elayan *et al.*,, 2015).

Table (4) Effect of gamma rays, genotypes and the interaction between them on the number of days to 50% flowering (day)

mutagenesis / genotypes	Gy 0	Gy 9	Gy 18	Gy 27	genotypes average
Sakha 1	no 111.28	hij 115.14	ef 117.36	de 118.28	e 114.25
Sakha 2	q 108.98	jkl 113.85	mn 112.28	b 121.04	c 115.31
Sakha 3	no 111.19	ghi 115.56	jk 114.14	bc 118.07	d 114.74
Sakha 5	klm 113.55	fg 116.60	gh 115.69	b 121.16	a 117.72
Sakha 6	opq 110.03	ijk 114.29	ef 117.51	bc 119.90	c 115.30
Giza 8	r 106.91	lm 112.70	de 118.28	a 122.47	e 114.11
Syrian	pq 109.58	jkl 113.77	cd 119.17	b 120.92	b 115.99
Poloni	op 110.39	h-k 114.50	ef 117.68	a 122.51	b 116.27
mutagenesis averages	d 110.24	c 114.55	b 116.51	a 120.54	

As for the binary interaction between gamma rays and the genotypes in this trait, the Giza 8 genotype was distinguished at the non-irradiated level 0 Gy by giving it the least number of days amounting to 106.91 days and a significant difference from the rest of the interactions, while the same genotypes at the level 27 Gy gave the highest number of days reached 122.47 days. This result may be attributed to the effect of high doses of gamma rays and the interaction of this effect with the genetic factors of the genotypes. Gamma rays had a significant effect on the period to maturity, as the irradiated plants excelled at the level of 27 Gy, and recorded the highest mean of the trait amounting to 164.04 days. Table (5), it should be noted that there is a positive relationship between the number of days to flowering 50% and the number of days to maturity, as well as the rays inhibited the vital activities of the plant, and this result is consistent with the results of Banakar *et al.,* (2015) and Naz *et al.,* (2019) when they studied several levels of gamma rays and their effect on the growth characteristics of sunflower crop. The genetic structures had a significant effect on this trait. As the genotypes differed significantly among themselves for this trait, where the Giza 8 genotype surpassed the lowest average of 158.20 days, while the Poloni genotype gave the highest number of days amounting to 162.01 days, and this indicates the appropriateness of the environmental conditions for the genotype. As for the binary interaction between the factors of the study, the non-irradiated Giza8 genotype was distinguished by giving it the lowest number of days, which amounted to 151.59 days, and a significant difference from the rest of the interactions, while the Sakha2 genotype at level 27 Gy recorded the highest number of days, which amounted to 165.86 days, and did not differ significantly from the other interactions. Genetic Sakha 6, Syrian and Poloni.

Table (5) Effect of gamma rays and genetic structures and the interaction between them on the character of the number of days to maturity (day)

mutagenesis / genotypes	Gy 0	Gy 9	Gy 18	Gy 27	genotypes average
Sakha 1	kl 155.43	hij 157.62	d-g 161.71	h 158.93	cd 158.42
Sakha 2	lm 154.68	hi 158.54	d-g 162.31	a 165.86	b 160.35
Sakha 3	h-k 157.11	d-g 161.93	g 160.88	b-e 162.95	b 160.72
Sakha 5	m 153.53	ijk 156.93	efg 161.52	abc 164.29	c 159.07
Sakha 6	jkl 156.07	hij 157.61	bcd 163.39	a 165.24	b 160.58
Giza 8	n 151.59	kl 155.60	fg 161.08	ab 164.55	d 158.20
Syrian	lm 154.83	hi 158.02	b-f 162.78	a 165.26	b 160.22
Poloni	h-k 157.15	b-e 163.13	c-g 162.56	a 165.22	a 162.01
mutagenesis averages	d 155.05	c 158.67	b 162.03	a 164.04	cd 158.42

Results of Table (6) showed that gamma rays had a significant effect on the plant height, as the non-irradiated plants recorded the highest height of 72.81 cm, while the plants below the level 27 Gy gave the lowest height of 65.42 cm, and the plant height gradually decreased with the height of the level. Radiation, and the reason may be attributed to the fact that rays affected growth regulators, especially auxins, as well as affecting vital activities inside the cell and thus inhibiting cell division and elongation, and this result is consistent with the results of Vasko and Kyrychenko (2016) and Alka (2013), Ravichandran and Jayakumar (2018). It is also noted that the Sakha 5 genotype was superior with the highest height of 77.45 cm, while the Giza 8 genotype gave the lowest height of 60.23 cm. The difference in genotypes in height is due to the nature of the genetic structure, as the flax plant varies according to its purpose, some of which have short and branched stems to produce seeds. Oil and some others are dual-purpose for oil and fiber production (Jhala and Hall, 2010). As for the interaction between gamma rays and the genotypes, it had a significant effect for this trait, as the non-irradiated Sakha 5 genotype was characterized by the highest plant height of 82.62 cm, while the Giza 8 genotype at the 18 Gy level gave the lowest height of 57.35 cm.

Results of Table (7) indicated that gamma rays had a significant effect on the Leaves ratio, as the plants irradiated at the level of 9 Gy gave the highest average of this trait amounted to 21.46%, and the percentage decreased with the increase in the level of rays, and the plants irradiated at the level of 27 Gy gave the lowest Leaves ratio percentage (19.86%), and the reason for this may be attributed to the decrease in the dry weight of the leaves as a result of the inhibition of gamma rays of the hormone ethylene, which contributes to the support and growth of leaves, and this results are in line with the results of Ali *et al.,* (2018) and Naz *et al.,* (2019). results of the same table showed a significant effect of the genotypes on this trait, as the Sakha5 genotype outperformed all the genotype, achieving the highest average of this trait amounted to 21.48%, while the Sakha6 genotype gave the lowest average of 19.49%, and the reason for the discrepancy of this trait may be due to the increase In the height of the plant. As for the interaction between the study factors, it had a significant effect for this trait, as the non-irradiated Sakha5 genotype was characterized by the highest percentage of leaves amounting to 23.51%, while the Sakha6 genotype at the 27 Gy level gave the lowest Leaves ratio percentage amounted to 18.82%.

Table (6) Effect of gamma rays, genotypes and the interaction between them on plant height (cm)

mutagenesis / genotypes	Gy 0	Gy 9	Gy 18	Gy 27	genotypes average
Sakha 1	ghi 69.88	jkl 66.74	lmn 65.15	no 62.86	e 66.15
Sakha 2	bcd 75.54	bcd 75.15	g-j 69.35	klm 66.10	bc 71.53
Sakha 3	bcd 75.71	def 73.22	h-k 68.71	lmn 65.16	c 70.70
Sakha 5	a 82.62	b 77.54	bc 75.89	c-f 73.76	a 77.45
Sakha 6	bcd 75.20	cde 74.31	efg 71.86	g-j 69.35	b 72.68
Giza 8	mno 63.96	op 61.48	q 57.35	q 58.15	g 60.23
Syrian	fgh 71.27	ghi 69.74	i-l 67.66	klm 66.51	d 68.79
Poloni	ijk 68.35	jkl 62.96	no 62.96	pq 59.58	f 64.42
mutagenesis averages	a 72.81	b 70.62	c 67.36	d 65.18	e 66.15

Table (7) Effect of gamma rays, genotypes and the interaction between them on the Leaves ratio percentage (%)

mutagenesis / genotypes	Gy 0	Gy 9	Gy 18	Gy 27	genotypes average
Sakha 1	f 21.15	jk 20.03	lm 19.73	g 20.91	d 20.53
Sakha 2	ij 20.17	de 21.85	op 19.25	op 19.19	f 20.11
Sakha 3	no 19.43	cd 21.95	jk 20.03	lmn 19.64	e 20.26
Sakha 5	a 23.51	de 21.76	h 20.56p	g 20.12	a 21.48
Sakha 6	ij 20.20	lm 19.78	p 19.15	q 18.82	g 19.49
Giza 8	kl 19.85	bc 22.15	gh 20.73	lmn 19.65	d 20.59
Syrian	e 21.63	bc 22.17	ij 20.22	mn 19.55	c 20.89
Poloni	b 22.24	de 21.71	gh 20.76	ij 20.23	b 21.23
mutagenesis averages	b 21.02	a 21.46	c 20.05	d 19.86	

Table (8) shows that gamma rays had a significant effect on the number of vegetative branches in the plant, and the non-irradiated plants were significantly superior to the rest of the treatments with an average capacity of 3.80 branches.plant^{-1}, while the irradiated plants at the level of 27 Gy gave the lowest average of 2.94 branches. Plant^{-1}, this can be attributed to the fact that gamma rays affected the lateral buds due to the effect on auxin, which leads to a decrease in the number of lateral branches. It is noted from the same table that the Sakha genotype was superior to all genotypes except for the Bolognese synthesis 3.63 branch plant^{-1}, while the Sakha 6 genotype gave the lowest average From the trait amounted to 3.35 branch plant^{-1}. The results of the interaction between gamma rays and the genotypes shown in Table (8) indicated that there were significant differences, as the non-irradiated Syrian genotype outperformed with the highest number of branches amounting to 4.28 plant^{-1} branch. And the irradiated at level 27 Gy, the lowest number of branches was 2.39 plant^{-1}. Data in Table (9) showed that the non-irradiated plants were distinguished in the number of capsules per plant by giving them the highest mean of 53.64 capsules plant^{-1}, with a significant difference from the rest of the treatments in this trait.

Table (8) The effect of gamma rays, genotype and the interaction between them on the character of the number of vegetative branches (branch plant^{-1})

mutagenesis / **genotypes**	**Gy 0**	**Gy 9**	**Gy 18**	**Gy 27**	**genotypes average**
Sakha 1	cd 3.91	b 4.10	k 3.25	jk 3.27	a 3.63
Sakha 2	b 4.08	ed 3.74	ijk 3.35	l 2.94	bc 3.52
Sakha 3	ed 3.79	efg 3.64	jk 3.27	l 2.85	d 3.39
Sakha 5	hij 3.43	ef 3.89	cd 3.67	l 2.95	c 3.48
Sakha 6	ef 3.69	hi 3.47	ijk 3.33	l 2.92	d 3.35
Giza 8	k 3.22	fgh 3.75	ef 3.61	ghi 3.49	bc 3.51
Syrian	a 4.28	ed 3.75	efg 3.65	m 2.39	bc 3.51
Poloni	bc 3.99	ed 3.81	efg 3.65	l 2.82	ab 3.57
mutagenesis averages	a 3.80	b 3.72	c 3.51	d 2.94	

Average reached 43.36 capsules plant^{-1}, and the reason for this is due to the decrease in the number of vegetative branches as well as to the effect of gamma rays on nutritional balance and thus inhibiting fruit growth, and these results are consistent with the results of Mudibu *et al.,* (2012), Bornare *et al.,* (2013) and Ravichandran and Jayakumar (2018). The Sakha1 genotype was also distinguished by the highest average of the capsules, which amounted to 54.35 capsules plant^{-1}, and a significant difference from the other of the genotype, while the Poloni genotype gave the lowest average of the trait, which amounted to 41.45 capsules plant^{-1}, that the reason for this result is due to an increase in the average number of vegetative branches or to genetic susceptibility to genetic makeup In the formation of offshoots and their interactions with environmental influences and the effects of competition, allowing genetic factors to express themselves, and the results of the binary interaction showed that there were significant differences in the character of the number of capsules. The rest of the interactions, while the Poloni genotype irradiated with the level of 27 Gy gave the lowest number of capsules, which was 32.72 capsules plant^{-1}.

Results of Table (10) showed that the non-irradiated plants were significantly superior to the number of seeds in the capsule, as they gave the highest mean of 9.56 Seed capsule^{-1}, and the reason for this may be due to the increase in the number of days to flowering with the high level of gamma rays, which affected the process of pollination and fertilization and thus on the production of seeds as well as the effect on the photosynthesis process as a result of a decrease in the percentage of leaves, and this result was in agreement with the results of Ravichandran and Jayakumar (2018), Ivanova and Smerea (2018), Naz *et al.,* (2019). The results of the same table indicated that there were significant effects of the genotypes in this trait, as the Syrian genotype gave the highest average of 9.78 seed capsule^{-1}, with a significant difference from the rest of the genotypes, while the Giza 8 genotype gave the lowest average of 8.68 seed capsule^{-1}. The differences between the genotypes in the

Table (9) The effect of gamma rays, genotypes and the interaction between them on the character of the number of capsules in a plant (capsule plant-1)

mutagenesis / genotypes	Gy 0	Gy 9	Gy 18	Gy 27	genotypes average
Sakha 1	a 62.22	de 55.65	ij 47.07	gh 52.45	a 54.35
Sakha 2	ed 55.83	I 48.63	o 36.72	p 33.67	f 43.71
Sakha 3	m 42.43	gh 52.42	b 60.20	ef 54.39	b 52.36
Sakha 5	cd 57.46	fg 53.16	lm 43.23	n 39.15	d 48.25
Sakha 6	bc 58.88	de 55.58	gf 53.35	lm 42.76	b 52.64
Giza 8	ef 55.09	I 47.98	m 41.73	no 37.36	e 45.54
Syrian	jk 46.03	ij 47.40	de 55.54	ef 54.36	c 50.83
Poloni	h 51.19	kl 44.46	no 37.44	p 32.72	g 41.45
mutagenesis averages	a 53.64	b 50.66	c 46.91	d 43.36	

Table (10) The effect of gamma rays and genotypes and the interaction between them on the character of the number of seeds in the capsule (seed capsule^{-1})

mutagenesis / genotypes	Gy 0	Gy 9	Gy 18	Gy 27	genotypes average
Sakha 1	a 9.96	c 9.69	n 8.11	p 7.80	c 8.89
Sakha 2	h 9.08	c 9.65	k 8.54	l 8.29	c 8.89
Sakha 3	e 9.50	g 9.22	ij 8.80	mn 8.20	c 8.93
Sakha 5	c 9.64	g 9.25	I 8.85	l 8.35	b 9.02
Sakha 6	cd 9.60	l 8.35	lm 8.29	f 9.39	c 8.91
Giza 8	h 9.02	ef 9.46	l 8.34	o 7.92	d 8.68
Syrian	b 9.83	a 9.96	b 9.80	ed 9.52	a 9.78
Poloni	ab 9.88	g 9.28	j 8.74	l 8.32	b 9.05
mutagenesis averages	a 9.56	b 9.36	c 8.68	d 8.47	

number of seeds are due to the difference in growth traits that achieved superiority in Table (8), (9) and (10). The binary interaction between gamma rays and the genotypes had a significant effect in Table (10), as the Sakha1 genotype and its interaction with the comparison treatment had the highest number of seeds that amounted to 9.96 seed capsule^{-1}. The seeds amounted to 7.80 seed capsule^{-1}.

Table (11) shows that the non-irradiated plants excelled in the trait of weight of 1000 seeds, as they gave the highest average of this trait amounted to 6.32 g, and the average of this trait decreased gradually with the increase in the level of gamma rays. , and this can be attributed to the increase in the number of days to maturity and the percentage of leaves with a high level of gamma rays, which affects the efficiency of the photosynthesis process and thus the effect is in the period of seed filling, results of the same table showed significant differences between the genotypes in this trait, as the Sakha 5 genotype was superior to the rest of the genotypes with a mean of 6.50 g, while the Giza 8 genotype gave the lowest average of 5.08 g. This result is attributed to the superiority of this genetic structure in the characteristic of the Percentage of leaves in Table (7), which contributed and reinforced the increase of dry matter and its transfer to the seed bed. As for the interaction between gamma rays and genotypes, the non-irradiated Sakha 5 genotype had the highest weight of this trait, which amounted to 7.18 g, with a significant difference from the rest of the interactions, while the lowest weight of the irradiated Giza 8 genotype was recorded at the level of 27 Gy, which amounted to 4.65 g.

Table (11): The effect of gamma rays, genotypes, and the interaction between them on the characteristic of weight of 1000 seeds (g)

mutagenesis / **genotypes**	**Gy 0**	**Gy 9**	**Gy 18**	**Gy 27**	**genotypes average**
Sakha 1	d 6.41	g 6.10	j 5.71	g 6.11	d 6.08
Sakha 2	b 6.84	b 6.84	f 6.25	h 5.91	b 6.46
Sakha 3	f 6.20	f 6.20	c 6.72	e 6.31	c 6.35
Sakha 5	a 7.18	b 6.83	f 6.19	I 5.80	a 6.50
Sakha 6	d 6.42	I 5.82	k 5.21	n 4.91	f 5.59
Giza 8	k 5.24	k 5.24	k 5.20	p 4.65	h 5.08
Syrian	d 6.47	d 6.45	j 5.70	m 4.99	e 5.90
Poloni	I 5.84	I 5.82	l 5.08	o 4.82	g 5.39
mutagenesis averages	a 6.32	b 6.16	c 5.76	d 5.44	

Results of Table (12) indicated that gamma rays had a significant effect on the trait of individual plant yield, as the non-irradiated plants outperformed the other treatments, achieving the highest average of this trait amounting to 2.04 g plant^{-1}, and the mean of this trait gradually decreased with the increase in the level of rays The plants irradiated at the 27 Gy level gave the lowest average in the yield of the plant, which amounted to 1.65 gm plant^{-1}. This may be due to a decrease in the average number of capsules, the number of seeds, and the weight of 1000 seeds per plant with a high level of gamma rays. This result was consistent with the results of Ravichandran and Jayakumar. (2018). results of the genotypes showed that there were significant differences for this trait, as the Sakha1 genotype recorded the highest average of 2.22 g plant^{-1}, with a significant difference from the rest of the genotypes, while the Poloni genotype gave the lowest average of 1.55 gm plant^{-1}. The differences between the genotypes in the trait of the individual plant yield to the difference in the superior growth traits with this trait, the interaction between gamma rays and genotypes was significant, as the non-irradiated Sakha1 genotype had the highest yield of the individual plant amounting to 2.89 gm plant^{-1}, while the irradiated Sakha6 genotype at the 27 Gy level gave the lowest yield of 1.41 gm plant^{-1}.

Table (12) The effect of gamma rays, genotypes, and the interaction between them on the trait of individual plant yield (g.plant^{-1})

mutagenesis / genotypes	Gy 0	Gy 9	Gy 18	Gy 27	genotypes average
Sakha 1	a 2.89	b 2.31	fgh 1.78	ef 1.92	a 2.22
Sakha 2	ef 1.92	hij 1.66	i-l 1.57	l 1.44	d 1.65
Sakha 3	efg 1.83	b 2.22	b 2.31	ed 1.97	b 2.08
Sakha 5	bc 2.15	efg 1.84	gh 1.74	h-k 1.62	c 1.83
Sakha 6	gh 1.74	ghi 1.71	jkl 1.50	l 1.41	ed 1.59
Giza 8	bc 2.25	efg 1.83	ghi 1.72	hij 1.65	c 1.86
Syrian	fgh 1.76	efg 1.88	cd 2.11	fgh 1.77	c 1.88
Poloni	fgh 1.76	jkl 1.52	kl 1.49	l 1.43	e 1.55
mutagenesis averages	a 2.04	b 1.87	c 1.78	d 1.65	

Results of Table (13) showed that gamma rays significantly affected the trait of the seeds yield of seeds, as the non-irradiated plants gave the highest average of this trait amounting to 408.8 kg ha^{-1}, and the mean of this trait decreased gradually with the increase in the level of rays, and the irradiated plants gave the level of 27 Gy the lowest The average of the trait was 330.82 kg ha^{-1}, The results of the same table indicated that there were significant differences between the genotypes in this trait, as the Sakha 1 genotype gave the highest average of the trait seeds yield amounted to 433.63 kg ha^{-1}, and at the same time it differed from all genotypes, and the Polish genotype gave the lowest average of 311.25 kg ha^{-1}. Interaction between gamma rays and genotypes showed a significant presence of this trait, as the non-irradiated Sakha 1 genotype was distinguished by the highest seeds yield of 578.60 kg ha^{-1}, while the irradiated Sakha 6 genotype at the 27 Gy level gave the lowest yield of 282.20 kg ha^{-1}.

Table (13) The effect of gamma rays and genotypes and the interaction between them on the characteristic of the seeds yield (kg.ha^{-1})

overlap between mutation and genotypes	**Gy 0**	**Gy 9**	**Gy 18**	**Gy 27**	**genotypes average**
Sakha 1	a 578.60	e 413.08	ji 357.04	fg 385.80	a 433.63
Sakha 2	fg 384.96	lm 332.27	no 315.19	qr 289.92	e 330.58
Sakha 3	fgh 377.58	c 444.42	b 462.39	f 389.08	b 418.37
Sakha 5	d 431.25	h 369.13	jk 345.76	mn 324.52	d 367.66
Sakha 6	jk 349.18	kl 343.70	pq 300.97	qr 282.20	f 319.01
Giza 8	c 442.95	hi 366.96	jk 345.45	lm 331.84	cd 371.80
Syrian	jk 351.95	gh 375.26	ed 423.69	ijk 355.58	c 376.62
Poloni	jk 353.98	op 305.06	pqr 298.28	r 287.67	g 311.25
mutagenesis averages	a 408.8	b 368.73	c 356.09	d 330.82	

CONCLUSION

It can be concluded from the above that increasing the doses led to a decrease in most of the studied traits within this generation (M1 mutation), and in general this effect may lead to discrepancies and give the appropriate opportunity for selection within the second mutational generation (M2) in the future and use it as an important selection indicator when Education to increase yield and access to adapted varieties within the conditions of the region.

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