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EFFECT OF GAMMA IRRADIATION, ETHYLEMETHANE SULPHONATE AND THEIR COMBINATIONS ON PERFORMANCE OF PEA (*Pisum sativum* L.)

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ABSTRACT

Seeds of three cultivars of pea *Pisum sativum* L. were irradiated with different doses of gammar-rays (2.5, 5, 10, 15, 20, 25 and 30 KR). Other portions the some of seeds were treated with different levels of EMS (0.025, 0.05 and 0.1%). The combined treatments of both mutagens were made. Generally, it was found that, higher doses of both mutagens decreased plant height when compared with untreated plants as well as other doses. In both seasons, the effect of the different treatments on the number of branches per plant were significant or highly significant in the three studied cultivars. The low doses of gamma-rays decreased the number of days from sowing till germination, while higher doses (25 and 30 KR) increased days to germination. However, EMS did not affect the number of days from sowing to germination in both seasons in the studied culitvars. The high doses of gamma-rays significantly reduce when pollen grains viability in the three studied cultivars in both seasons compared with the control and other doses of both mutagens. Seed yield/plant, number of pods/plant and number of seeds/pod were reduced consistently with the increase the combined treatments of both mutagens as the levels are increased.

INTRODUCTION

Peas *Pisum sativum* L. is one of the popular and important winter vegetables all over the world as well as in Egypt, due to its high protein content, low fertilizer requirements and its ability to grew easily in the new reclaimed lands.

Artificial induction of mutations proved to be a useful tool for generating variability in many species, especially in self-fertilized plants. Moreover techniques of mutation induction could be used with a good chance of success to alter the genetic pattern of crop plants.

Leguminous plants were the target of great deal of investigations concerning induced variability using either irradiation or chemicals. For example, Badr (1974), Abdalla *et al.* (1977), Abd El-Mageed *et al.* (1984), El-Sahhar *et al.* (1984), Moustafa *et* al (1987), Metwally *et al.* (1992), Sarkar *et al.* (1997) and Selim and El-Banna (2001), showed that variability could be achieved using mutagens.

The main objective of the present investigation was to study the effects of different doses of gamma-rays, different levels of EMS and combination between them in inducing variability for some vegetative traits and yield and its components of pea.

MATERIALS AND METHODS

The experiments were carried out at the Experimental Farm, Faculty of Agriculture at Kafr El-Sheikh during two successive winter seasons of 1999/2000 and 2000/01. Dry seeds of three commercial cultivar of pea (*Pisum sativum* L.); namely: Master B. Little Marvel and Progress No. 9; were exposed to different doses of gamma-rays; i.e., 2.5, 5, 10, 15, 20, 25 and 30 KR. Gamma-radiation was obtained from a cobalt-60 source at the Middle Eastern Regional Radioisotope Center of the Arab countries, Dokki, Cairo, Egypt. Dry seeds of the three pea cultivars were treated with freshly prepared aqueous solution of ethylmethane sulphonate (EMS). The concentrations at which the mutagen was applied to the seeds were 0.0, 0.025, 0.05 and 0.1% for 12 hours at room temperature.

Irradiated seeds by the low doses of gamma rays from the three cultivars (2.5, 5 and 10 KR) were divided into three classes, each class was soaked for 12 hours in 0.025, 0.05 and 0.1% of EMS. While irradiated seeds by the high doses of gamma-rays (15, 20, 25 and 30 KR) were not treated.

After treating the seeds of the three cultivars with different levels of the two mutagens field experiments were conducted to evaluate the M_1-generation from the three cultivars. Randomized complete blocks design with four replications was used to evaluate the different treatments including the control.

The estimates were recorded for the M_1-generation in the two successive experimental seasons on plant height, number of branches per plant, flowering time, pollen grain viability percentage, seed yield per plant, number of pods per plant and number of seeds per pod.

Data were statistically analyzed according to the regular analysis of variance. Duncan's multiple range test was used for the comparison among treatment means (Duncan's, 1955).

RESULTS AND DISCUSSION

The effect of single and combined treatments of gamma-rays and EMS in M_1-generation were estimated by observing the different characters under study.

1.Plant height:

Data presented in Tables 1, 2 and 3 show that there were highly significant differences among the treatment means in both seasons. Plant height was decreased in all the cultivars with the increase in the dose of both mutagens (gamma-rays and EMS). The extant of reduction differed from cultivar to other. In cultivar Master B, a considerable reduction was occurred when a dose of 15 KR and above was used, but in cultivar Little Marvel a considerable reduction was occurred using a dose at 30 KR. The cultivar Progress No. 9 at the dose of 30 KR only gave a high value for plant height in the first season. This inhibition effect may be due to increased rate of cell division and/or cell elongation (Badr *et al.*, 1978). The simulative effect of low

dosage of gamma-rays on the growth may be due to increasing cell length, cell number or size. These could shift the metabolism by promoting and the stimulating the effect of phytohormones on the biosynthesis of nucleic acids (Hammad and Abd El-Halem, 1988). These results are nearly in agreement with those obtained by Selim and El-Banna (2001) on pea who reported that low radiation doses stimulated cell division and differentiation of xylem fibers, sclereids and tracheids up to 10 Gy of gamma-rays. Whereas, the decrease existed with high doses may be attributed to either to the retarding effect of radiation on cell division and/or cell elongation, or may be due to the inhibitory effect of radiation on respiration and protein synthesis. They also found that, stimulating (at low doses) or inhibitory (at high doses) effect on the growth may ascribed to the hormonal balance (the ratio of promoters IAA, GA and cytokinin/inhibitor ABA). In general, the decrease in plant height with increasing mutagen doses was also obtained by other workers such as Selim *et al.* (1974), Abd El-Mageed *et al.* (1984) and Metwally *et al.* (1992).

Table 1: Effect of single and combined treatments of gamma-rays and EMS on vegetative traits of pea cultivar "Master B" in M_1-generation in 1999/2000 and 2001/01 seasons.

Treatments	Plant height (cm)		No. of branches/plant		Days from soign to flowering		Viability of pollen grains %	
	1999/00	2000/01	1999/00	2000/01	1999/00	2000/01	1999/00	2000/01
2.5 KR	42.3 efg	40.1 ab	0.6 bc	2.0 abc	37.0 c	41.0 d	94.8 ab	97.0 ab
5 KR	42.2 egf	40.5 ab	0.9 abc	1.8 a-d	37.0 c	41.0 d	92.8 bc	95.0 b
10 KR	41.0 fgh	40.4 ab	0.8 abc	1.6 b-f	37.0 c	41.0 d	88.3 cde	90.0 c
15 KR	38.0 gh	35.6 cd	1.2 ab	0.9 g	40.0 b	41.0 d	81.5 g-j	85.0 e
20 KR	39.4 fgh	33.7 cde	1.2 ab	1.1 efg	40.0 b	46.0 b	82.0 ghi	85.0 e
25 KR	36.7 h	33.6 cde	0.8 abc	1.4 c-g	42.0 a	49.0 a	77.5 ij	80.0 f
30 KR	30.0 I	33.2 de	0.6 bc	1.3 d-g	42.0 a	49.0 a	65.5 l	70.0 h
0.025 % EMS	56.5 a	31.7 e	1.4 a	1.7 b-e	37.0 c	42.0 d	85.0 efg	88.0 cd
0.05 % EMS	40.9 fgh	26.7 f	0.8 abc	1.6 b-f	37.0 c	42.0 d	83.5 fg	87.0 de
0.1% EMS	42.7 d-g	34.6 cde	1.1 abc	1.0 fg	37.0 c	44.0 c	81.5 g-j	85.0 e
2.5 KR+0.025% EMS	41.1 fgh	35.7 cd	0.3 c	1.0 fg	37.0 c	42.0 d	87.8 def	90.0 c
2.5 KR+0.05% EMS	47.7 bcd	43.1 a	0.9 abc	1.6 b-e	37.0 c	42.0 d	81.5 g-j	85.0 e
2.5KR+0.1% EMS	48.2 bc	41.2 a	0.9 abc	1.8 a-d	37.0 c	45.0 bc	72.3 k	75.0 g
5KR+0.025%EMS	43.8 c-f	35.8 cd	1.1 ab	1.2 efg	37.0 c	42.0 d	92.0 bcd	95.0 b
5KR+0.05%EMS	41.9 e-h	36.5 cd	0.3 c	1.9 abc	37.0 c	41.0 d	92.5 bc	90.0 c
5KR+0.1%EMS	40.9 fgh	37.4 bc	1.1 ab	1.7 b-e	37.0 c	41.0 d	78.0 hij	70.0 h
10KR+0.025%EMS	42.0 e-h	30.9 e	0.8 abc	2.0 abc	37.0 c	41.0 d	86.3 efg	90.0 c
10KR+0.05%EMS	47.1 b-e	32.6 de	1.3 ab	2.4 a	37.0 c	41.0 d	82.3 gh	85.0 e
10KR+0.1%EMS	49.1 b	33.9 cde	1.4 a	1.2 efg	37.0 c	41.0 d	77.3 j	80.0 f
Control	44.2 b-f	41.4 a	0.8 abc	2.2 ab	37.0 c	41.0 d	98.3 a	98.0 a
F-test	**	**	*	**	**	**	**	**

2.Number of branches per plant:

The effect of the different treatments on the number of branches per plant were significant or highly significant in the three cultivars in both seasons. In the cultivar Master B a significant increase was found at 0.025% EMS and combined treatment 10 KR + 0.1% EMS in the first season, while in the cultivar

Little Marvel a significant increase was found at 30 KR in both seasons. Morover, the cultivar Progress No. 9 a highly significant increase was found at 5 KR + 0.05% EMS in the first season, and at 2.5 KR + 0.025% EMS in the second season. This response of number of branches per plant to radiation, might be due to the balance between the stimulating effect of the lower doses of mutagens and the inhibiting of their higher doses (Badr *et al.*, 2000). It would be also due to the reduction of IAA from the apical meristem which was detrimental to the mitotic activity of the cambial cells which consequently suppressed the branching (Abdel-Maksoud, 1992).

Table 2: Effect of single and combined treatments of gamma-rays and EMS on vegetative traits of pea cultivar "Little Marvel" in M_1-generation in 1999/2000 and 2001/01 seasons.

Treatments	Plant height (cm)		No. of branches/plant		Days from soign to flowering		Viability of pollen grains %	
	1999/00	2000/01	1999/00	2000/01	1999/00	2000/01	1999/00	2000/01
2.5 KR	46.5 de	46.5 de	0.9 a-d	0.7 bc	50.0 e	49.0 f	94.5 a-d	98.0 a
5 KR	52.7 cde	50.0 abc	0.9 abc	0.9 bc	50.0 de	50.0 ef	91.8 e	95.0 b
10 KR	58.3 bc	47.1 bcd	0.8 a-d	0.8 bc	51.0 d	51.0 cde	91.3 e	95.0 b
15 KR	62.2 abc	47.7 bcd	0.4 bcd	0.4 bc	52.0 bc	52.0 bc	87.0 f	90.0 c
20 KR	66.4 ab	51.3 abc	0.7 a-d	1.0 ab	52.0 b	52.0 b	85.5 f	90.0 c
25 KR	70.3 a	46.5 cd	0.4 bcd	0.6 bc	57.0 a	57.0 a	81.8 g	85.0 d
30 KR	42.8 e	49.0 abc	1.1 a	1.5 a	58.0 a	57.0 a	66.0 I	70.0 f
0.025 % EMS	52.5 cde	49.3 abc	0.9 a-d	0.6 bc	50.0 de	50.0 ef	92.0 de	95.0 b
0.05 % EMS	66.8 ab	55.0 a	0.8 a-d	0.7 bc	51.0 cd	51.0 cde	87.0 f	90.0 c
0.1% EMS	56.6 bcd	49.6 abc	0.5 a-d	0.8 bc	51.0 cd	51.0 cde	80.3 g	80.0 e
2.5 KR+0.025% EMS	63.1 abc	46.9 bcd	0.4 bcd	0.3 c	50.0 de	50.0 def	95.0 abc	98.0 a
2.5 KR+0.05% EMS	60.0 abc	49.7 abc	0.5 a-d	0.6 bc	50.0 de	50.0 ef	92.5 cde	95.0 b
2.5KR+0.1% EMS	56.4 bcd	47.3 bcd	0.7 a-d	0.4 c	51.0 d	50.0 def	82.3 g	85.0 d
5KR+0.025%EMS	58.4 bc	41.9 d	0.3 d	0.9 bc	50.0 de	50.0 def	95.5 ab	98.0 a
5KR+0.05%EMS	61.9 abc	50.2 abc	0.4 bcd	0.7 bc	51.0 d	50.0 def	95.0 abc	98.0 a
5KR+0.1%EMS	57.3 bcd	49.9 abc	0.4 cd	0.5 bc	51.0 d	50.0 def	93.8 b-e	97.0 ab
10KR+0.025%EMS	57.8 bcd	49.0 abc	0.8 a-d	0.8 bc	50.0 d	51.0 bcd	92.3 de	95.0 b
10KR+0.05%EMS	53.8 cde	53.2 ab	0.8 a-d	0.7 bc	50.0 de	51.0 cde	85.5 f	90.0 c
10KR+0.1%EMS	55.0 bcd	51.5 abc	0.4 bcd	0.4 bc	50.0 de	50.0 def	77.5 h	80.0 e
Control	54.0 cde	52.2 abc	1.0 ab	0.9 bc	50.0 de	50.0 def	97.0 a	98.0 a
F-test	**	**	*	*	**	**	**	**

3.Flowering time:

Data in Tables 1, 2 and 3 show that, the three cultivars in both seasons had a shorter period from, growing to flowering at the low and intermediate doses of gamma-rays, while the higher doses of gamma rays (25 and 30 KR) increased number of days from sowing till flowering. The statistical analysis indicated that there were highly significant differences among the different treatment means in both seasons. Furthermore, the effect of EMS alone or combined with gamma-rays in the three studied cultivars of pea showed that there were no differences among these treatments and the untreated control.

Early flowering, could be attributed to the low doses of radiation and

sometimes to the intermediate doses which generally, stimulate cell growth and produce early flowering (Badr *et al.*, 2000). These results are in agreement with those reported by Omar (1995) on *Gomphrena globosa* L. who found that dry seeds irradiated with 15 KR flowered earlier than those plants treated by 30 KR dose of gamma-rays which delayed flowering.

Table 3: Effect of single and combined treatments of gamma-rays and EMS on vegetative traits of pea cultivar "Progress No. 9" in M_1-generation in 1999/2000 and 2001/01 seasons.

Treatments	Plant height (cm)		No. of branches/plant		Days from soign to flowering		Viability of pollen grains %	
	1999/00	2000/01	1999/00	2000/01	1999/00	2000/01	1999/00	2000/01
2.5 KR	32.2 b-e	34.8 cd	0.5 de	1.4 efg	47.0 e	37.0 c	94.8 ab	98.0 a
5 KR	28.0 f	33.5 cde	0.5 e	2.2 c-g	47.0 e	38.0 bc	94.5 ab	97.0 ab
10 KR	33.0 b-e	32.1 cde	0.9 cde	1.9 d-g	47.0 e	38.0 bc	94.3 abc	97.0 ab
15 KR	33.4 b-e	35.4 cd	1.6 c	2.6 b-g	49.0 d	40.0 b	91.8 cd	95.0 b
20 KR	39.4 a	32.3 cde	3.2 ab	3.9 a-d	49.0 d	44.0 a	56.8 h	60.0 f
25 KR	33.3 b-e	35.9 bcd	3.2 ab	1.9 d-g	61.0 a	45.0 a	56.3 h	60.0 f
30 KR	38.8 a	35.0 cd	2.5 b	2.5 b-g	61.0 a	46.0 a	46.8 I	50.0 g
0.025 % EMS	33.8 bcd	31.8 cde	1.1 cde	2.4 b-g	54.0 c	38.0 bc	92.3 bcd	95.0 b
0.05 % EMS	32.4 b-e	37.0 bcd	1.5 cd	4.5 ab	57.0 b	37.0 bc	76.8 g	80.0 c
0.1% EMS	32.5 b-e	37.3 a-d	2.7 b	2.4 b-g	57.0 b	38.0 bc	46.5 I	50.0 g
2.5 KR+0.025% EMS	30.4 def	40.6 a-d	0.7 cde	5.9 a	54.0 c	38.0 bc	91.3 d	95.0 b
2.5 KR+0.05% EMS	29.6 ef	37.3 a-d	1.3 cde	3.5 b-e	57.0 b	38.0 bc	81.5 f	85.0 d
2.5KR+0.1% EMS	31.1 c-f	42.0 a-d	1.0 cde	1.1 fg	57.0 b	38.0 bc	76.5 g	80.0 e
5KR+0.025%EMS	30.5 def	31.3 de	1.0 cde	3.0 b-f	55.0 c	39.0 bc	85.3 e	90.0 c
5KR+0.05%EMS	35.5 b	47.7 a	3.7 a	4.2 abc	57.0 b	39.0 bc	82.8 f	85.0 d
5KR+0.1%EMS	31.0 c-f	40.4 a-d	1.2 cde	3.6 bcd	57.0 b	40.0 b	75.3 g	80.0 e
10KR+0.025%EMS	31.5 c-f	42.5 abc	0.7 cde	0.7 g	55.0 c	38.0 bc	87.3 e	90.0 c
10KR+0.05%EMS	32.2 b-e	38.8 a-d	0.4 e	4.1 abc	55.0 c	37.0 c	81.0 f	85.0 d
10KR+0.1%EMS	34.5 bc	46.3 ab	1.1 cde	1.1 fg	58.0 b	38.0 bc	76.8 g	80.0 e
Control	32.1 b-e	24.1 e	1.0 cde	1.0 fg	46.0 e	37.0 bc	96.5 a	98.0 a
F-test	**	**	**	**	**	**	**	**

4.Viability of pollen grains percentage:

Data presented in Tables 1, 2 and 3 show that there were highly significant differences among the different doses of gamma-rays on pollen grains viability percentage. The doses of 25 and 30 KR had the lowest values of pollen grains viability percentage in the three studied cultivars. Generally, it was found that gamma-rays gave a higher effect on pollen grains viability percentage than EMS. On the other hand, the increasing pollen grains viability percentage by using low doses of gamma-radiation (1-15 KR) may be due to their stimulatory effect on division and growth of sporogenous pollen mother and tapentum layer cells which led to the formation of fertile pollen grains (Abdel-Maksoud, 1980). This result, agrees with Sarker *et al.* (1997) who found in *Vigna radiata* L. that radiation caused a liner reduction in pollen grains fertility percentage as gamma-rays doses were increased.

5.Seed yield/plant:

Data shown in Tables 4 indicated that seed yield per plant in cultivar Master B was increased as a result of exposure to 2.5 and 5 KR of

gamma-rays, while a highly significant decrease was observed at 15 KR and higher doses, compared to the control. The largest reduction in seed yield/plant was obtained at 30 KR dose in both seasons. The dose of 0.025% EMS in the first season and the dose of 5 KR in the second season gave the largest values of seed yield/plant, respectively. The data in Table 5 showed that seed yield/plant of the cultivar Little Marvel was decreased with the increasing of gamma-rays doses, and the statistical analysis indicated that there were highly significant differences among the different treatment means in both seasons. The doses of 2.5 KR and 10 KR + 0.1% EMS gave high values of seed yield/plant in the first and second season, respectively.

Table 4: Effect of single and combined treatments of gamma-rays and EMS on yield and its components of pea cultivar "Master B" in M_1-generation in 1999 / 2000 and 2000/01 seasons.

Treatments	1999/2000			2000/01		
	Seed yield/ plant (g)	No. of pods/plant	No. of seeds/pod	Seed yield/ plant (g)	No. of pods/plant	No. of seeds/pod
2.5 KR	4.2 bcd	4.8 efg	5.8 bcd	5.6 ab	7.2 a	5.3 bc
5 KR	4.9 b	6.1 a-e	5.4 cde	6.3 a	7.1 ab	6.0 b
10 KR	4.5 bc	6.4 a-e	4.8 c-f	4.7 cd	5.3 c-f	6.1 b
15 KR	2.8 ghi	7.4 abc	2.6 gh	3.0 ghi	4.5 e-h	4.4 cd
20 KR	3.1 f-l	7.9 a	2.7 gh	2.8 hi	5.2 d-g	3.7 de
25 KR	3.2 e=l	5.9 a-e	3.7 fg	2.8 hi	4.5 e-h	4.3 d
30 KR	1.0 j	3.6 g	2.2 h	3.4 f-l	5.4 cde	4.2 d
0.025 % EMS	7.1 a	6.6 a-e	7.2 a	2.6 l	5.8 cd	3.1 e
0.05 % EMS	2.6 hi	4.7 efg	3.8 fg	2.6 l	4.4 fgh	4.0 de
0.1% EMS	4.0 b-f	5.7 b-f	4.8 c-f	2.7 hi	4.1 hi	4.5 cd
2.5 KR+0.025% EMS	3.4 c-g	3.7 g	6.9 ab	3.5 fgh	4.5 e-h	5.3 bc
2.5 KR+0.05% EMS	3.5 d-h	6.3 a-e	3.8 fg	5.6 ab	7.1 ab	5.3 bc
2.5KR+0.1% EMS	4.1 b-e	6.0 a-e	4.7 c-f	4.5 cde	7.7 a	4.0 de
5KR+0.025%EMS	3.3 d-l	5.4 c-g	4.6 def	4.1 c-f	5.2 d-g	5.4 bc
5KR+0.05%EMS	2.9 ghi	3.8 fg	5.2 cde	4.0 def	6.2 bc	4.4 cd
5KR+0.1%EMS	2.4 i	6.4 a-e	2.6 gh	4.4 cde	3.3 l	9.1 a
10KR+0.025%EMS	3.1 f-l	5.0 d-g	4.2 ef	2.7 hi	4.2 gh	4.4 cd
10KR+0.05%EMS	2.6 hi	7.0 a-d	2.6 gh	3.7 efg	5.6 cd	4.6 cd
10KR+0.1%EMS	2.6 hi	7.6 ab	2.8 gh	3.7 efg	6.0 cd	4.2 d
Control	4.6 bc	5.4 c-g	5.9 bc	4.9 bc	5.8 cd	5.8 b
F-test	**	**	**	**	**	**

Data in Table 6 showed that the seed yield of the cultivar Progress No. 9 showed variable differences among the used treatments. In the first season, the dose 2.5 KR gave a high value of seed yield per plant, however, 2.5 KR + 0.05% EMS gave a high value of seed yield per plant in the second season. For EMS treatments, a highly significant reduction in seed yield per plant was recorded in the three cultivars as a result of EMS treatments with concentration of 0.05% and 0.1% in both seasons.

Low concentrations of EMS induced some stimulating effect on plant growth, while the higher concentrations resulted in an inhibiting effect which was reflected on the seed yield per plant. It is again due to the physiological damage occurred cumulatively by increasing EMS dosage as described by Gaul *et al.* (1966).

6.Number of pods/plant:

The number of pods per plant was decreased with increasing gamma-rays doses in the three studied cultivars as compared to the control. In the cultivar Master B, a highly significant decrease was found at 30 KR in the first season, but the combined treatments of 5 KR + 0.1% EMS caused a highly significant decrease than the other treatments and the control in the second season.

Table 5: Effect of single and combined treatments of gamma-rays and EMS on yield and its components of pea cultivar "Little Marvel" in M_1-generation in 1999 / 2000 and 2000/01 seasons.

Treatments	1999/2000 season			2000/01 season		
	Seed yield/ plant (g)	No. of pods/ plant	No. of seeds/ pod	Seed yield/ plant (g)	No. of pods/ plant	No. of seeds/ pod
2.5 KR	4.1 a	10.0 bc	3.6 ab	5.3 d-h	9.8 d-h	4.8 bcd
5 KR	3.9 ab	9.2 b-f	3.8 a	5.9 c-f	11.4 b-f	4.6 bcd
10 KR	3.6 abc	9.2 b-e	3.4 ab	4.7 e-l	8.5 f-l	4.7 bcd
15 KR	2.5 ef	9.5 bcd	2.3 de	4.3 f-l	8.0 ghi	4.8 bcd
20 KR	3.5 abc	13.1 a	2.4 cde	4.6 e-l	11.0 c-f	3.7 d
25 KR	2.0 f	10.5 b	1.7 e	4.1 f-j	9.1 d-l	4.0 cd
30 KR	1.2 g	6.0 h	2.0 e	2.4 j	11.6 b-e	2.0 e
0.025 % EMS	2.5 def	6.5 gh	3.4 ab	5.2 d-h	9.4 d-l	5.1 abc
0.05 % EMS	3.2 bcd	9.3 bcd	3.1 abc	7.8 ab	13.9 ab	4.9 a-d
0.1% EMS	2.2 ef	6.9 e-h	2.9 bcd	3.9 g-j	9.0 d-l	3.8 d
2.5 KR+0.025% EMS	2.5 def	8.0 c-h	2.8 bcd	5.1 d-h	8.6 e-l	5.2 ab
2.5 KR+0.05% EMS	2.9 cde	6.7 gh	3.8 a	5.1 e-l	10.2 d-g	4.3 bcd
2.5KR+0.1% EMS	2.6 def	6.4 gh	3.6 ab	3.8 g-j	8.9 d-l	3.7 d
5KR+0.025%EMS	2.5 def	6.6 gh	3.4 ab	3.2 ij	6.7 l	6.0 a
5KR+0.05%EMS	3.0 cde	7.5 d-h	3.6 ab	3.4 hij	7.0 hi	4.3 bcd
5KR+0.1%EMS	2.7 def	6.8 fgh	3.5 ab	5.6 d-g	10.6 d-g	4.6 bcd
10KR+0.025%EMS	2.6 def	7.3 d-h	3.1 abc	6.3 b-e	10.6 d-g	5.2 ab
10KR+0.05%EMS	2.5 def	7.4 d-h	3.1 a-d	7.6 abc	13.8 bc	4.9 a-d
10KR+0.1%EMS	2.4 ef	6.9 fgh	3.2 abc	9.1 a	16.4 a	4.9 a-d
Control	2.8 de	8.7 b-g	2.9 bcd	7.0 bcd	11.8 bcd	5.2 ab
F-test	**	**	**	**	**	**

In the cultivar Little Marvel, there was a highly significant effect of treatments on the number of pods per plant in both seasons where the doses of 30 KR and 5 KR + 0.025% EMS gave low values of number of pods per plant in the first and second season, respectively.

In the cultivar Progress No. 9, the lowest number of pods per plant was obtained at the dose 5 KR of gamma-rays in the first season, and the combined treatments of 2.5 KR+ 0.1% EMS in the second season.

The reduction in number of pods per plant at a high mutagenic doses may be attributed to the reduction in the growth characters (Badr *et al.*, 2000).

7.Number of seeds/pod

The number of seeds per pod for the three cultivars under study were decreased as gamma-rays doses increased (Tables 4, 5 and 6). The results showed that highly significant differences among treatments and the untreated

control were observed in all cultivars under study. A highly significant decrease was found at 25 and 30 KR in both seasons. Furthermore, the effect of EMS differed in the three cultivars of pea, while there were no significant effect in the three cultivars in both seasons.

The reduction in seed yield and its components with increasing the doses of both mutagens may be due to the reduction in fertility which may be attributed to chromosomal aberrations or attributed to physiological damage (Abd El-Rahman 2000). It may be also attributed to the inhibiting effect of gamma-rays on cell division and consequently on the DNA replication. The low doses of radiation may affect the activity of certain enzymes involved in the synthesis of endogenous hormones, however the mechanism involved is still not clear (Selim and El-Banna 2001).

Table 6:Effect of single and combined treatments of gamma-rays and EMS on yield and its components of pea cultivar "Progress No. 9" in M_1-generation in 1999 / 2000 and 2000/01 seasons.

Treatments	1999/2000			2000/01		
	Seed yield/ plant (g)	No. of pods/ plant	No. of seeds /pod	Seed yield/ plant (g)	No. of pods/ plant	No. of seeds /pod
2.5 KR	7.7 a	5.0 de	6.3 a	10.2 bc	8.5 b-f	4.9 b-e
5 KR	5.9 a-e	4.4 e	5.6 ab	8.0 bc	7.2 c-f	4.5 c-f
10 KR	6.0 a.e	6.3 de	4.0 c-f	9.0 bc	9.8 b-f	4.0 c-f
15 KR	4.7 cde	7.4 cd	2.7 gh	6.5 bc	8.4 b-f	3.2 d-g
20 KR	6.7 a-d	13.2 a	2.6 gh	12.8 bc	13.1 bc	4.0 c-f
25 KR	2.5 fgh	10.3 b	1.7 hi	4.3 bc	7.9 c-f	2.6 efg
30 KR	2.0 gh	6.8 cde	0.7 I	5.9 bc	10.3 b-f	2.4 fg
0.025 % EMS	7.5 ab	7.3 cd	4.2 cd	9.9 bc	7.8 c-f	5.2 a-d
0.05 % EMS	5.4 b-e	7.2 cde	3.0 efg	15.2 bc	20.3 a	3.1 d-g
0.1% EMS	4.6 cde	9.2 bc	2.1 gh	5.9 bc	7.2 c-f	3.6 def
2.5 KR+0.025% EMS	6.8 abc	4.8 de	5.8 a	17.0 b	19.3 a	3.7 c-f
2.5 KR+0.05% EMS	6.7 a-d	6.0 de	4.6 bc	29.6 a	12.3 bcd	3.7 c-f
2.5KR+0.1% EMS	6.2 a-e	5.6 de	4.5 bc	10.5 bc	5.7 f	7.1 ab
5KR+0.025%EMS	6.0 a-e	5.5 de	4.6 bc	8.4 bc	10.6 b-f	3.5 def
5KR+0.05%EMS	1.5 h	7.6 cd	0.9 I	1.8 c	7.4 c-f	1.0 g
5KR+0.1%EMS	4.9 cde	7.0 cde	2.8 fgh	7.9 bc	13.8 b	2.4 fg
10KR+0.025%EMS	6.2 a-e	6.3 de	4.1 cde	8.2 bc	6.3 ef	6.0 abc
10KR+0.05%EMS	3.9 efg	5.1 de	3.1 d-g	8.5 bc	12.1 b-e	2.9 d-g
10KR+0.1%EMS	4.4 def	7.2 cd	2.5 gh	7.1 bc	7.1 def	4.3 c-f
Control	7.7 a	5.2 de	6.0 a	10.2 bc	5.3 f	7.4 a
F-test	**	**	**	*	**	**

The results of this study are in harmony with those obtained by Badr (1974) who found, in pea, that early and total yield as well as yield components were favourably increased by low of intermediate radiation treatments. Marawan *et al.* (1974) on pea, found that seed yield, number of pods per plant, number of seeds per pod and seed index in R_1-generation were significantly reduced by the higher radiation doses of gamma-rays. Hegazy (1980) on bean, found that total green yield, number of pods per plant and seed yield were decreased by increasing the doses of gamma radiation. Mostafa (1987) on

cowpea, found that dry yield and its components were favourably increased by radiation treatments, especially when the intermediate doses were used.

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تأثير أشعة جاما والمطفر الكيماوى إيثايل ميثان سلفونيت والتفاعل المشترك بينهما على نبات البسلة

١ – الجيل الأول

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شععت بذور ثلاثة أصناف من البسلة وهى ماستر بى ، لتل مارفل وبروجرس رقم ٩ بجرعات مختلفة من أشعة جاما وهى صفر ، ٢,٥ ، ٥ ، ١٠ ، ١٥ ، ٢٠ ، ٢٥ و ٣٠كيلو راد.

كذلك تم أخذ كمية أخرى من بذور الثلاثة أصناف السابقة ونقعت لمدة ١٢ ساعة فى تركيزات مختلفة من المطفر الكيماوى إيثايل ميثان سلفونيت وهذه التركيزات هى صفر ، ٠,٠٢٥ ، ٠,٠٥ ، ٠,١٪.

كذلك تم عمل معاملات مشتركة بين البذور المعاملة بجرعات منخفضة من أشعة جاما (٢,٥ ، ٥ ، ١٠كيلو راد .(والتركيزات المختلفة من المطفر الكيماوى) إيثايل ميثان سلفونيت .(ويمكن تلخيص أهم النتائج المتحصل عليها فى الآتى:

- حدث انخفاض لكل من طول النبات ، محصول البذور الجافة للنبات ، عدد القرون لكل نبات وعدد البذور فى القرن فى الجيل الإشعاعى الأول وذلك بزيادة أشعة جاما أو بزيادة التركيزات المختلفة من المطفر الكيماوى إيثايل ميثان سلفونيت وكذلك فى المستويات المرتفعة من المعاملات المشتركة بين المطفرين وذلك فى الثلاثة أصناف تحت الدراسة فى كلا الموسمين.
- كان تأثير كلا من المطفرين بسيطا على عدد الأفرع لكل نبات فى كلا الموسمين فى الثلاثة أصناف المستخدمة فى الدراسة.
- أدت الجرعة المرتفعة من أشعة جاما إلى تأخير التزهير وخفض فى حيوية حبوب اللقاح فى كلا الموسمين وذلك فى الثلاثة أصناف المستخدمة فى الدراسة.