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# EFFECTS OF SOME MUTAGEN AGENTS ON CERTAIN BOTANICAL ASPECTS OF FABA BEANS

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## ABSTRACT

A cultivar Giza2 of *Vicia faba* was treated with gamma rays doses of 30 and 60 Gy and ethyl methane sulfonate (EMS) at conc. of 0.15 and 0.30% and the effects were assessed in M5 and M6 generations. The effect of mutagens was studied using a number of parameters, such as morphological growth characters, some physiological parameters, flowering and yield attributes, and nutritive values of seeds.

All faba bean mutants induced by gamma irradiation and EMS tended to increase in most growth characters, and the maximum increase in this respect was achieved by the mutants No. 7, 4 and 10. On the other hand, mutant No.1 was nearly similar to the untreated plants in most growth characters.

Concentration of chlorophyll a, b and total chlorophyll as well as carotenoids tended to arise in all mutants (except mutant No.2) over the untreated plants, mutants No.7, 8, 9 and 1 had the highest pigments conc. in both M5 and M6 generations. The ratios of chl.a/b as well as total chl./carotenoids in most mutants of both generations did not show clearly changes comparable with the control.

Leaves in all mutants had higher total water content (TWC) and relative water content (RWC) but lower water deficit (LWD) except mutants No. 4 for TWC and 8 for both RWC and LWD that showed a reverse trend. The best mutant for the highest RWC and the lowest LWD was mutant No.1. Transpiration rate was significantly reduced in most mutants except some mutants in M5 generation, and the lowest one was recorded by mutant No.7. Use of water by mutants for producing dry seeds and dry matter (WUE) was more efficient than that the untreated plants, mutants No.1 and 4 showed the best WUE.

Mutants showed different trends in the number of flowers, the greatest one was achieved by mutants No.1, 2, 3, 4 and 7. Mutants exceeded over the untreated plants in pod set (%), sharply reduced in flower and pod shedding percentage, mutant No.1 (M5) and No.7 (M6) were the best in this respect. Pod, seed and straw yield tended to increase in most mutants, mutants No. 1 and 4 had the highest pod and seed yield while the highest straw yield was achieved by mutants No.8 (M5) and 1 (M6). Mutants No.4, 5, 2 and 8 (M5) and No.1, 4 and 8 (M6), recorded the highest seed index. Shelling percentage was higher in all mutants except mutants No.3 and 10.

The chemical composition of faba bean mutants seeds in both M5 and M6 generations indicate that most mutants had higher nutritive value with some exceptions. It is worthy that mutants No.5, 4 and 7 recorded the highest protein conc. while mutants No.6 and 9 contained the highest carbohydrate conc. comparable with the other mutants.

**Keywords:** Faba bean, mutation induction, growth, photosynthetic pigments, water relations, flowering and fruiting, yield attributes, seeds nutritive value.

## INTRODUCTION

Nowadays, a great attention is concentrated at mutants induction especially to the high yield mutant (Wongpiyasatid *et al.*, 1999; Al-Hamdany *et al.*, 1998; Atia *et al.*, 1995), the high value nutritive mutant (Farag, 1999; Nayeem *et al.*, 1999; Bundenny and Naumov, 1994; Nair and Abraham, 1992), the mutants resistant against diseases (Wongpiyasatid *et al.*, 1999; Al-Hamdany *et al.*, 1998) or to stress conditions (Atia *et al.*, 1995; Bundenny and Naumov, 1994; Nair and Abraham, 1992). Mutagen agents as a good tool for crops improvement were reported by several investigators (Kharkwal, 1999; Abada, 1995; Abo-Hegazi, 1972). In this respect, several mutagen agents: physical such as gamma rays, fast neutrons or laser and chemical agents such as EMS (ethyl methanesulfonate), ethidium bromide, ethyleneimine (EI), NMU (N-methyl-N-nitrosourea), NEU (N-ethyl-N-nitrosourea), hydroxylamine, colchicine, were used, but gamma rays and EMS have proved to be the most efficient agents for mutants induction (Kharkwal, 1999; Solanki and Sharma, 1999; Nair and Abraham, 1992; Mustafa *et al.*, 1989). It had been found that gamma rays and chemical mutagen agents caused many changes in morphological, physiological, genetic and yield characters of plants. Marked changes in plant height, root length, leaf area, growth habit, maturity and flowering behavior as well as yield components were reported by Solanki and Sharma (1999) on lentil, Surender-Kumar *et al.* (1999) on *Brassica juncea*; Al-Hamdany *et al.* (1998) and Atia *et al.* (1995) on faba bean and Thiede *et al.*, (1995) on *Helianthus annus*. Production mutant high protein content was stated by Nayeem *et al.* (1999) on wheat; Farag (1999) on sunflower; Aparna-Das *et al.*, (1999) on potato; Nair and Abraham (1990, 1992) on yam bean and Leiva *et al.* (1988) on *Phaseolus vulgaris*. Also, mutagen agents induced mutants varied in chlorophyll content (Seyyedi *et al.*, 1999) and carotenoids (Datta, 1999). Also, it was found that sugar content was slightly lower but starch content increased in yam bean affected by EMS for 5 hrs if compared with the control (Nair and Abraham, 1990 and 1992).

Therefore, this investigation was carried out to study the changes occurred in the morphological characters, photosynthetic pigments, plant water relations, flowering, fruiting and yield attributes as well as its composition in the induced mutants (M5 and M6 generations) from cv. Giza2 of faba bean by gamma irradiation and EMS. Water use efficiency was also studied.

## MATERIALS AND MRETHODS

Pot experiments were carried out during 1998 and 1999 to through some light on the variations in the botanical aspects and yield of some faba bean mutants (progenies of M5 and M6) induced by gamma-radiation and EMS.

**Mutants induction:**

Faba bean seeds (*Vicia faba*, L., cv. Giza2) were divided into three batches. In the 1st seeds were irradiated by gamma rays doses 30 and 60 Gy. Seeds in the 2nd were submerged in freshly EMS (Ethyl methanesulfonate) solutions at concentrations of 0.15 and 0.30% at room temperature for 4 hrs. The3rd batch was used as a control (untreated seeds). In the Experimental Farm belonging to the Egyptian Atomic Energy Authority. Inshas, the treated and untreated seeds were sown to obtain M1 seeds. which planted to give the M2 generation. Seeds of the M2 selected plants were sown to give the M3 which give the M4 generation seeds. The M4 selected plants were sown to give M5 generation. In the Agricultural Botany Dept., Faculty of Agriculture, Menoufiya University, Shibin El-Kom, A.R.E. seeds of M5 generation plants were sown to give M6 generation. Characters of the ten selected faba mutants (M5 and M6 generations) are illustrated in Table (1).

**Table (1): Characters of the ten selected faba bean mutants (M5 and M6 generations).**

| Mutant No. | Characteristics | Mutant Mark |
|---|---|---|
| 1 | Brown L. seed H.Y. | B.L.Hy 30 |
| 2 | Brown L. seed H.Y. | B.L.Hy 60 |
| 3 | Brown S. seed | B.S. 0.15 |
| 4 | Brown M. seed | B.M. 0.15 |
| 5 | White L. seed | W.L. 0.15 |
| 6 | Brown M. seed | B.M. 0.15 |
| 7 | Violet S. seed | V. S. 0.15 |
| 8 | Violet M. seed | V.M. 0.15 |
| 9 | Green M. seed | G. M. 0.15 |
| 10 | Brown S. seed | B. S. 0.30 |
| Control | Brown M. seed | B.M. seed |

**Sowing and agricultural practices:**

Seeds of M5 and M6 generations were sown on November 2, 1998 and 1999. Five seeds of each mutant beside the control seeds (untreated) were sown in plastic pots 30-cm inner diameter, each filled with 7 kg clay loam soil (pH= 7.97, O.M.(%)=1.98, EC= 0.62 $dSm^{-1}$, TSS (%)= 0.16). The seeds were inoculated with effective strains of Rhizobia (*Rhizobium leguminosarum*) before sowing. Pots were arranged in five replicates randomized block design. After twenty-one days seedlings were thinned to four seedlings per pot. The moisture in soils of the experiments was kept at 60-65% of the water holding capacity during the experimental period. Other agricultural practices were done.

**Samples:**

After seventy-five days from sowing, a random sample of five plants was carefully taken from each treatment and the following measurements were done: Plant height (cm), root length (cm) and diameter (mm), leaflet length and its maximum width (cm), number of leaves and

(mm), leaflet length and its maximum width (cm), number of leaves and branches per plant, total number of nodules per plant, fresh and dry weights of root, stem and leaves (g/plant), dried at 70°C for 72 hrs in an electric oven, then the shoot/root ratio was calculated, total leaf area ($cm^2$/plant) using the disk method according to Bremner and Taha (1966) and leaf area index (LAI= total leaf area, $cm^2$/area of pot surface, $cm^2$). Relative growth rate (RGR, $mg.g^{-1}.week^{-1}$) and net assimilation rate (NAR, $mg.cm^{-2}.week^{-1}$) during the period 55-75 days using the equations of Simane *et al.*, (1993). Photosynthetic pigments were extracted from fresh leaves using acetone 80% and estimated according to Wettestein (1958), then calculated as mg/g dry weight. Total water content (TWC, %) and transpiration rate ($mg.\ cm^{-2}.\ h^{-1}$) were measured according to the methods described by Kreeb (1990). Leaf water deficit (LWD, %), relative water content (RWC, %) and degree of sclerophylly (DScl, %) estimated using the methods of Kalapos (1994).
Water use efficiency (WUE), which is the weight of water used (kg) in producing one gram dry matter of a plant (seeds, straw and whole plant), [WUE = Dry weight (g)/ Weight of water used (kg)], was determined at the end of experiment using special formula of Vites (1965).

The number of flowers per plant, the number of pods, pod set (%) and total shedding percentage, pods, seed and straw yields (g/plant) as well as seed index (weight of 100 seeds) and shelling percentage were recorded.

Dry seeds of faba bean for each treatment were ground in an agate mortar, 0.2 gm of dried ground of seeds was digested in $H_2SO_4$: $H_2O_2$ (5:1) and prepared for chemical analysis of nitrogen, phosphorus, potassium and sodium. Nitrogen was determined using micro kjeldahl method, P using stannous chloride method, K and Na using flame photometer according to Allen (1974), then calculated as mg/g D.Wt. Seed crude protein (mg/g D.Wt.) was estimated by multiplying N concentration by 6.25. Another weights of 0.2 gm of ground dried seeds were used to determine the carbohydrates (total, soluble and non-soluble, mg/g D.Wt.) and the total free amino acids (mg/g dwt.) using the methods described by Sadasivam and Manickam (1992). The Na/K as well as C/N ratios were calculated.
Data obtained were statistically analyzed and the LSD test at 5% level of probability was used to compare the means of the treatments (Gomez and Gomez, 1984) with help the COSTAT C Statistical package (American Computer Program).

## RESULTS AND DISCUSSION

### 1. Vegetative growth characteristics:

Data obtained in Table (2) show that all progenies of faba bean mutants in both M5 and M6 generations were taller than the untreated plants. In M5 progeny, the tallest mutant was mutant No.10 followed by mutants No.4 and No.2, whereas the tallest one was No.4 followed by mutants No.10 and No.2 in M6 progeny.

Table (2): Some growth characters of induced faba bean mutants (M5 and M6 generations) by gamma radiation and EMS at age of 75 days.

| Mut. No. | Treat. | Plant height (cm) | Branches No./ plant | Root Length (cm) | Root Diameter (mm) | Nodules No. / plant | Leaves No. / plant | Leaflet Length (cm) | Leaflet Width (cm) | Leaf area ($cm^2$/ plant) | Leaf area index |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **M5 Generation** | | | | | | | | | | |
| 1 | 30 Gy | 57.00 | 3.33 | 19.00 | 45.00 | 17.00 | 39.33 | 6.82 | 3.35 | 543.18 | 3.08 |
| 2 | 60 Gy | 71.67 | 2.67 | 19.17 | 35.00 | 11.33 | 32.00 | 6.34 | 3.87 | 405.36 | 2.30 |
| 3 | 0.15% EMS | 68.00 | 2.00 | 19.33 | 35.00 | 13.67 | 30.50 | 7.20 | 4.03 | 418.67 | 2.37 |
| 4 | 0.15% EMS | 72.33 | 3.00 | 21.00 | 33.33 | 8.33 | 33.67 | 7.95 | 4.23 | 812.97 | 4.60 |
| 5 | 0.15% EMS | 66.50 | 3.00 | 22.00 | 40.00 | 5.00 | 24.50 | 6.05 | 3.47 | 615.84 | 3.49 |
| 6 | 0.15% EMS | 61.50 | 3.50 | 23.00 | 41.00 | 13.00 | 37.00 | 6.30 | 3.63 | 569.02 | 3.22 |
| 7 | 0.30% EMS | 66.50 | 2.50 | 25.00 | 38.00 | 15.00 | 36.50 | 8.80 | 4.52 | 827.71 | 4.69 |
| 8 | 0.15% EMS | 60.50 | 3.00 | 19.00 | 30.33 | 4.50 | 28.00 | 8.23 | 4.43 | 789.36 | 4.47 |
| 9 | 0.15% EMS | 63.00 | 4.00 | 26.00 | 24.00 | 12.50 | 31.50 | 7.48 | 3.80 | 526.45 | 2.98 |
| 10 | 0.30% EMS | 74.50 | 3.50 | 24.00 | 30.67 | 21.67 | 28.50 | 8.21 | 3.97 | 685.89 | 3.32 |
| --- | Untreated (cont.) | 56.00 | 3.67 | 20.05 | 20.33 | 7.00 | 24.00 | 7.60 | 3.38 | 358.75 | 1.16 |
| | L.S.D. at 5% | 1.890 | 1.005 | 3.77 | 3.36 | 2.59 | 2.79 | 1.05 | 0.27 | 41.337 | 0.30 |
| | **M6 Generation** | | | | | | | | | | |
| 1 | 30 Gy | 63.50 | 3.50 | 20.27 | 47.50 | 12.35 | 42.50 | 8.53 | 4.63 | 648.83 | 3.67 |
| 2 | 60 Gy | 72.50 | 3.00 | 20.70 | 36.00 | 17.00 | 34.50 | 9.57 | 4.60 | 399.76 | 2.26 |
| 3 | 0.15% EMS | 69.33 | 2.75 | 21.27 | 52.50 | 20.50 | 32.00 | 8.50 | 5.04 | 491.44 | 2.78 |
| 4 | 0.15% EMS | 77.00 | 3.33 | 23.80 | 40.00 | 7.62 | 34.50 | 9.13 | 4.50 | 721.91 | 4.09 |
| 5 | 0.15% EMS | 67.67 | 3.33 | 24.20 | 43.20 | 5.50 | 25.00 | 8.20 | 4.05 | 755.88 | 4.28 |
| 6 | 0.15% EMS | 63.00 | 3.75 | 24.15 | 46.50 | 12.31 | 39.00 | 8.05 | 5.24 | 626.12 | 3.55 |
| 7 | 0.30% EMS | 66.33 | 3.10 | 27.50 | 39.50 | 16.00 | 38.00 | 8.80 | 5.44 | 993.22 | 5.63 |
| 8 | 0.15% EMS | 60.67 | 3.95 | 21.85 | 32.50 | 5.00 | 33.00 | 9.45 | 4.80 | 963.15 | 5.45 |
| 9 | 0.15% EMS | 63.67 | 4.10 | 31.20 | 23.00 | 16.67 | 36.50 | 9.60 | 5.10 | 608.14 | 3.44 |
| 10 | 0.30% EMS | 76.33 | 5.33 | 28.80 | 26.50 | 27.50 | 38.50 | 9.67 | 4.90 | 633.61 | 3.58 |
| --- | Untreated (cont.) | 60.00 | 3.50 | 21.39 | 22.50 | 6.50 | 24.50 | 8.87 | 3.50 | 367.20 | 1.16 |
| | L.S.D. at 5% | 1.384 | 0.668 | 1.461 | 1.568 | 2.492 | 1.756 | 0.79 | 0.77 | 18.131 | 0.20 |

Table (2): Cont.

| Mut. No. | Treat. | Fresh weight (g/plant) Root | Fresh weight Stem | Fresh weight Leaves | Dry weight (g/plant) Root | Dry weight Stem | Dry weight Leaves | Shoot/ Root ratio | RGR* (mg. $g^{-1}$ . $w^{-1}$) | NAR** (mg. $m^{-2}$ . $w^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **M5 Generation** | | | | | | | | |
| 1 | 30 Gy | 2.33 | 7.90 | 8.17 | 0.86 | 1.33 | 1.60 | 3.41 | 0.27 | 3.27 |
| 2 | 60 Gy | 3.08 | 13.80 | 10.04 | 1.46 | 3.09 | 1.83 | 3.37 | 0.24 | 2.66 |
| 3 | 0.15% EMS | 3.25 | 14.38 | 10.58 | 1.06 | 1.83 | 1.58 | 3.22 | 0.31 | 3.48 |
| 4 | 0.15% EMS | 3.59 | 18.95 | 15.32 | 1.34 | 3.79 | 3.06 | 5.11 | 0.36 | 4.49 |
| 5 | 0.15% EMS | 3.67 | 13.97 | 8.69 | 1.46 | 3.89 | 2.00 | 3.83 | 0.31 | 3.64 |
| 6 | 0.15% EMS | 2.47 | 13.50 | 9.19 | 1.04 | 3.25 | 1.80 | 4.86 | 0.25 | 2.47 |
| 7 | 0.30% EMS | 3.56 | 17.70 | 11.49 | 1.25 | 1.81 | 1.87 | 2.95 | 0.38 | 3.88 |
| 8 | 0.15% EMS | 3.99 | 16.81 | 11.90 | 1.50 | 3.67 | 1.79 | 3.64 | 0.25 | 2.18 |
| 9 | 0.15% EMS | 3.83 | 16.15 | 9.76 | 1.53 | 3.88 | 1.57 | 3.56 | 0.27 | 2.72 |
| 10 | 0.30% EMS | 3.63 | 15.49 | 10.47 | 1.43 | 3.31 | 2.59 | 4.83 | 0.31 | 4.52 |
| --- | Untreated (cont.) | 2.35 | 7.10 | 7.12 | 0.96 | 1.52 | 0.85 | 2.42 | 0.13 | 1.64 |
| | L.S.D. at 5% | 0.29 | 1.64 | 0.63 | 0.17 | 0.29 | 0.23 | 0.17 | 0.03 | 0.29 |
| | | **M6 Generation** | | | | | | | | |
| 1 | 30 Gy | 2.45 | 8.79 | 8.67 | 0.95 | 1.58 | 1.91 | 3.64 | 0.25 | 2.94 |
| 2 | 60 Gy | 3.95 | 14.38 | 9.04 | 1.81 | 3.31 | 1.81 | 2.83 | 0.23 | 2.41 |
| 3 | 0.15% EMS | 3.98 | 15.44 | 10.29 | 1.39 | 2.62 | 1.85 | 3.22 | 0.24 | 2.35 |
| 4 | 0.15% EMS | 4.01 | 19.90 | 14.42 | 1.58 | 4.58 | 2.72 | 4.62 | 0.33 | 3.77 |
| 5 | 0.15% EMS | 2.99 | 14.40 | 9.80 | 1.20 | 4.32 | 2.45 | 5.64 | 0.26 | 3.49 |
| 6 | 0.15% EMS | 2.75 | 14.35 | 9.01 | 1.24 | 3.87 | 1.98 | 4.72 | 0.22 | 1.90 |
| 7 | 0.30% EMS | 4.56 | 19.77 | 11.23 | 1.82 | 2.37 | 2.25 | 2.54 | 0.34 | 3.56 |
| 8 | 0.15% EMS | 4.33 | 19.65 | 12.10 | 1.69 | 4.32 | 2.18 | 3.85 | 0.24 | 1.74 |
| 9 | 0.15% EMS | 3.96 | 16.61 | 9.53 | 1.62 | 4.48 | 1.81 | 3.88 | 0.23 | 2.26 |
| 10 | 0.30% EMS | 3.93 | 17.55 | 9.95 | 1.49 | 2.98 | 2.39 | 3.61 | 0.32 | 4.04 |
| --- | Untreated (cont.) | 2.51 | 9.70 | 6.71 | 0.86 | 1.50 | 1.00 | 2.91 | 0.12 | 1.71 |
| | L.S.D. at 5% | 0.40 | 1.79 | 1.06 | 0.23 | 0.33 | 0.14 | 0.55 | 0.04 | 0.19 |

RGR* = Relative growth rate during the period of 60-75 days from sowing.

NAR** = Net assimilation rate during the period of 60-75 days from sowing.

Data in the same Table indicate that mutant No.9 in M5 and No.10 in M6 generations gave the greatest number of branches/plant whereas mutant No.3 gave the lowest one in both M5 and M6 generations if compared with the control.

In progenies of M5 and M6, mutants No.9, 10 and 7 recorded the tallest roots, whereas mutants No.1, 2 and 3 did not significantly differ if compared with the untreated plants. Other mutants recorded an increase in root length but did not reach to the level of significance. As for the root diameter, it can be observed that roots of all mutants were thicker than the untreated plants. Mutants No.1, 6 and 5 in M5, while mutants No.3, 1,6, 5 and 4 in M6 gave the thickness roots if compared with other mutants (Table, 2).

Nodules number was significantly increased in mutants No.1, 2, 3, 6, 7, 9 and 10, but was significantly decreased in mutants No.5 and 8 if compared with the untreated plants. Mutant No.4 did not show any significant change in this respect. These results were true in both M5 and M6 generations. Mutant No.10 had the highest number, followed by No.7 then No.3 in M5 generation. Again, mutant No.10 gave the highest one, followed by No.3, then No.2, 9 and 7 in M6 generation.

The obtained results in Table (2) show that number of leaves was significantly increased in all mutants except mutant No.5 which had the same leaves number if compared with the control. The maximum increase was recorded by mutant No.1.

Leaflet length was increased in mutants No.7, 8 and 10 (M5 generation) and in No.10, 9, 8, 2 and 4 (M6 generation); reduced in mutants No.1, 2, 5 and 6 (M5) and in No.5 and 6 (M6), nearly similar to the control in mutants No.3, 9 and 4 (M5) and No. 1, 3 and 7 (M6). The tallest leaflet was recorded by mutant No.7 in M5 and mutant No.10 in M6.Concerning the leaflet breadth, it was observed that all faba bean mutants except the mutant No.1 in M5 generation recorded marked increases in this aspect. Mutant No.7 in both of M5 and M6 generations gave the maximum leaflet width.

In both M5 and M6 generations, the fresh and dry weights of root, stem and leaves tended to increase in all mutants with exception of mutant No.1 which had similar fresh and dry weights of root and stems of the control. The heaviest fresh and dry weights for root, stem and leaves was inconsistent in M5 and M6 generations. Mutant No.8 was the heaviest weight in M5 but No.7 in M6 for fresh root, mutant No.9 in M5 and mutant No.7 in M6 for dry root. Mutant No.4 was the heaviest weight in M5 and M6 generations for fresh stem, while mutant No.5 in M5 and No.4 in M6 for dry stem. Mutant No.4 was the heaviest weight (fresh and dry) in both M5 and M6 generations (Table, 2)

Data presented in the same Table show that shoot/root ratios were significantly differed among the mutants. All mutants recorded higher shoot/root ratios except the mutant No.9 that had a similar ratio of the untreated plants (control). Mutants No.4, 6 and 10 gave the highest ratios.

Total leaf area (TLA) and leaf area index (LAI) in faba bean mutants were significantly increased over the untreated plants by 2-4 times. Mutants No.7, 8, 4 and 5 achieved the highest increases. These results were true in both two generations (Table, 2).

Using gamma radiation doses of 30 and 60 Gy (Mutant No. 1 and 2) and EMS at conc. of 0.15 and 0.30% (Mutants No.3 - 10) led to a significant increase in both relative growth rate (RGR) and net assimilation rate (NAR) in all mutants if compared with the controlled plants (Table, 2). The greatest RGR was recorded by mutants No.10, 5 and 3 followed by No.7, 1 and 9 then No.4, 6 and 8, whereas the greatest one in NAR was found in mutants No.10 and 4 followed by No.1, 2 and 3 in both M5 and M6 generations.

From the above results, it could be said that all faba bean mutants induced by gamma irradiation (doses of 30 and 60 Gy) and EMS (conc. of 0.15 and 0.30%) tended to increase in most growth characters, and the maximum increase in this respect was achieved by the mutants No. 7, 4 and 10. On the other hand, mutants No.1 was nearly similar to the untreated plants in most growth characters. Similar results were reported by Charbajck and Nabulsi (1999) on grapevine mutants induced with gamma radiation; Solanki and Sharma (1999) on lentil mutants induced with gamma rays and EMS; Surender-Kumar *et al.* (1999) on mutants induced with gamma rays and EMS; Al-Hamdany *et al.* (1998) on faba bean using gamma rays; Waghmare and Mehra (1998) on *Lathyrus sativus* using gamma rays and EMS; Sushil-Kumar *et al.* (1998) on khesari using gamma rays and EMS and Thiede *et al.* (1995) on *Helianthus annus* using gamma radiation. Sagan *et al.* (1995) obtained several mutant lines differed in nodulation characters in *Medicago truncatula* after gamma rays mutagenesis.

The increase associated with low gamma radiation doses or low concentration of EMS may be due to its stimulating effect on cell division and elongation. Aysha-Khan *et al.* (1999) reported that low radiation doses or the low conc. of colchicine (chemical mutagen) stimulated cell division and differentiation of xylem fibers and sclereids and tracheids in explants given upto 10 Gy of gamma rays. Recently, it was found that stimulating (at low doses of 4 kR) or inhibitory (at high doses of 10 kR) effect on the growth may ascribe to the hormonal balance (the ratio of promoters (IAA, GA and cytokinins) / inhibitors (ABA)) as reported by Rabie *et al.* (1996).

**2. Physiological aspects:**

**2.1. Photosynthetic pigments:**

Data presented in Table (3) show that; in M5 progeny all mutants except of mutant No.2 (similar to the control) showed increases in the conc. of *chl.a*. The highest conc. was found in mutant No.7 and 8 followed by 9 and 1. In M6 progeny, another trend was noticed. Mutant No.7 followed by 8 and 1 had the highest conc., then No. 4, 3, 9, 6 and 5. Also, It can be observed that the conc. of chl.a in M6 progeny was higher than that in M5 progeny. As for *chl.b*, similar conc. was found in mutants No.2, 3, 4 and 10, on the contrast higher conc. were noticed in mutants No.7, 8 and 9 (Table, 3). These results were true in both M5 and M6 generations. The obtained results in the same Table show that *the total chlorophyll (chl.a+b)* was positively affected by gamma irradiation and EMS and behaved a similar trend of that chl.a. It can be said that mutants No.7, 8 and 1 could be considered as higher chlorophyll mutants. Concerning *carotenoids* concentration, it was observed generally that there was an increase in it with using gamma rays or EMS as show in all mutants. The highest increase was recorded by mutant No.8 followed by 7 and 1 in M5 whereas mutants No.1 followed by 8 and 9 in M6. The *chl.a/b ratio* was significantly raised only in mutant No.4, significantly lowered in mutants No.7 and 5, and not significantly affected in the rest of mutants. The increase or decrease in *chl.a/b ratios* ascribed to the high or low concentration of chl.a beside the low value of chl.b resulted from above treatments. Regarding the *total chlorophyll / carotenoids ratio*, it showed that mutant No.7 was the single mutant that recorded a higher ratio in both M5 and M6 generations, whereas other mutants tended to still in this respect.

**Table (3): Photosynthetic pigments of induced faba bean mutants (M5 and M6 generations) by gamma radiation and EMS at age of 75 days.**

| Mut. No. | Treat. (Characters) | Chl. a | Chl.b | Total Chl. | Carotenoids | Chl. a/b | Total Chl. / Carotenoids |
|---|---|---|---|---|---|---|---|
| | | Mg / g Dwt. | | | | | |
| | | M5 Generation | | | | | |
| 1 | 30 Gy | 6.11 | 2.50 | 8.62 | 2.52 | 2.44 | 3.41 |
| 2 | 60 Gy | 3.27 | 1.40 | 4.67 | 1.48 | 2.33 | 3.16 |
| 3 | 0.15% EMS | 4.28 | 1.82 | 6.09 | 1.76 | 2.35 | 3.45 |
| 4 | 0.15% EMS | 4.99 | 1.69 | 6.69 | 1.84 | 2.95 | 3.63 |
| 5 | 0.15% EMS | 4.86 | 2.30 | 7.16 | 1.89 | 2.11 | 3.78 |
| 6 | 0.15% EMS | 5.14 | 2.18 | 7.32 | 2.10 | 2.36 | 3.48 |
| 7 | 0.30% EMS | 8.74 | 4.33 | 13.07 | 2.78 | 2.02 | 4.70 |
| 8 | 0.15% EMS | 8.16 | 3.41 | 11.56 | 3.16 | 2.39 | 3.66 |
| 9 | 0.15% EMS | 6.30 | 2.66 | 8.97 | 2.36 | 2.37 | 3.80 |
| 10 | 0.30% EMS | 4.60 | 1.99 | 6.59 | 1.82 | 2.31 | 3.62 |
| --- | Untreated (cont.) | 3.18 | 1.22 | 4.40 | 1.23 | 2.61 | 3.58 |
| | L.S.D. at 5% | 0.665 | 0.691 | 1.161 | 0.243 | 0.207 | 0.297 |
| | | M6 Generation | | | | | |
| 1 | 30 Gy | 8.45 | 2.79 | 11.24 | 2.83 | 3.03 | 3.98 |
| 2 | 60 Gy | 4.88 | 1.67 | 6.55 | 1.77 | 2.92 | 3.71 |
| 3 | 0.15% EMS | 7.58 | 2.52 | 10.10 | 2.55 | 3.01 | 3.97 |
| 4 | 0.15% EMS | 7.77 | 2.09 | 9.86 | 2.30 | 3.73 | 4.29 |
| 5 | 0.15% EMS | 6.50 | 2.47 | 8.96 | 1.95 | 2.64 | 4.59 |
| 6 | 0.15% EMS | 6.75 | 2.27 | 9.01 | 2.21 | 2.98 | 4.08 |
| 7 | 0.30% EMS | 8.99 | 3.19 | 12.18 | 2.03 | 2.82 | 6.00 |
| 8 | 0.15% EMS | 8.73 | 2.68 | 11.41 | 2.77 | 3.26 | 4.12 |
| 9 | 0.15% EMS | 7.25 | 3.13 | 10.38 | 2.78 | 2.31 | 3.73 |
| 10 | 0.30% EMS | 5.21 | 1.76 | 6.97 | 1.67 | 2.95 | 4.18 |
| --- | Untreated (cont.) | 3.70 | 1.11 | 4.81 | 1.14 | 3.32 | 4.21 |
| | L.S.D. at 5% | 0.788 | 0.392 | 0.505 | 0.380 | 0.429 | 0.411 |

Seyyedi *et al.* (1999) and Datta (1999), found variation in chlorophylls as well as carotenoids in the induction mutants. Also, it can be observed that the low dose of gamma rays caused a marked increase in the photosynthetic pigments, but no marked change at 60 Gy. These results are accordance with those obtained by Ismaeil (1995) on faba bean, Hussein *et al.* (1995) on *Datura metel*, Selim and Atia (1996b) on wheat plant, Youssef *et al.* (1996) on *Melaeuca armillaris* and Selim and El-Bana (2001) on pea plant. The observed changes in chlorophylls and carotenoids concentrations that existed in leaves resulted from different gamma exposures could be interpreted on the basis of the widely and diversely effects of gamma radiation on many enzymes, genes and hormones through many aspects of growth that could be altered (Chiscon, 1962; Rabie *et al.*, 1996).

**2.2. Leaf water relations:**

Data obtained in Table (4) indicate that the *total water content* (TWC) in leaves of faba bean mutants No.3, 8, 9, 7 and 10 was higher, whereas in mutants No.4 and 5 was lower, other mutants were similar comparing with the control. These results were true in the progeny of M5 generation. Another trend was observed in the progeny of M6 generation where the higher values were recorded by mutants No.8 and 3, lower values by mutants No.5, 4 and 1, similar values to the control by other mutants.

Concerning the *relative water content* (RWC) and *leaf water deficits* (LWD), it can be observed that the highest RWC and the lowest LWD were found in mutants No.1 and 7, whereas the lowest RWC and the highest LWD were in mutants No.8, 6 and 4 if compared with the untreated plants (Table, 4). Other mutants tended to be similar or having a slight increase or decrease in this respect.

**Table (4): Water relations in the induced faba bean mutants (M5 and M6 generations) by gamma radiation and EMS at age of 75 days.**

| Mut. No. | Characters / Treat. | Total Water Content (%) | Relative Water Content (%) | Leaf Water Deficit (%) | Sclerophylly Degree (%) | Transpiration Rate (mg. cm$^{-2}$ . h$^{-1}$) |
|---|---|---|---|---|---|---|
| | | **M5 Generation** | | | | |
| 1 | 30 Gy | 88.51 | 71.90 | 28.10 | 19.54 | 3.15 |
| 2 | 60 Gy | 89.91 | 59.33 | 40.67 | 18.26 | 4.75 |
| 3 | 0.15% EMS | 93.60 | 61.32 | 38.68 | 14.91 | 5.26 |
| 4 | 0.15% EMS | 82.51 | 52.05 | 47.95 | 24.99 | 3.10 |
| 5 | 0.15% EMS | 84.73 | 62.93 | 37.07 | 22.97 | 3.25 |
| 6 | 0.15% EMS | 88.44 | 51.71 | 48.29 | 19.60 | 3.33 |
| 7 | 0.30% EMS | 92.08 | 68.63 | 31.37 | 16.29 | 1.92 |
| 8 | 0.15% EMS | 93.50 | 49.66 | 50.34 | 15.00 | 4.59 |
| 9 | 0.15% EMS | 92.33 | 61.96 | 38.04 | 16.06 | 4.97 |
| 10 | 0.30% EMS | 90.54 | 54.87 | 45.13 | 17.69 | 5.60 |
| --- | Untreated (cont.) | 88.76 | 56.64 | 43.36 | 19.31 | 4.56 |
| | L.S.D. at 5% | 1.714 | 2.013 | 1.116 | 1.109 | 0.977 |
| | | **M6 Generation** | | | | |
| 1 | 30 Gy | 86.02 | 71.04 | 28.96 | 21.80 | 2.82 |
| 2 | 60 Gy | 88.44 | 59.63 | 40.37 | 19.60 | 4.43 |
| 3 | 0.15% EMS | 90.57 | 60.80 | 39.20 | 17.66 | 4.44 |
| 4 | 0.15% EMS | 83.12 | 52.21 | 47.79 | 24.44 | 3.24 |
| 5 | 0.15% EMS | 83.05 | 61.35 | 38.65 | 24.50 | 3.05 |
| 6 | 0.15% EMS | 86.52 | 50.54 | 49.46 | 21.35 | 3.05 |
| 7 | 0.30% EMS | 88.33 | 67.75 | 32.25 | 19.25 | 1.63 |
| 8 | 0.15% EMS | 91.08 | 48.84 | 51.16 | 17.20 | 4.01 |
| 9 | 0.15% EMS | 89.65 | 59.82 | 40.18 | 18.50 | 4.31 |
| 10 | 0.30% EMS | 89.98 | 52.67 | 47.33 | 18.20 | 5.04 |
| --- | **Untreated (cont.)** | 88.22 | 54.12 | 45.88 | 19.80 | 5.25 |
| | L.S.D. at 5% | 1.108 | 2.474 | 1.193 | 1.514 | 0.444 |

*Sclerophylly degree* (DScl) was higher in mutants No.4 and 5 in M5 generation, but in mutants No.4, 5, 1 and 6 in M6 generation. Other mutants tended to have lower DScl if compared with the control (Table, 4).

As *for transpiration rate* (TR), data presented in the same Table show that TR tended to increase in mutants No.10 and 3, to decrease in mutants No.1, 4, 5, 6 and 7, to be equal in mutants No.2, 8 and 9 in comparison to control. These results were true in M5 generation. Another trend was noticed in M6 generation. All mutants showed a significant reduction in TR except mutant No.10 that was equal to the control. It is noteworthy that mutant No. 7 recorded the lowest TR in both M5 and M6 generations and this reduction arrived about 57.9 and 68.6 % respectively less than the control.

### 3. Flowering and yield attributes:
#### 3.1. *Flowering and fruiting:*

It can be observed that mutants No.1, 2, 3, 4 and 7 produced a great number of flowers per plant, whereas mutants No.5, 6, 8, 9 and 10 given a lower one if compared with the untreated plants. The highest number of flowers was produced by mutants No.1 and 2 (followed by No.3, 4 and 7), whereas the lowest one was produced by mutants No.5 and 6. These results were true in the progeny of M5. In M6 generation, another trend was noticed where it was found that all mutants (except No.9 and 10 that were similar to control plants) produced a higher number of flowers. Mutants No.1 and 4 (followed by N0.2 and 3) gave the highest number of flowers. That means that mutant No.1marked as a high flower production mutant (Table, 5).

Data in the same Table show that the percentage of pod set significantly raised in all mutants of M5 and M6 if compared with the control. Mutant No.1 in M5 and mutant No.7 in M6 recorded the highest pod set percentage.

Total shedding percentage tended to decrease sharply in all mutants if compared with the control plants. Again, mutants No.1 in M5 and No.7 in M6 showed the lowest shedding percentage (Table, 5).

In this respect, Solanki and Sharma (1999) obtained lentil mutants varied in flowering behavior. Kumar and Mishra (1999) on greengram found that the mutagenic treatments (gamma rays 10, 20, 30 and 40 kR and diethyl sulfate (DES); 0.25, 0.50, 0.75 and 1.00%, separately) caused an increases in pollen sterility and days to flowering.

#### 3.2.Yield attributes:

Number of pods per plant significantly increased in all mutants except mutants No.6 and 10 that showed a marked decrease in it if compared with the control. The greatest number was achieved by mutant No.1 (followed by No.2 and 4) in both M5 and M6 generations as shown the obtained results in Table (5).

Pod yield as well as seed yield tended to increase in all mutants except mutants No.5 and 6 that showed a depression in this respect in comparison with the control. A slight change in trend of M6 was observed where it was noticed that there was a reduction in mutant No. 9 for pod yield and mutant No.10 for seed yield. The highest pod and seed yield were recorded by mutants No.1, 2 and 4 (Table, 5).

Straw yield was higher in all mutants of both M5 and M6 generations except the mutants No.10 in M5 and No.9 in M6 that gave lower straw yield as well as mutant No.10 in M6, which gave a similar straw yield to the control plants (Table, 5).

Seed index was significantly increased in mutants No.2, 4, 5, 8 (M5) and mutants No.4, 5, 8, 9 (M6). Some mutants showed either a slight decrease (mutants No.1, 7 in M5 and No.1, 2, 6 and 7 in M6) or a marked decrease (mutant No.3 in both M5 and M6) in it. The highest seed index value was recorded by mutants No.2 and 4, while the lowest one by mutant No.3 (Table, 5).

**Table (5): Yield attributes and water use efficiency of induced faba bean mutants (M5 and M6 generations) by gamma radiation and EMS.**

| Mut. No. | Treat. | Flowers No/ plant | Pod Set (%) | Shedding (%) (flowers+pods) | Pods No./ plant | Pod Yield (g/plant) | Seed Yield (g/plant) | Straw Yield (g/plant) | Seed Index | Shelling (%) | Water Use Efficiency (g dry matter/kg $H_2O$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Seeds | Straw | Whole |
| | | M5 Generation | | | | | | | | | | | |
| 1 | 30 Gy | 69.00 | 96.96 | 15.94 | 58.00 | 53.10 | 49.70 | 40.93 | 40.50 | 93.60 | 3.73 | 3.07 | 6.80 |
| 2 | 60 Gy | 65.00 | 87.78 | 34.77 | 42.40 | 44.80 | 40.14 | 44.40 | 47.42 | 89.60 | 3.01 | 3.33 | 6.34 |
| 3 | 0.15% EMS | 62.75 | 79.68 | 41.75 | 36.55 | 36.73 | 27.76 | 41.01 | 36.57 | 75.57 | 2.08 | 3.08 | 5.16 |
| 4 | 0.15% EMS | 60.25 | 83.82 | 33.61 | 40.00 | 46.25 | 44.30 | 53.40 | 50.61 | 95.78 | 3.32 | 4.01 | 7.33 |
| 5 | 0.15% EMS | 29.50 | 84.75 | 22.03 | 23.00 | 20.78 | 15.05 | 44.67 | 44.33 | 72.41 | 1.13 | 3.35 | 4.48 |
| 6 | 0.15% EMS | 25.00 | 88.00 | 20.80 | 19.80 | 18.90 | 14.86 | 34.72 | 41.45 | 78.62 | 1.11 | 2.60 | 3.72 |
| 7 | 0.30% EMS | 59.25 | 84.39 | 35.02 | 38.50 | 29.80 | 27.20 | 39.04 | 40.58 | 91.28 | 2.04 | 2.93 | 4.97 |
| 8 | 0.15% EMS | 42.75 | 93.57 | 29.82 | 30.00 | 32.93 | 28.00 | 60.72 | 48.54 | 85.02 | 2.10 | 4.55 | 6.65 |
| 9 | 0.15% EMS | 44.25 | 90.40 | 19.77 | 35.50 | 39.48 | 33.40 | 46.80 | 40.58 | 84.60 | 2.51 | 3.51 | 6.02 |
| 10 | 0.30% EMS | 35.00 | 85.71 | 37.14 | 22.00 | 37.52 | 25.06 | 25.24 | 36.53 | 66.79 | 1.88 | 1.89 | 3.77 |
| ---Untreated (cont.) | | 53.75 | 65.12 | 46.98 | 28.50 | 28.73 | 21.92 | 29.92 | 41.06 | 76.30 | 1.64 | 2.24 | 3.89 |
| L.S.D. at 5% | | 2.125 | 1.728 | 1.669 | 2.303 | 1.281 | 1.734 | 1.805 | 1.538 | 1.531 | 0.372 | 0.373 | 0.448 |
| | | M6 Generation | | | | | | | | | | | |
| 1 | 30 Gy | 67.65 | **85.85** | 24.24 | 51.25 | 46.27 | 45.17 | 47.30 | 41.91 | 97.61 | 3.39 | 3.55 | 6.94 |
| 2 | 60 Gy | 62.33 | 80.17 | 31.17 | 42.90 | 42.87 | 34.30 | 38.63 | 41.98 | 80.02 | 2.57 | 2.90 | 5.47 |
| 3 | 0.15% EMS | 60.00 | 78.33 | 45.00 | 33.00 | 43.74 | 34.99 | 23.44 | 37.61 | 79.98 | 2.62 | 1.76 | 4.38 |
| 4 | 0.15% EMS | 67.20 | 88.54 | 34.82 | 43.80 | 49.26 | 44.11 | 46.72 | 48.02 | 89.56 | 3.31 | 3.50 | 6.81 |
| 5 | 0.15% EMS | 51.25 | 87.80 | 20.39 | 40.80 | 44.33 | 39.30 | 32.58 | 46.20 | 88.65 | 2.95 | 2.44 | 5.39 |
| 6 | 0.15% EMS | 48.50 | 86.60 | 37.11 | 30.50 | 40.80 | 31.23 | 35.25 | 41.00 | 76.55 | 2.34 | 2.64 | 4.99 |
| 7 | 0.30% EMS | 50.50 | 92.90 | 18.32 | 41.25 | 35.10 | 34.30 | 34.50 | 42.58 | 97.72 | 2.57 | 2.59 | 5.16 |
| 8 | 0.15% EMS | 45.00 | 88.89 | 25.19 | 33.67 | 40.60 | 35.11 | 45.25 | 45.05 | 86.49 | 2.63 | 3.39 | 6.03 |
| 9 | 0.15% EMS | 39.75 | 84.91 | 28.55 | 28.40 | 29.74 | 24.85 | 24.89 | 45.70 | 83.55 | 1.86 | 1.87 | 3.73 |
| 10 | 0.30% EMS | 42.50 | 88.24 | 50.59 | 21.00 | 31.27 | 25.06 | 27.07 | 38.95 | 80.15 | 1.88 | 1.93 | 3.81 |
| ---Untreated (cont.) | | 43.50 | 74.71 | 48.06 | 22.59 | 32.15 | 24.91 | 27.44 | 44.25 | 77.48 | 1.87 | 2.06 | 3.93 |
| L.S.D. at 5% | | 1.222 | 1.574 | 1.510 | 1.736 | 1.368 | 0.507 | 1.178 | 1.073 | 1.802 | 0.344 | 0.714 | 0.192 |

Shelling percentage was higher in all mutants in both two generations except mutants No5 and 10 in M5 generat on. Mutants No.1 and 4 in M5 and mutants No.1 and 7 in M6 achieved the highest value in this respect (Table, 5).

The increase in yield and its components at low doses of gamma rays or EMS low conc. may be attributed to its stimulative effect on growth, number and weight of pods and 100 seed weight. Similar results were revealed by Atia *et al.* (1995) on faba bean using gamma rays and EMS; Kumar *et al.* (1995) on pea using colchicine; Kumari (1996) on faba bean; Al-Hamdany *et al.* (1998) on faba bean using gamma rays; Kumar and Mishra (1999) on greengram using gamma rays and DES separately and Bordoloi and Talukdar (1999) on rice using gamma rays.

**4. Some chemical aspects of seeds**

**4.1. Mineral status:**

Seed-N concentration in faba bean mutants of M5 generation increased significantly in mutants No.5, 4, 7, 8, 1, 2, 6 and 10 and significantly decreased in mutant No.9, not significantly affected in mutant No.3 (Table, 6). In M6 generation, all mutants showed marked increases in this respect if compared with the untreated plants. It is worthy that the highest seed-N concentration was achieved by mutants No.4, 5 and 7 in both of M5 and M6 generations.

Data presented in the same Table show clearly that phosphorus concentration in seeds of faba mutants increased significantly in all mutants except mutant No.3 that had a similar (in M5 generation) or lower (in M6 generation) seed-P conc. of the control. Mutants No.5, 2 and 4 in M5generation, whereas mutants No.4, 2, 6 and 5 had the highest seed-P conc.

As for seed-K *concentration*, it was significantly decreased in some mutants such as mutants No.8, 3 and 6, increased in another such as mutants No.4, 7, 1 and 9, not affected in mutants No.10, 2 and 6 (Table, 6).

Concerning the *seed-Na conc.* in mutants, it can be observed that mutants No. 1, 2 and 3 only had higher seed-Na whereas the rest of mutants had lower one if compared with the untreated plants. It is worthy that mutants N0.1 and 2 induced by gamma radiation had the highest seed-Na conc., while the lowest one was recorded by mutant No.10 in both M5 and M6 generations (Table, 6).

The ratio of Na/*K* in seeds of mutants tended to increase in mutants No. 1, 2 and 3, but to decrease in other mutants. The highest Na/K ratio was found in mutant No.3, 2 and 1, whereas the lowest one was in mutant No.10. In this respect, Atia (1986) on field bean, reported a stimulative effect of gamma radiation on NPK contents, while Battah (1986), on fenugreek, noticed opposite effects of gamma rays on NPK contents. Also, Selim and Atia (1996a) on wheat and Hussein *et al.* (1995) on *Datura metel* came to similar results.

**4.2. Carbohydrates:**

As shown from data in Table (6), gamma rays and EMS agent at low levels significantly affected the concentration of total, soluble and non-soluble carbohydrates in faba bean seeds. It was found that seeds of all mutants (except mutant No.1) contained higher concentrations of total, soluble and non-soluble if compared with the untreated plants. In this respect. Nair and Abraham (1990 & 1992) found that sugar content in Yam bean was slightly lower, whereas starch content increased in the samples affected by EMS for 5 hrs than that in the control. Thiede *et al.* (1995) stated that carbohydrate was higher as a result of exposure the *Helianthus annus* plants to 40 Gy.

**4.3. Total protein:**

Data recorded in Table (6) indicate that irradiation doses of 30 and 60 Gy as well as 0.15% and 0.30% EMS caused marked changes in protein conc. of faba bean seeds. Mutants No.1 and 2 induced by gamma radiation as well as mutants No.4, 5, 6,7, 8 and 10 induced by EMS had higher seed protein conc. On the other hand, total protein in seeds of mutants No.9 and 3 was reduced. It can be noticed that mutants No.5, 4 and 7 can be considered mutants highly protein content. Similar results were mentioned by Leiva *et al.* (1988), who found that the protein conc. in *Phaseolus vulgaris* L. increased in M5 mutants yield. Also, Moustafa *et al.* (1989) on chickpea (M4) using gamma rays and EMS; Nair and Abraham (1990, 1992) on yam bean using EMS found that the total protein was enhanced in the samples of mutants.

The decline in protein concentration might be attributed to the depression in RNA synthesis as reported by Farid *et al.* (1995) and Selim And El-Bana (2001). Selim and Atia (1996b) found that treating wheat grains with irradiation doses of 5 and 10 kR significantly increased the concentrations of DNA, RNA total nucleic acids as well as total protein in leaves, doses over 10 Kr caused a gradually reduction its concentrations.

**4.4. Total free amino acids:**

Data illustrated in Table (6) declare that the concentration of total free amino acids (TFAA) differed in response to the exposed doses of gamma radiation and the conc. of EMS. It was found that mutants No.1 and 3 had lower TFAA, mutant No.4 has a similar one, whereas other mutants recorded higher TFAA conc. Naji *et al.* (1988) on broad bean; Moustafa *et al.* (1989) on chickpea; Ismaeil (1995) on faba been and Hooshmand and Klopfenstein (1995) on corn, wheat and soybeans came to similar results.

**4.5. C/N ratio:**

The C/N ratios in seed of mutants in both M5 and M6 generations showed lower values in 6 mutants (N0.1, 2, 4, 5, 7, 8), a slight increase in mutants No.6 and 10, a marked increase in mutants No.3 and 9 when compared with the control. The decrease in C/N ratios in the above induction mutants might be ascribed to the lower carbohydrates content and the higher protein content. The reverse was true in the mutants having higher C/N ratios.

Table (6): Some chemical aspects of seeds of induced faba bean mutants (M5 and M6 generations) by gamma radiation and EMS.

| Mut. No. | Treat. | N | P | K | Na | Na / K | Total Free Amino Acids (mg/g Dwt.) | Total Protein (mg/g Dwt.) | Carbohydrates (mg/g Dwt.) Total | Soluble | Non Soluble | C / N Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mineral nutrients (mg / g Dwt.) | | | | | | | | | | |
| | | **M5 Generation** | | | | | | | | | | |
| 1 | 30 Gy | 48.36 | 1.218 | 28.32 | 1.167 | 0.041 | 96.53 | 302.38 | 457.21 | 60.82 | 396.39 | 1.512 |
| 2 | 60 Gy | 48.86 | 1.450 | 25.76 | 1.167 | 0.045 | 143.10 | 305.38 | 517.20 | 80.33 | 436.87 | 1.694 |
| 3 | 0.15% EMS | 41.02 | 1.020 | 23.20 | 1.167 | 0.050 | 97.20 | 256.38 | 552.25 | 79.70 | 473.55 | 2.154 |
| 4 | 0.15% EMS | 55.48 | 1.404 | 39.60 | 0.500 | 0.013 | 123.53 | 346.75 | 530.10 | 96.11 | 433.99 | 1.529 |
| 5 | 0.15% EMS | 58.05 | 1.135 | 27.04 | 0.500 | 0.019 | 144.45 | 362.82 | 506.00 | 98.00 | 408.00 | 1.395 |
| 6 | 0.15% EMS | 47.13 | 1.518 | 24.48 | 0.333 | 0.014 | 222.08 | 294.56 | 586.40 | 82.33 | 504.07 | 1.991 |
| 7 | 0.30% EMS | 50.04 | 1.215 | 39.60 | 0.667 | 0.017 | 168.08 | 312.75 | 543.00 | 79.25 | 443.75 | 1.736 |
| 8 | 0.15% EMS | 49.49 | 1.279 | 21.92 | 0.500 | 0.023 | 210.60 | 309.31 | 551.75 | 76.31 | 475.44 | 1.784 |
| 9 | 0.15% EMS | 34.97 | 1.113 | 28.32 | 0.333 | 0.012 | 141.08 | 218.56 | 581.75 | 80.35 | 501.40 | 2.662 |
| 10 | 0.30% EMS | 44.18 | 1.110 | 25.76 | 0.167 | 0.007 | 249.08 | 276.13 | 551.10 | 63.90 | 487.20 | 1.996 |
| --- | Untreated (cont.) | 42.42 | 1.024 | 25.76 | 1.000 | 0.039 | 122.85 | 265.13 | 496.50 | 61.80 | 435.70 | 1.873 |
| | L.S.D. at 5% | 1.439 | 0.125 | 1.678 | 0.127 | 0.014 | 9.121 | 12.521 | 4.617 | 1.907 | 6.611 | 0.071 |
| | | **M6 Generation** | | | | | | | | | | |
| 1 | 30 Gy | 46.40 | 1.318 | 28.75 | 1.192 | 0.042 | 100.08 | 290.00 | 511.20 | 75.33 | 435.87 | 1.763 |
| 2 | 60 Gy | 47.81 | 1.490 | 27.50 | 1.200 | 0.044 | 153.53 | 298.81 | 520.20 | 81.10 | 439.10 | 1.741 |
| 3 | 0.15% EMS | 42.23 | 1.000 | 26.25 | 1.197 | 0.046 | 101.45 | 263.94 | 640.10 | 78.11 | 561.99 | 2.425 |
| 4 | 0.15% EMS | 57.45 | 1.514 | 39.38 | 0.500 | 0.013 | 143.45 | 359.06 | 550.25 | 99.70 | 450.55 | 1.533 |
| 5 | 0.15% EMS | 57.00 | 1.405 | 28.13 | 0.500 | 0.018 | 174.53 | 356.25 | 600.10 | 100.70 | 499.40 | 1.685 |
| 6 | 0.15% EMS | 45.34 | 1.430 | 26.88 | 0.500 | 0.019 | 250.08 | 283.38 | 590.60 | 86.31 | 504.29 | 2.084 |
| 7 | 0.30% EMS | 51.01 | 1.245 | 39.38 | 0.333 | 0.009 | 190.45 | 318.81 | 550.00 | 84.25 | 465.75 | 1.725 |
| 8 | 0.15% EMS | 47.45 | 1.370 | 25.63 | 0.500 | 0.020 | 235.08 | 296.56 | 555.10 | 85.33 | 469.77 | 1.872 |
| 9 | 0.15% EMS | 43.50 | 1.125 | 28.75 | 0.333 | 0.012 | 170.45 | 271.88 | 600.75 | 90.75 | 510.00 | 2.210 |
| 10 | 0.30% EMS | 43.28 | 1.125 | 27.50 | 0.167 | 0.006 | 280.08 | 270.50 | 560.25 | 83.67 | 476.58 | 2.072 |
| --- | Untreated (cont.) | 41.98 | 1.120 | 27.76 | 0.833 | 0.030 | 132.45 | 262.38 | 500.60 | 71.75 | 428.75 | 1.908 |
| | L.S.D. at 5% | 1.231 | 0.094 | 1.816 | 0.110 | 0.006 | 0.247 | 4.614 | 10.541 | 1.894 | 4.813 | 0.114 |

**5. Water use efficiency:**

Data recorded in Table (5) show that, mutant No.1 and 4 followed by No.2 and 8 (M5) or No.5, 2 and 8 (M6) gave the highest WUE for seed ($WUE_s$) recording an increase by about 127.4, 102.4, 83.5 and 53.1% (M5 generation); 81.3, 77.1, 57.8, 40.1 and 40.6% (M6 generation) over the control plants, respectively. That means that mutant No.1 is the best $WUE_s$ As for WUE for straw yield ($WUE_{st}$), it was observed that all mutants recorded an increase in it except mutant No. 10 in M5 and No.3, 9 and 10 slightly decreased. Mutants No.8, 4 in (M5), No. 1, 4 and 8 (M6) had the best $WUE_{st}$ if compared with the other mutants. Regarding the WUE for whole plant ($WUE_w$), mutants No. 4 and 1 followed by No. 8 and 2 in both M5 and M6 generations were the best $WUE_w$.

The increase in WUE in most mutants induced with low doses of gamma rays and low concentration of EMS may be attributed to the promotive effect on the efficiency of water uptake as well as its adverse effect on transpirational water loss and the increase in production of dry matter.

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# تأثير بعض المواد المطفرة على الصفات النباتية للفول البلدى

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عوملت بذور الفول البلدى صنف "جيزة٢" بجرعات من أشعة جاما (٣٠ و ٦٠ جراى) و تركيزات مختلفة من مادة الايثيل ميثان سلفونات (٠,١٥% و ٠,٣٠%) وباستخدام برنامج تربية تم الحصول على طفرات أختير منها عشر طفرات فى الجيل الطفرى الخامس والسادس لدراسة التغيرات التى أحدثتها هذه المواد فى صفات النمو الخضرى وبعض الصفات الفسيولوجية و التزهير و صفات المحصول وكذلك القيمة الغذائية لبذور نتاجهما مقارنة بالصنف الأصلى صنف "جيزة٢" . وقد أوضحت الدراسة مايلى:

جميع طفرات الفول المستحدثة باستخدام أشعة جاما ومادة الايثيل ميثان سلفونات تميل لأن تتفوق عن النبات الأصلى فى معظم صفات النمو وسجلت الطفرات ٧ و ٤ و ١٠ أعلى زيادة فى معظم صفات النمو. وعلى الجانب الآخر وجد أن الطفرة ١ تميل لأن تكون مماثلة للنبات الأصلى الغير معامل فى معظم صفات النمو.

تركيزات كلوروفيل "أ " و "ب" والكلور وفيلات الكلية وكذلك الكاروتنويدات تميل لأن تزيد فى أوراق جميع الطفرات (ماعدا الطفرة ٢) عن النباتات الغير معاملة، و كانت الطفرات ٧ و٨ و٩ و ١ هى الأعلى محتوى من الصبغات التمثيلية. ولم تظهر نسبة كلوروفيل أ/ب وكذلك الكلوروفيلات الكلية/الكاروتنويدات أى تغير ملموس فى معظم الطفرات المستحدثة.

أوراق جميع الطفرات باستثناء الطفرة ٤ (لمحتوى ا لماء الكلى) والطفرة ٨ (لكل من محتوى الماء النسبى ونقص الماء الورقى) كان محتوى المائى الكلى وكذلك محتوى الماء النسبى بها عاليا يقابله انخفاضا واضحا فى نقص الماء الورقى، وكانت الطفرة ١ هى الأعلى فى محتوى الماءالنسبى والأقل فى نقص الماء الورقى. كما انخفض معدل النتح الورقى فى الطفرات المستحدثه باستثناء بعض الطفرات فى نتاج الجيل الخامس، وسجلت الطفرة ٧ اقل معدل نتح.

كانت كفاءة استخدام الطفرات للماء فى إنتاج البذور والمادة الجافة أعلى بدرجة ملحوظة من كفاءة النبات الأصلى وكانت الطفرات ١ و٤ هى الأعلى كفاءة.

أظهرت الطفرات اتجاهات مختلفة بالنسبة لعدد الأزهار للنبات وكانت الطفرات ١ و٢ و٣ و٤ و٧ هى المنتجة لأكبر عدد من الأزهار مقارنة بالنبات الأصلى و بقية الطفرات. كما سجلت الطفرات المستحدثه زيادة فى نسبة العقد وانخفاضا فى نسبة تساقط الأزهار والقرون يفوق النبات الأصلى وكانت الطفرة ١ (فى الجيل الطفرى الخامس) والطفرة ٧ (فى الجيل الطفرى السادس) المسجلة لأعلى نسبة عقد وأقل نسبة تساقط للأزهار والقرون.

محصول القرون والبذور والقش للنبات يميل لأن يزيد فى معظم الطفرات وسجلت الطفرات ١ و٤ أعلى محصول للقرون والبذور فى حين سجلت الطفرة ٨ (فى الجيل الطفرى الخامس) والطفرة ١(فى الجيل الطفرى السادس) أعلى محصول للقش. كما لوحظ أن الطفرات ٤ و٥ و٢ و٨ (فى الجيل الطفرى الخامس) والطفرات ١ و٤ و٨ (فى الجيل الطفرى السادس) هى الأثقل فى وزن ١٠٠ بذرة (مدلول البذرة). كما سجلت الطفرات (باستثناء الطفرات ٣ و١٠) نسبة تصافى عالية.

المكونات الكيميائية لبذور طفرات الفول البلدى نتاج الجيلين الطفريين الخامس والسادس تشير إلى أن القيمة الغذائية لها (مع بعض الاستثناءات) تفوق النبات الأصلى. وجدير بالذكر أن الطفرات ٥ و٤ و٧ احتوت بذورها على أعلى نسبة بروتين كلى والطفرات ٦ و٩ على أعلى محتوى من المواد الكربوهيدراتية إذا ما قورنت ببقية الطفرات.

وعليه يمكن التوصية باستخدام بعض الطفرات اقتصاديا مثل الطفرات ٥ و٤ و٧ كمصدر للبروتين العالى، الطفرات ١ و٤ كطفرات لمحصول البذور العالى ، والطفرات٦ و٩ كطفرات بذورها عالية المحتوى الكربوهيدراتى ، والطفرات ٧ و٨ و٩ و ١ كطفرات عالية المحتوى من الصبغات التمثيلية.