STIMULATORY EFFECT OF GAMMA RAYS ON GROWTH, WATER RELATIONS, CHEMICAL COMPOSITION, FLOWERING, YIELD AND ITS QUALITY OF TWO OKRA CULTIVARS

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ABSTRACT: *Two field experiments were carried out at the Experimental Farm, Faculty of Agriculture, Minufiya University in 2007 and 2008 seasons. This work aimed to investigate the effect of low doses gamma radiation [0 (control), 5, 10, 15, 20 and 25 k. rad) as pre-sowing treatment on growth, some physiological characteristics, yield and its quality on okra cultivars (El-Balady and Punjab Podmini). Results showed that, low doses of gamma radiation up to 10 k. rad significantly increased root length, plant height, number of leaves and branches / plant, leaf area ratio, relative growth rate, net assimilation rate, relative water content, photosynthetic pigments, total sugars, total carbohydrates, total amino acids, N, P, K, protein % in fruits and yield, while high doses decreased its as compared to control plants. The reverse effect was obtained in leaf water deficit and total phenols. Data showed that the two cultivars differed significantly for all studied characters. Irradiation dose of 10 k. rad recorded the lowest values for flowering date. El-Balady cultivar gave significantly increase in all studied characters except protein % as compared to Punjab Podmini. Cultivar Punjab Podmini gave higher values for protein percentage in fruits. Interaction between irradiation and cultivars significantly improved of all studied characters at low doses of gamma rays. The best results for flowering date, number and weight of pods / plant were recorded with El-Balady cultivar at 5 and 10 k. rad. The best results for yield quality (protein and fibers % in fruits) recorded with Punjab Podmini cultivar at 5 k. rad.*

Key words: *Okra, radiation, net assimilation rate, total sugars, total amino acids, protein, fibers, yield and its quality.*

INTRODUCTION

Okra (*Abelmoschus esculentus* L. *Moench*) is an important fresh vegetable crop in spring and summer for cooking, also used as dry fruits for all year round cooking.

Gamma irradiation has long been known as a method of food preservation as described by Taub *et al.* (1976). Now, it is well known and established that gamma radiation are used as perfect tool to stimulate plant growth and flowering characters and to increase crops productivity as reported by

Shamsi and Sofajy (1980) and Mohamed (1989).

Many investigators studied the effect of gamma radiation on the chemical constituents of many plants. Variation in protein and amino acids contents, was reported by several investigators when pre-sowing seed irradiation was applied i.e., Maltsev and Kuzin (1974), El-Ghinbihi (1980) and Abo El-Seoud *et al.* (1991).

As increase in sugars and carbohydrates content were observed in plants induced from gamma irradiated seeds as reported by Chirilei *et al.* (1973).

The aim of the present investigation was planned to study the effect of gamma radiation as pre-sowing treatment on growth, some chemical constituents earliness (early flowering), as well as yield and its quality of two cultivars of okra were tested i.e., El-Balady and Punjab Podmini to improve the yield and its quality as well as earliness (early flowering) in okra which is an important objective in Egypt, thence increase in early maturity caused early yield to compensate the increasing consumption in this time of year.

MATERIALS AND METHODS

The present study was carried out on the summer seasons of 2007 and 2008 at the Experimental Farm, Faculty of Agriculture, Minufiya University to investigate the effect of pre-sowing gamma radiation on growth, yield and quality of two okra cultivars (El-Balady and Punjab Podmini) were obtained from Vegetable Seed Production Technology Dept., Hort. Res. Inst., Agric. Res. Center, Giza, Egypt.

Seeds of okra (*Abelmoschus esculentus* L. *Moench*) were irradiated with gamma rays with generated from the cobalt-60 source installed the atomic Energy Establishment at Inchas, A.R.E. and were exposed to different doses of gamma rays being 0 (control), 5, 10, 15, 20 and 25 kilo-rad (KR). The dose rate was 23.81 rad / second.

The experiment was designed as split plot where the radiation represented the main plots (A) and the cultivars of okra represented the sub plots (B) with three replicates was adopted each plot contained 5 rows each of 4.0 m length and 0.7 m width. Seeds of two cultivars viz, El-Balady and Punjab Padmini were planted in the field on March 8th of 2007 season and 15th 2008 season. Twelve plants were cultivated in each row. Standard cultural practices were employed throughout the two experimental seasons. Ammonium sulphate (20.5% N), superphosphate (15.5% P_2O_6) and potassium sulphate (48% K_2O), were added at the rates of 200, 300 and 100 kg/fed., respectively. Phosphatic fertilizer was applied during soil preparation. Nitrogen and potassium fertilizers were splitted for three equal parts and added through growing season. Ten plants were randomly chosen in each plot to determine the following characters:

1. Growth analysis:

Two samples were taken through the growth period at 75 and 90 days after sowing. At each sampling date, seven plants were taken randomly and separated to different parts and the following data were recorded : leaf area / plant, dry weight of plant organs and physiological parameters were calculated; leaf area ratio (LAR), relative growth rate (RGR) and net assimilation rate (NAR), following the formula proposed by Buttery and Buzzel (1974).

$$\text{LAR } (cm^2 / g \text{ dry weight}) = \frac{\text{Leaf area } (cm^2)}{\text{Dry weight of plant (g)}}$$

$$\text{RGR (mg / g / day)} = \frac{\log w_2 - \log w_1}{t_2 - t_1}$$

$$\text{NAR (mg / g / day)} = \frac{w_2 - w_1}{A_2 - A_1} \times \frac{(\log A_2 - \log A_1)}{t_2 - t_1}$$

Where; w_1, w_2 are the total dry weight per plant after 75 (t_1) and 90 (t_2) days from sowing, and A_1, A_2 are the leaf area per plant at t_1 and t_2, respectively. Also the following data were recorded at 90 days from sowing: root length, plant height, number of leaves and branches / plant.

2. Physiological and chemical analysis:

The following parameters were calculated from plant samples were collected at 90 days after sowing:

a) Water relations: Relative water content (RWC%) and leaf water deficit (LWD%) according the method described by Kalapos (1995).
b) Chlorophyll concentration was determined in fresh leaves by the method described by Witham *et al.* (1971).
c) Total soluble sugars (TSS) and total carbohydrates (TC) were determined in dry leaves using the phenol sulfuric acid method as described by Dubois *et al.* (1956).
d) Total free amino acids (TAA) were determined in dry leaves according to the method of Rosen (1957). Total phenols were determined in okra leaves a dry weight basis according to methods outlines by Snell and Snell (1953).
e) Mineral concentration were measured in dry leaves, nitrogen was measured using micro-kjeldahl method described by A.O.A.C. (1975), phosphorus was determined colourimetrically by method described by Snell and Snell (1954). Potassium was measured using flamephotometer method described by Chapman and Pratt (1961).

3. Flowering date, yield and its components:

Number of days from planting to the first flower anthesis, it was counted as the mean of 15 plants per replicate. Harvesting period began from mid May and continued to mid-Sept., pods were picked with their pedicels in the morning every three days then studied early pods yield (number and weight/plant) in the first 21 days of harvesting and total edible pods yield (g / plant), it was calculated by the total edible weight of pods during the for 4 months throughout the okra harvesting season.

4. Yield and its quality:

a) Carbohydrates in dry fruits using the methods described by Dubois *et al.* (1956).
b) Protein percentage were determined in okra fruit on a dry weight basis according to methods outlined by A.O.A.C (1975).
c) Percentage of crude fibers in fruits (g / 100 g): Crude fibers were determined in fruit on dry weight basis according to methods according to A.O.A.C (1960).

All obtained data were statistically analyzed and (L.S.D) were estimated according to Snedecor and Cochran (1972).

RESULTS AND DISCUSSION

1. Growth analysis:

Results in Table (1) indicate that irradiation doses of 5 and 10 k. rad increased significantly plant height, number of leaves and branches per plant for cultivar El-Balady while 5 k. rad recorded the highest values for Punjab Podmini cultivar in both seasons. Moreover, increasing doses of gamma radiation progressively decreased these parameters. Also, data showed that root length significantly affected of the irradiated seeds in two cultivars as compared to unirradiated seeds.

The results obtained (Table 2) showed that gamma radiation at the doses of 15 to 25 k. rad caused a highly significant reduction in leaf area ratio (LAR), relative growth rate (RGR) and net assimilation rate (NAR) meanwhile low doses of 5 and 10 k. rad caused a significant increase in these parameters in both seasons. The stimulation of plant growth by low doses of radiation may be due to the effect of irradiation on the auxin balance as supported by the findings of Sax (1963) and Gordon *et al.* (1965). Moreover, the highest reduction in plant height resulting from irradiated with gamma rays at high doses was due either to retarding effects of radiation on cell division and or cell elongation (Mujeeb and Greig, 1976). These results are in good line with those reported by Matter (1997), Youssef and Moussa (1998) and Naguib *et al.* (2007). In addition Jamie (2002) and Norfadzrin *et al.* (2007) reported that, plant height, shoot dry weights of tomato and okra decreased with increasing dose of gamma rays.

Table (1). Effect of gamma radiation on some growth parameters of okra cultivars during 2007 and 2008 seasons.

Character / Treatment		Root length (cm)			Plant height (cm)			Number of leaves / plant			Number of branches / plant		
		Bala.	Punj.	Mean	Bala.	Punj.	Mean	Bala.	Punj.	Mean	Bala.	Punj.	Mean
Season 2007													
Gamma irradiation (k. rad)	0	30.00	26.00	28.00	75.33	64.00	69.66	15.00	14.33	14.66	1.67	1.33	1.50
	5	35.00	28.33	31.66	99.67	74.00	86.83	19.33	16.33	17.83	2.33	1.67	2.00
	10	32.00	25.67	28.83	88.00	63.67	75.83	17.00	13.00	15.00	2.00	1.33	1.66
	15	27.00	24.00	25.50	74.00	61.33	67.66	14.33	12.67	13.50	1.67	1.00	1.33
	20	25.67	23.33	24.50	71.33	58.33	64.83	12.33	11.00	11.66	1.33	1.00	1.66
	25	24.33	20.33	22.33	70.00	55.33	62.66	10.33	10.00	10.66	1.00	1.00	1.00
Mean		29.00	24.61		79.72	62.77		14.72	12.88		1.67	1.22	
L.S.D 5%		A=1.84 B=3.72 AB=4.01			A=0.57 B=3.89 AB=4.19			A=0.24 B=2.01 AB=2.17			A=0.14 B=0.87 AB=0.94		
Season 2008													
Gamma irradiation (k. rad)	0	26.67	24.33	25.50	77.67	68.33	73.00	16.33	11.67	14.00	2.00	1.67	1.83
	5	29.33	26.67	28.00	85.33	76.00	80.66	18.33	15.33	16.83	3.00	2.00	2.50
	10	28.67	23.00	25.83	80.00	65.67	72.83	17.67	12.00	14.83	2.33	1.67	2.00
	15	25.00	22.33	23.66	63.00	59.00	61.00	13.00	10.67	11.83	1.67	1.33	1.50
	20	24.33	21.00	22.66	61.00	56.67	58.33	12.67	10.00	11.33	1.33	1.00	1.16
	25	22.00	19.00	20.50	58.00	52.00	55.00	12.00	9.33	10.67	1.00	1.00	1.00
Mean		26.00	22.72		70.83	62.94		15.00	11.50		1.88	1.44	
L.S.D 5%		A=2.60 B=2.69 AB=2.90			A=2.23 B=3.55 AB=3.83			A=0.90 B=2.11 AB=2.28			A=0.38 B=0.95 AB=1.02		

Table (2). Effect of gamma radiation on leaf area ratio (LAR), relative growth rate (RGR), net assimilation rate (NAR), relative water, content (RWC) and leaf water deficit (LWD) of okra cultivars during 2007 and 2008 seasons.

Characters / Treatments		LAR (cm^2/g dt.w)			RGR (mg/g day)			NAR (mg/g week)			RWC %			LWD %		
		Bala.	Punj.	Mean	Bala.	Punj.	Mean	Bala.	Punj.	Mean	Bala.	Punj.	Mean	Bala.	Punj.	Mean
Season 2007																
Gamma irradiation (k. rad)	0	20.92	18.88	19.90	0.025	0.036	0.031	0.030	0.018	0.024	78.30	77.67	77.98	21.70	22.33	22.01
	5	24.20	22.82	23.51	0.029	0.049	0.035	0.060	0.022	0.041	81.10	80.00	80.55	18.90	20.00	19.45
	10	21.09	18.12	19.60	0.028	0.033	0.031	0.057	0.015	0.036	79.13	76.24	77.68	20.87	23.76	22.31
	15	17.62	17.96	17.79	0.023	0.029	0.026	0.026	0.014	0.020	75.61	73.40	74.50	24.39	26.60	25.49
	20	16.70	17.90	16.80	0.021	0.027	0.024	0.019	0.012	0015	73.60	72.03	82.81	26.40	27.97	27.18
	25	14.99	17.19	16.09	0.016	0.024	0.020	0.010	0.010	0.010	70.82	70.11	70.46	29.18	29.89	29.53
Mean		19.26	18.64		0.024	0.033		0.034	0.015		76.43	74.90		23.57	25.09	
L.S.D 5%		A=0.56 B=1.17 AB=1.27			A=0.001 B=0.004 AB=0.005			A=0.003 B=0.013 AB=0.014			A=0.16 B=2.10 AB=2.26			A=0.16 B=2.10 AB=2.26		
Season 2008																
Gamma irradiation (k. rad)	0	21.58	20.33	20.96	0.021	0.035	0.018	0.023	0.013	0.018	78.85	76.11	77.48	21.15	23.89	22.52
	5	24.12	21.08	22.60	0.024	0.038	0.026	0.036	0.017	0.026	81.35	79.50	80.42	18.65	20.50	19.56
	10	23.10	19.50	21.30	0.023	0.031	0.020	0.028	0.012	0.020	79.80	75.33	77.56	20.20	24.67	22.43
	15	20.98	19.13	20.05	0.019	0.029	0.016	0.021	0.011	0.016	74.08	74.02	74.05	25.92	25.98	25.95
	20	20.53	18.22	19.37	0.015	0.028	0.012	0.015	0.010	0.012	73.02	72.43	72.72	26.98	27.58	27.27
	25	19.61	17.40	18.52	0.010	0.027	0.011	0.013	0.009	0.011	72.00	71.33	71.66	28.00	28.67	28.33
Mean		21.66	19.27		0.02	0.03		0.02	0.01		76.52	74.78		23.48	25.20	
L.S.D 5%		A=0.32 B=0.79 AB=0.85			A=0.002 B=0.002 AB=0.002			A=0.001 B=0.004 AB=0.004			A=1.17 B=2.13 AB=2.30			A=1.19 B=2.13 AB=2.30		

On the other hand, using irradiation doses significantly affected with two cultivars of okra plants in both seasons. In this connection, cultivar El-Balady recorded the highest values in all growth parameters under the lower levels

of irradiation. The differences in previously mentioned results could be, generally, related to the differences in tolerance among species. The tolerance and sensitivity is known to be genetically controlled characters. Moreover, the sensitivity of a particular species could be altered by changing the environment, such as the moisture content of seeds, when exposed to radiation (Azer, 2001).

Significant differences in all growth parameters were noticed due to the interaction among radiation treatments and okra cultivars. Cultivar El-Balady was surpassed cultivar Punjab Podmini in both seasons.

2. Physiological and chemical analysis:

a. Water relations:

In both seasons, results in Table (2) clearly revealed that irradiation treatments significantly affected relative water content (RWC) and leaf water deficit (LWD). The highest values of RWC and the lowest values of LWD were obtained at low dose of gamma irradiation (5 k. rad). This may owe to the stimulate effect by low doses of radiation on the auxin balance as supported by Sax (1963).

The results in the same table indicated that, there were marked differences between the okra cultivars in its RWC and LWD. Generally, El-Balady gave the highest values of RWC and the lowest values of LWD in both seasons.

Significant differences in RWC and LWD were noticed due to the interaction among radiation treatments and okra cultivars in both seasons. Cultivar El-Balady showed the best results.

b. Photosynthetic pigments:

Data given in Table (3) indicated that, chlorophyll a + b and carotenoids concentrations were decreased by all doses of gamma radiation except for 5 and 10 k. rad treatments which increased its as compared with control in both seasons. Similar results were observed by El-Ghinbihi (1980) and Naguib *et al.* (2007), who reported that, gamma irradiation might induce an inhibiting effect on photosynthetic pigments formation.

Data listed in Table (3) showed that, photosynthetic pigments were significantly affected by type of cultivars in the two seasons. Cultivar El-Balady gave the highest values as compared with variety Punjab Podmini especially at 10 k.rad treatment. In this respect Khalil *et al.* (1986) found that, differential sensitivities of barley cultivars to gamma radiation.

The data given in the previous table revealed also that, the interaction between cultivars and irradiation treatments significantly affected on photosynthetic pigments in both seasons.

c. Total sugars and total carbohydrates:

Data given in Table (3) showed a significant increase in total sugars (TS) and total carbohydrates (TC) of okra plants grown from seeds irradiated at 5 and 10 k. rad gamma rays for cultivar El-Balady while at 5 k. rad for cultivar Punjab Podmini. Higher doses of gamma rays adversely affected in the two experimental seasons when compared with the control. These results are in agreement with those obtained by Frank and Lendvi (1971) and El-sherbeny *et al.* (1992) who stated that, the reduction in TS and TC of pea plants as a result of increasing gamma radiation might be simply considered a continuation deleterious effects of irradiation on growth and development of plants.

Table (3). Effect of gamma radiation on photosynthetic pigments total sugars, total carbohydrates and total amino acids of okra cultivars during 2007 and 2008 seasons.

Character / Treatment		Chlorophyll a + b (mg/g d.w)			Carotenoids (mg/g d.w)			Total amino acids (mg/g d.w)			Total sugars (mg/g d.w)			Total carbohydrates (mg/g d.w)		
		Bala.	Punj.	Mean	Bala.	Punj.	Mean	Bala.	Punj.	Mean	Bala.	Punj.	Mean	Bala.	Punj.	Mean
Season 2007																
Gamma irradiation (k. rad)	0	3.75	3.79	3.77	1.81	1.75	1.78	3.17	3.05	3.11	17.85	16.80	17.32	108.33	88.66	98.49
	5	5.59	4.19	4.89	2.57	1.95	2.26	5.88	4.39	5.13	21.07	18.59	19.83	135.30	96.05	115.63
	10	4.00	2.65	3.32	2.17	1.24	1.70	4.68	2.71	3.69	19.26	12.82	16.04	129.15	76.52	102.83
	15	3.05	2.44	2.74	1.45	1.12	1.28	3.10	2.63	2.86	14.56	11.74	13.20	114.10	71.17	92.64
	20	2.85	2.35	2.60	1.35	1.08	1.21	2.92	2.47	2.69	12.62	10.56	11.59	101.06	68.65	84.85
	25	2.09	1.72	1.90	0.99	0.85	0.92	2.36	2.04	2.20	10.02	8.44	9.23	86.05	52.51	69.28
Mean		3.55	2.85		1.72	1.33		3.68	2.88		15.89	13.17		112.33	75.59	
L.S.D 5%		A=0.07 B=0.36 AB=0.39			A=0.13 B=0.27 AB=0.29			A=0.54 B=0.41 AB=0.44			A=0.88 B=2.38 AB=2.55			A=5.48 B=8.23 AB=8.88		
Season 2008																
Gamma irradiation (k. rad)	0	3.52	2.75	3.13	1.62	1.73	1.67	4.05	3.45	3.53	19.31	15.40	17.35	103.05	95.40	99.22
	5	4.65	3.26	3.96	2.95	2.43	2.69	5.71	5.01	5.36	23.30	19.10	21.20	140.49	123.31	131.90
	10	4.14	2.60	3.37	2.31	1.41	1.86	4.33	2.61	3.47	20.10	13.10	16.60	127.50	86.65	107.07
	15	3.43	2.51	2.97	1.55	1.36	1.45	3.65	2.01	2.83	15.40	12.70	14.05	89.21	77.29	83.25
	20	3.15	2.40	2.77	1.40	1.21	1.30	3.05	2.11	2.58	13.30	11.67	12.48	78.19	71.18	74.85
	25	2.77	2.27	2.52	1.24	0.96	1.10	2.85	1.85	2.35	10.31	8.90	9.60	70.85	65.65	68.25
Mean		3.61	2.63		1.84	1.51		3.94	2.76		16.95	13.47		101.55	86.58	
L.S.D 5%		A=0.01 B=0.36 AB=0.39			A=0.10 B=0.28 AB=0.30			A=0.15 B=0.33 AB=0.35			A=1.99 B=1.36 AB=1.45			A=5.16 B=5.66 AB=6.11		

d. Total free amino acids and total phenols:

Data presented in Table (3 and 4) cleared that, irradiation doses of 5 and 10 k. rad increased of total free amino acids (TAA) of okra leaves, whereas application of high levels (15 – 25 k. rad) for cv. Balady and 10 – 25 k. rad for cv. Punjab Podmini) decreased its content compared with control. The higher content of TAA was obtained by dose of 5 k. rad in both seasons. On the other hand, radiation doses had a gradual promotion effect of total phenols percentage of okra leaves. The maximum values were found with exposing plants to 25 k. rad gamma irradiation (high dose) which reached 21.56 and 31.45% in the first and second seasons, respectively over the control. Similar results obtained by Maltsev and Ruzin (1974) on *Vicia faba* and *Trifloum pratense*, Hammam (1992) on sunflower, Moldovan and Hodisan (2004) on *Tagetes patula* and Naguib *et al.* (2007) on *Tagetes erecta*.

The data in both seasons showed that, cultivars exerted a highly significant influence on TAA and total phenols concentrations. It is clear that, El-Balady cultivar was superior compared with Punjab Podmini cultivar.

Concerning effect of radiation doses and cultivars, results indicated that, these treatments caused a marked increase in TAA and total phenols in both seasons. The highest mean values of TAA and total phenols which obtained with cv. Balady with the lowest gamma for TAA and were obtained with the highest gamma dose (25 k. rad) for total phenols.

e. Mineral concentration:

Data presented in Table (4) showed that, there was a significant increase in the nitrogen (N), phosphorus (p) and potassium (K) concentrations in okra leaves by decreasing gamma-ray doses, while high doses were decreased its as compared with control plants in both seasons. On the other hand, the high doses of gamma irradiation, particularly 20 and 25 k. rad significantly decreased N, P and K content in leaves. The obtained data were in line with those obtained by El-Ghinbihi (1980). The increase in mineral concentration may be attributed to the increase in root length.

Data in the same table clearly revealed that, the two cultivars differed significantly regarding its concentration of N, P and K in both seasons. However, the highest values were produced by El-Balady cultivar as compared to Punjab Podmini.

Significant differences in the concentrations of N, P and K were noticed due to the interaction between irradiation and cultivars. The highest values of N, P and K uptake were noticed in cv. El-Balady irradiated at dose 5 k. rad.

Table (4). Effect of gamma radiation on total phenols and minerals concentrations in leaves of okra cultivars during 2007 and 2008 seasons.

Character / Treatment		Total phenols (mg caticol / 100 g d.w)			% N			% P			% K		
		Bala.	Punj.	Mean	Bala.	Punj.	Mean	Bala.	Punj.	Mean	Bala.	Punj.	Mean
Season 2007													
Gamma irradiation (k. rad)	0	16.80	15.30	16.05	3.18	3.01	3.09	0.33	0.29	0.31	2.01	1.88	1.94
	5	17.80	15.90	16.85	4.05	3.75	3.90	0.57	0.44	0.50	2.46	2.33	2.39
	10	18.00	16.20	17.10	3.92	2.66	3.29	0.48	0.27	0.37	2.15	1.80	1.97
	15	18.60	16.50	17.55	2.95	2.47	2.71	0.30	0.25	0.27	1.95	1.62	1.78
	20	18.91	17.80	18.36	2.74	2.30	2.52	0.28	0.21	0.24	1.70	1.17	1.43
	25	20.10	18.60	19.35	2.57	2.10	2.33	0.25	0.18	0.21	1.15	0.91	1.03
Mean		18.37	16.72		3.23	2.71		0.36	0.27		1.90	1.61	
L.S.D 5%		A=0.06	B=0.48	AB=0.52	A=0.55	B=0.47	AB=0.51	A=0.01	B=0.04	AB=0.04	A=0.12	B=0.17	AB=0.1
Season 2008													
Gamma irradiation (k. rad)	0	15.10	14.60	14.85	2.95	2.38	2.66	0.41	0.32	0.36	3.00	2.03	2.51
	5	16.90	15.00	15.96	4.11	3.91	4.01	0.55	0.50	0.52	4.05	2.67	3.36
	10	17.60	16.80	17.20	3.82	2.21	3.01	0.47	0.30	0.38	3.65	1.75	2.70
	15	18.20	17.10	17.65	2.71	2.07	2.39	0.35	0.27	0.31	2.05	1.48	1.76
	20	19.05	18.10	18.58	2.51	1.95	2.22	0.30	0.23	0.26	1.88	1.30	1.59
	25	19.85	19.01	19.43	2.41	1.80	2.10	0.29	0.20	0.24	1.32	1.11	1.21
Mean		17.78	16.77		3.08	2.38		0.39	0.30		2.66	1.72	
L.S.D 5%		A=0.10	B=0.30	AB=0.33	A=0.28	B=0.42	AB=0.46	A=0.01	B=0.03	AB=0.04	A=0.05	B=0.21	AB=0.2

3. Flowering date, yield and its components:

Data reported in Table (5) clearly showed that, there were a significant increase in number and weight of pods of early yield as well as weight of pods of total yield of okra plants grown from seeds irradiated with 5 and 10 k. rad gamma-rays, while recorded a lowest number of days to the first appearance of flower (flowering date) in both seasons. It was clearly noticed that, a progressive depression in these respects except flowering date were correlated with increasing doses of gamma rays.

Table (5). Effect of gamma radiation on flowering, yield and its components of okra cultivars during 2007 and 2008 seasons.

Character / Treatment		Number of days to flowering			Number of pods for early yield/plant			Weight of pods for early yield (g/plant)			Weight of pods for total yield (g/plant)		
		Bala.	Punj.	Mean	Bala.	Punj.	Mean	Bala.	Punj.	Mean	Bala.	Punj.	Mean
Season 2007													
Gamma irradiation (k. rad)	0	32.17	38.60	35.24	21.67	16.37	19.01	140.38	104.80	122.59	525.47	410.66	468.06
	5	29.04	34.37	31.70	22.33	17.78	20.05	141.13	110.07	125.60	536.52	421.52	479.02
	10	29.08	34.40	31.79	22.87	18.19	20.53	141.10	110.08	125.59	539.68	409.10	474.39
	15	30.09	34.80	32.44	21.13	14.77	17.95	140.39	108.16	124.27	522.42	406.77	464.59
	20	32.08	36.32	34.20	19.16	14.50	16.83	139.87	104.80	122.33	521.33	402.90	462.11
	25	32.16	37.99	35.05	19.14	14.30	16.72	139.86	102.60	121.23	520.80	402.53	461.66
Mean		30.77	30.02		21.05	17.09		140.46	106.75		527.70	408.91	
L.S.D 5%		A=0.10 B=0.47 AB=0.51			A=0.53 B=0.82 AB=0.89			A=0.26 B=0.71 AB=0.76			A=1.86 B=1.49 AB=1.61		
Season 2008													
Gamma irradiation (k. rad)	0	33.66	38.19	34.93	32.80	23.37	28.08	140.31	109.80	125.06	528.33	415.20	471.76
	5	29.14	34.30	31.72	33.21	24.50	28.85	141.33	110.68	126.00	544.57	430.21	487.39
	10	29.16	34.50	31.80	33.23	24.46	28.84	141.42	110.76	126.09	547.56	413.28	480.42
	15	30.13	34.77	32.45	32.33	24.32	28.32	141.33	110.53	125.93	525.76	410.47	468.11
	20	32.20	36.37	34.28	31.67	22.78	27.22	140.76	104.72	122.74	525.42	402.72	464.07
	25	32.33	37.78	35.06	23.87	21.52	22.69	139.42	103.78	121.60	521.63	402.45	462.02
Mean		30.77	35.98		32.68	22.07		140.76	108.38		532.21	402.45	
L.S.D 5%		A=0.03 B=0.26 AB=0.28			A=0.13 B=0.44 AB=0.47			A=0.30 B=0.90 AB=0.97			A=1.10 B=1.60 AB=1.73		

The positive effect of low doses of gamma rays may be due its improving the biosynthesis of okra plants and translocation of the photosynthetic assimilates carbohydrates from vegetative parts to fruits. These results are agreement with these obtained by El-Sherbeny *et al.* (1997) and Sobieh (1999). In this connection Naguib *et al.* (2007) reported that, irradiated seeds of *Tagetes erecta* L. with 6 k. rad of gamma-rays increased flower yield per plant and attributed this to the increase in the number of flowers and pods / plant.

Results shown in the same table indicated that the type of okra cultivars significantly affected flowering date, number and weight of pods for early yield as well as total yield in both seasons. However, the highest values of total yield were increased about 31.15 and 32.49% were produced by El-

Balady cultivar as compared to Punjab Podmini cultivar in the first and second seasons respectively. Similar results obtained by Langaroodi and Kazarani (2000) who reported that, okra cultivars differ significantly in their growth, yield and its components.

Also, the interaction between irradiation and cultivars on flowering date, yield and its quality was highly significant in both seasons. The best results were noticed in cultivar El-Balady after irradiation with 5 and 10 k. rad of gamma-rays.

4. Fruit quality:

a. Total carbohydrates:

Data presented in Table (6) showed that, irradiated plants with gamma doses up to 10 k. rad stimulated the carbohydrates content in fruits, while the higher doses prohibited carbohydrates accumulation. Similar results reported by Sakr (1992). The increase in total carbohydrates may be due to the enhancement of photosynthetic pigments which increases photosynthesis.

The data in both seasons revealed that, cultivars exerted a highly significant influence on TC in fruits which El-Balady was superior as compared with Punjab Podmini.

Regarding the interaction between irradiated plants and cultivars, results show clearly that the highest values of TC were obtained from cultivar El-Balady with the application of 5 K. rad of gamma rays.

b. Protein percentage:

Data percentage in Table (6) demonstrate that irradiation doses of 5 and 10 k. rad increased protein percentage in okra fruits while 15, 20 and 25 k. rad decreased it compared with control. The highest content was obtained by dose of 5 k. rad for cultivar Punjab Podmini in both seasons. Such protein reduction was probably due to radiation induced protein denaturation as states by Chow and Subha (1986).

Significant differences in the concentration of protein in okra fruits due cultivars. In this respect, the cultivar Punjab Podmini showed superiority over El-Balady under all doses of gamma irradiation in both seasons.

As regards the interaction of gamma irradiation doses cultivars, it was highly significant for the concentration of protein in okra fruits.

c. Percentage of crude fibers:

Results in Table (6) indicate that with increasing doses of gamma radiation, there was progressively decreased percentage of crude fibers in the two experimental seasons. The lowest values (8.13 and 9.65%) were reported at the dose of 25 k. rad in the first and second seasons, respectively, while the control gave the highest record.

Table (6). Effect of gamma radiation on fruit quality of two okra cultivars during 2007 and 2008 seasons.

Character / Treatment		Total carbohydrates (mg/g d.w)			% Protein			% Crude fiber		
		Bala.	Punj.	Mean	Bala.	Punj.	Mean	Bala.	Punj.	Mean
2007 season										
Gamma irradiation (k. rad)	0	93.50	69.30	81.40	16.30	17.41	15.85	17.90	13.23	15.57
	5	105.20	86.00	95.60	20.52	23.87	22.19	16.33	10.77	13.55
	10	100.40	74.20	87.30	15.10	21.55	18.32	13.50	9.65	11.58
	15	97.80	63.00	80.40	14.05	16.01	15.03	13.40	9.10	11.25
	20	90.40	61.13	75.77	12.30	15.30	13.80	13.00	8.65	10.83
	25	88.30	55.30	71.80	11.44	13.25	12.34	12.21	8.13	10.17
Mean		95.93	68.16		14.95	17.90		14.39	9.92	
L.S.D 5%		A=0.34 B=0.51 AB=0.54			A=0.41 B=1.79 AB=1.93			A=1.27 B=2.02 AB=2.18		
2008 season										
Gamma irradiation (k. rad)	0	90.10	77.50	83.80	15.82	18.52	17.17	17.17	15.35	16.26
	5	106.30	85.50	95.90	21.42	22.31	21.86	15.80	13.60	14.70
	10	100.00	73.07	86.53	13.75	20.75	17.25	15.10	12.80	13.95
	15	95.50	70.50	83.00	12.48	15.82	14.15	14.24	11.48	12.86
	20	86.30	68.00	77.15	11.65	14.82	13.23	13.50	10.37	11.94
	25	84.00	63.50	73.75	10.45	13.31	11.88	12.07	9.65	10.86
Mean		93.70	73.01		14.26	17.59		14.65	12.21	
L.S.D 5%		A=0.42 B=0.58 AB=0.63			A=1.72 B=2.36 AB=2.54			A=0.21 B=0.24 AB=0.25		

Data collected in the same table clearly revealed that, the tested two cultivars significantly differed regarding this trait in both seasons. In this connection, the cultivar Punjab Podmini showed superiority over El-Balady.

The interaction between various doses of gamma irradiation and cultivars was significantly affect in the percentage of crude fibers in okra fruits in both seasons.

Therefore, it can be recommended that, irradiation of okra seeds with gamma rays at low doses stimulation growth, water relations, some physiological and chemical aspects, earliness (early flower) as well as yield and its quality of okra cultivars. El-Balady cultivar showed better performance than Punjab Podmini cultivar for most studied characters. Cultivar Punjab Podmini gave higher values for protein percentage and the

lower values for the percentage of fibers in fruits compared to El-Balady cultivar.

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التأثير المنشط لأشعة جاما على النمو والعلاقات المائية والتركيب الكيماوى والتزهير والمحصول وجودته فى صنفين من الباميا

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الملخص العربى

أجريت تجربتان حقليتان فى المزرعة التجريبية لكلية الزراعة جامعة المنوفية خلال موسمى ٢٠٠٧ ، ٢٠٠٨ وذلك لدراسة تأثير الجرعات المنخفضة من أشعة جاما قبل الزراعة (صفر "كنترول" ، ٥ ، ١٠ ، ١٥ ، ٢٠ ، ٢٥ كيلوراد) على النمو التأثيرات الفسيولوجية والمحصول وجودته الصنفين من الباميا (البلدى ، بانجاب بودمينى) وأشارت النتائج المتحصل عليها إلى حدوث زيادة معنوية فى طول الجذر والنبات وعدد الأوراق والأفرع / نبات ومساحة الأوراق النسبية ومعدل النمو الأمثل وكذلك معدل التمثيل النهائى ومحتوى الماء النسبى وصبغات التمثيل الضوئى والسكريات والكربوهيدرات الكلية والأحماض الأمينية الكلية ، % للبروتين فى الثمار والمحصول مع الجرعات المنخفضة من أشعة جاما حتى ١٠ كيلوراد ، بينما نقصت معنوياً تلك الصفات مع الجرعات العالية مقارنةً بنباتات الكنترول وحدث العكس مع نقص الماء فى الورقة والفينولات الكلية .

وكانت أهم النتائج المتحصل عليها كالتالى :

- أشارت النتائج فى حدوث اختلافاً معنوياً لجميع الصفات المدونة لصنفى الباميا .
- أدت معاملات الإشعاع عند ١٠ كيلوراد إلى التبكير فى التزهير .
- أعطى الصنف البلدى زيادة معنوية فى جميع الصفات المدروسة فيما عدا % للبروتين فى الثمار مقارنةً بالصنف بانجاب بودمينى .
- أعطى الصنف بانجاب أعلى القيم للنسبة المئوية للبروتين فى الثمار (جودة الثمار) .
- التفاعل بين الإشعاع والأصناف قد حسّن معنوياً جميع الصفات المدروسة عند الجرعات المنخفضة من أشعة جاما .
- أفضل النتائج فيما يتعلق بميعاد التزهير ، عدد ووزن القرون للنبات قد سُجل للصنف البلدى عند ٥ ، ١٠ كيلوراد .
- أفضل النتائج فيما يتعلق بجودة المحصول (% للبروتين والألياف فى الثمار) قد سجل للصنف بانجاب بودمينى عند ٥ كيلوراد .