Journal of Horticulture and Forestry Vol. 2(3) pp. 038-051, March, 2010
Available online http://www.academicjournals.org/jhf
ISSN 2006-9782 © 2010 Academic Journals

Full Length Research Paper

The effect of gamma irradiation on enhancement of growth and seed yield of okra [*Abelmoschus esculentus* (L.) Monech] and associated molecular changes

A. Z. Hegazi[1]* and N. Hamideldin[2]

[1]Horticulture Research Institute, Agriculture Research Center, Giza, Egypt.
[2]Natural Product Department, National Center for Radiation Research and Technology, NCRRT. Atomic Energy Authority P. O. Box 29, Nasr City, Cairo, Egypt.

Accepted 23 December, 2009

This investigation was carried out to study the effect of different gamma irradiation doses and water soaking on okra [*Abelmoschus esculentus* (L.) Moench- Malvaceae] seeds of two varieties (Sabahia and Balady). Both varieties showed similar trends in response to different treatments. Gamma irradiation at 400 Gy was superior for both varieties in growth criteria enhancement, photosynthetic pigment contents, seed yield and seed quality. The results also showed that 300 Gy had positive effects with respect to all studied growth parameters. Seeds irradiated with either 500 Gy or soaked in water (hydropriming) for 12 h before planting showed lower effects than other treatments but still greater than the control (direct dry seed sowing). Soaking in water or application of gamma irradiation induced changes in the number of protein bands in the two varieties, but high doses of gamma irradiation (400 and 500 Gy) caused highest changes. The variation in DNA profile in responses to gamma irradiation treatments was detected by RAPD-PCR technique. In variety Sabahia, the percentage of polymorphism was 47.37%, but in variety Balady it was 50%. The relatively high doses of gamma irradiation (400 and 500 Gy) induced more changes in genomic DNA pattern than the low dose (300 Gy).

Key words: Okra, gamma irradiation, hydropriming, protein patterns, RAPD-PCR.

INTRODUCTION

Okra is a multipurpose vegetable crop low in calories and is a good source of many nutrients including vitamins B and C, fiber, calcium, and folic acid. The pods are variable in colors (white, red, green and purple). Gamma irradiation was found to increase plant productivity. In this connection, Jaywardena and Peiris (1988) stated that gamma rays represent one of the important physical agents used to improve the characters and productivity of many plants (e.g. rice, maize, bean, cowpea and potato). Also Gamma irradiation has been found to be very useful for both sterilization and for preservation of food and cereal grain in nutrition and agriculture (Mokobia and Anomohanran, 2005). Results of experiments conducted in New Delhi, India by Sharma and Rana (2007) revealed that the productivity and economic returns from castor cultivation could be enhanced through adoption of suitable cultivar and level of gamma radiation. On the other hand, high dose of gamma ray, applied to the seeds before sowing, had adverse effect on traits of plants under investigation. This depended on plant species or varieties and the dose of irradiation. In faba bean, Artk and Peksen (2006) found a reduction in seed yield and harvest index in some varieties and also stated that, 25 and 50 Gy gamma radiation varied from the control treatment in many of the studied variables.

Gamma rays were also found to cause modulation in protein patterns by inducing appearance and/or disappearance of some protein bands. This conclusion was attained by Rashed et al. (1994). Yoko et al. (1996) studied the effect of gamma irradiation on the genomic DNA of corn, soybeans and wheat. They concluded that, large DNA strands were broken into small strands at low irra-

*Corresponding author. E-mail: amalhegazi2000@yahoo.com.

diation dose but small and large DNA strands were broken at higher irradiation doses. The RAPD method was also used by Raisheed et al. (2001) to detect the genetic variation induced by gamma rays. Radiation by gamma rays leads to increasing the level of DNA break formation. These different types of DNA damages could be detected by changes in RAPD profiles (Senthamizh et al., 2008).

Another technique such as hydroprimming (presoaking seeds in water so that germination processes begin, but radicle emergence does not occur) is efficient in enhancing seedling establishment and hence increase crop yield. Therefore, Basra et al. (2005) investigated the effects of pre-sowing seed treatments on the germination, emergence and seedling establishment of wheat and had positive results. Also, Farooq et al. (2008) conducted a study to explore the possibility of improving late sown wheat performance by seed priming techniques. Seed priming strategies were: on-farm seed priming, (hydro-priming) for 24 h, seed hardening for 12 h and osmohardening with KCl or $CaCl_2$ for 12 h. Seed priming improved emergence, stand establishment, tiller numbers, allometry, grain and straw yield, and harvest index. However, seed priming techniques did not affect plant height, number of spikelets, number of grains and grain weight.

The present work has been intended to investigate the response of two okra varieties to different doses of gamma irradiation (300, 400 and 500 Gys) and hydropriming in terms of growth, seed yield and quality. Certain associated molecular changes were also aimed to be studied.

MATERIALS AND METHODS

Seeds of two okra (*Abelmoschus esculentus* (L.) Moench-Malvaceae) varieties were obtained from Vegetable Crop Seed Production and Technology Department, Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. The first variety namely "Sabahia" has green pods, the other one is "Balady" with red pods. Seeds of each variety were divided into 5 groups. The first group did not have any treatment to serve as control, while the second group was soaked in distilled water for 12 h at room temperature (25°C) (hydropriming). The other three groups were irradiated with Gamma rays (300, 400 and 500 Gray) at the National Center for Research and Technology, Nasr City, Cairo, Egypt.

Two field experiments were conducted during the summer seasons of each 2006 and 2007 at Kaha Horticulture Research Station, Kalyiobia Governorate, Egypt to study the effect of different doses of gamma irradiation (300, 400 and 500 Gray) and hydropriming on growth, seed yield and seed quality of the two okra varieties.

Seeds were sown on the first week of April for both seasons. Each treatment was planted in 6 rows, 4 m long and 0.6 m wide, making an area of 14.4 m^2. Hills were 30 cm apart; 5 seeds per hill then thinned three weeks later to 1 plant/ hill. Other agricultural practices such as: irrigation, weeding, fertilization and pest control were carried out as recommended.

The experiment was laid out in a split plot design with three replicates. The main plots were the two okra varieties. The sub-plots consisted of five treatments as follows: 1) dry seeds as control, 2) seeds soaked in water for 12 hours at 25°C, 3), 4) and 5) represented seeds irradiated with gamma rays with doses 300, 400 and 500 Gray, respectively.

Measurements

Vegetative growth characters

After 10 weeks from sowing, the following growth criteria were recorded, using eight random plants from each treatment; plant height (cm), number of branches/ plant, leaf area/ plant ($cm^{2)}$, fresh weight/ plant (g) and dry weight/ plant (g). Also, photosynthetic pigments: Chlorophylls a, b, "a+b" and carotenoids in leaves were determined calorimetrically.

Seed yield

At seed harvest stage, eight random plants from each treatment were used to record the following data: number of pods/ plant, length of pod, weight of pods/ plant, weight of seeds/ plant (g), weight of seeds/ plot (g), number of seeds/ pod and seed index (weigh of 100 seeds).

Seed quality

Four random samples, 100 seeds each, were used from each treatment for calculating the following records: germination percentage (%) and germination rate (day), seedling and root length (cm), and fresh and dry weight of seedling (g). Germination rate was calculated according to the following formula:

$$\text{Germination rate} = \frac{(G1 \times N1) + (G2 \times N2) + \ldots\ldots(Gn \times Nn)}{G1 + G2 + \ldots\ldots Gn}$$

Where: G = Number of germinated seeds in a certain day, n = Number of this certain day.

Statistical analysis

The data were tabulated and statistically analyzed, using the analyses of variance method and the treatment means were compared using the Duncan Multiple Range Test (Duncan, 1965).

Sodium dodecyl sulphate-polyacrylamide gel electrophoresis (SDS-PAGE) for protein analysis

At seed maturity harvest stage, seeds from different treatments were taken for protein analysis. Proteins were extracted from the seed samples in liquid nitrogen. The tris buffer system used was that originally devised by Laemmli (1970), as described by Dunn (1993), with 2% (w/v) SDS and 5% (v/v) 2-mercaptoethanol to cleave the disulphide bonds. The slurry was centrifuged for 20 min at 12000 rpm. The samples were heated in a boiling water bath for 15 minutes before loading to ensure dissociation. Gel preparation was carried out according to Hames (1981), where 15% resolving gel was used. Bromophenol blue (0.001%) tracking dye was used for marking the buffer front during electrophoresis. The gel was electophoresed at 25 - 30 mA constant current, then at 200 V (for about 8 - 9 h). Staining was done using coomassie brilliant blue, and a solution of 10% acetic acid and 45% methanol was used for destaining. In the quantitative analysis of the protein bands, laser densitometry was used to image the stained profiles.

Table 1. Sequences of the five primers used

No	Name	Sequence
1	OP-B15	5´GGAGGGTGTT 3´
2	OP-B16	5´TTTGCCCGGA 3´
3	OP-B17	5´AGGGAACGAG3´
4	OP-B18	5 ´CCACAGCAGT3´
5	OP-B19	5 ´GGACCCTTAC3´

RAPD-PCR of genomic DNA

DNeasy TM plant mini kit (Qiagen Inc. cat. No 96104) was used for DNA isolations from plants. Leaf tissue of 40 day-old plants (100 mg) was ground under liquid nitrogen to a fine powder. Extraction and purification of samples were carried out with use of DNeasy mini spin columns as described in details by Hamid (2005). RAPD-PCR reaction was conducted using five 10 mer arbitrary primers with the sequences shown in Table 1.

Amplification was carried out in a programmed PCR for 42 cycles as follows: 94℃/4 min (1 cycle), 94℃/1 min, 37℃/1 min, 72℃/2 min (40 cycles), 72℃/10 min (1 cycle) and 4℃ (infinitive). Agarose (1.2%) was used for analyzing the PCR products (Maniatis et al., 1982).

RESULTS AND DISCUSSION

Vegetative growth

The results presented in Tables 2a and b show an increase in most vegetative criteria of both okra varieties (Sabahia and Balady) as a result of soaking seeds in water or irradiation with gamma rays before sowing. In the first season (Table 1a), there was no significant difference between the two varieties in plant height and number of branches/ plant but Balady gave a significant increase in the leaf area, as well as the fresh and dry weights/ plant. In second season, Balady recorded the highest values for all studied characters except plant height. As regard to different seed treatments , it is clear that 400 Gy gave the best results in both seasons regarding significant increase than the control (dry seeds) followed by 300, then 500 Gy.

From the results presented in Table 1a and b it can be noticed that the higher dose of gamma rays (500 Gy) was less effective than the other lower doses (300 or 400 Gy). These results also demonstrated by Norfadzrin et al. (2007) who noticed that higher gamma ray doses particularly 600 and 800 Gy had negative effect on the morphological characteristics of tomato and okra seedlings derived from irradiated seeds. Irradiating okra seeds either Sabahia or Balady with 400 Gy enhanced vegetative growth parameters in the two seasons of the experiment (Table 2b). Balady variety gave high records for number of branches/ plant, leaf area/ plant and fresh and dry weight/ plant when compared to the other variety Sabahia which recorded the high value of plant height when both had the same irradiation dose of 400 Gy. In this connection, Dubey et al. (2007) showed an increase in plant height, number of leaves and branches per plant when okra seeds were irradiated with different doses of gamma rays. Dhankhar and Dhankhar (2003) noticed that, seeds of a purple stem line of okra when subjected to gamma irradiation at 0.6 or 0.7 Kr some plants exhibited flat and Y-shaped branching. In some cases, the main shoot bifurcated in 2 parallel branches, and these parallel branches divided further, repeating the pattern of Y-shaped branching. The emergence of 8 - 10 branches at the cell elongation zone of the stem was also observed in few plants. Vinod and Mishra (1999) noticed the peculiar Y-shaped branching in okra plants derived from seeds treated with 0.4 and 0.6 kGy doses. Also Norfadzrin et al. (2007) indicated that low doses of gamma irradiation have profound effect on plant height, dry weights of tomato and okra.

Photosynthetic pigment

Data presented in Table 3a indicated that there was a significant difference between the two varieties (with superiority of Balady) in total pigments content, chlorophyll “a” and carotenoids. However, these differences did not reach to the significance level with chlorophyll “b” and total chlorophyll. All photosynthetic pigment contents were significantly increased as a result of water soaking and gamma irradiation treatments. In both seasons, best results were obtained by using 400 Gy except in carotenoids in first season, 300 Gy gave higher result (6.28) than 400 Gy (6.14).

Interaction between varieties and seed treatments (Table 3b) showed that all irradiation doses (300, 400 and 500 Gy) showed significant increase than the control in both seasons for both varieties and 400 Gy treatment recorded high values for the two used varieties. Balady variety showed better responsiveness than Sabahia with regard to treatments with either gamma irradiation or soaking in water.

Responses of different okra genotypes to gamma rays and effects on chlorophyll were studied by Singh et al. (2000). They stated that gamma radiation was more effective than ethyl methane sulfonate treatment. Higher doses of mutagens were most effective to produce chlorophyll mutations in all the genotypes. A dose dependent increase in frequency of chlorophyll mutations was noticed. Rejili (2008) showed that exposure of two *Medicago sativa* populations (Mareth and Gannouch) to gamma irradiation (350 Gy), alone or in combination with salt stress, increased significantly chlorophyll b content, especially for the Gannouch population, while no change occurred for the Mareth population.

Seed yield

The results obtained in the present work (Table 4a)

Table 2a. Effect of varieties and seed treatments on growth criteria of okra varieties during summer seasons 2006 and 2007.

Character treatments	Plant height (cm)		Number of branches/ plant		Leaf area/ plant (cm2)		Fresh weight/ plant (g)		Dry weight/ plant (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd Season	1st Season	2nd Season
Varieties										
Sabahia	93.36 A	115.00 A	5.22 A	6.05 B	1413.9 B	1626.6 B	139.3 B	149.5 B	25.73 B	27.44 B
Balady	90.53 A	97.75 B	5.75 A	7.20 A	2619.6 A	3019.3 A	298.7 A	304.9 A	44.94 A	46.66 A
Seed treatments										
control	82.13 B	95.63 C	4.73 B	5.75 C	1807.5 D	2063.5 C	190.1 B	202.6 C	30.89 C	33.30 C
Water 12h	84.69 B	102.75 B	4.71 B	6.25 BC	1928.3 CD	2200.6 BC	201.5 AB	216.0 BC	33.88 BC	35.06 BC
γ 300 Gy	94.93 A	108.88 B	6.09 A	7.06 AB	2099.8 AB	2375.6 AB	219.6 AB	233.2 AB	37.96 A	38.47 AB
γ 400 Gy	103.16 A	116.38 A	6.25 A	7.31 A	2210.8 A	2595.0 A	269.2 A	254.4 A	37.98 A	41.04 AB
γ 500 Gy	94.81 A	108.25 B	5.63 A	6.75 AB	2037.5 BC	2379.9 AB	214.6 AB	229.9 B	35.96 AB	37.36 ABC

Values within the same column followed by the same letters are not significantly different, using Duncan's Multiple Range Test at 5% level.

Table 2b. Effect of interaction between varieties and seed treatments on growth criteria of okra varieties during summer seasons 2006 & 2007.

Character treatments		Plant height (cm)		Number of branches/ plant		Leaf area/plant (cm2)		Fresh weight/ plant (g)		Dry weight/ plant (g)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd Season	1st Season	2nd Season
	control	83.18 D	103.75 D	4.38 D	5.38 C	1275.3 G	1408.3 G	126.8 C	130.5 F	23.03 E	24.21 E
	Water 12h	86.20 CD	112.25 BC	4.40 D	5.50 C	1374.0 FG	1532.0 FG	133.8 C	142.0 F	24.68 DE	26.16 E
Sabahia	γ 300 Gy	93.73 BC	115.50 B	6.05 AB	6.38 BC	1467.3 EF	1607.3 FG	143.4 C	149.2 F	27.65 D	27.20 E
	γ 400 Gy	106.58 A	126.75 A	5.75 BC	6.63 B	1548.8 E	1888.5 E	152.3 C	175.3 E	27.40 D	31.92 D
	γ 500 Gy	97.13 B	116.75 B	5.50 BC	6.38 BC	1404.3 EFG	1697.0 EF	140.4 C	150.5 F	25.90 DE	27.70 E
	control	81.08 D	87.50 F	5.08 CD	6.13 BC	2339.8 D	2718.8 D	253.5 B	274.8 D	38.75 C	42.40 C
	Water 12h	83.18 D	93.25 EF	5.03 CD	7.00 AB	2482.5 C	2869.3 CD	269.2 B	290.0 CD	43.08 B	43.95 BC
Balady	γ 300 Gy	96.13 B	102.25 D	6.13 AB	7.75 A	2732.3 AB	3144.0 AB	295.9 B	317.1 AB	48.28 A	49.74 A
	γ 400 Gy	99.75AB	106.00 CD	6.75 A	8.00 A	2872.8 A	3301.5 A	386.2 A	333.5 A	48.55 A	50.16 A
	γ 500 Gy	92.50 BC	99.75 DE	5.75 BC	7.13 AB	2670.8 B	3062.8 BC	288.8 B	309.3 BC	46.03 AB	47.02 AB

Values within the same column followed by the same letters are not significantly different, using Duncan's Multiple Range Test at 5% level.

demonstrated that there were significant differences between the two varieties in most studied seed yield traits. Sabahia was greater than Balady in both seasons regard to the number of pods/ plant, pod length, weight of seeds/plant and seed yield/ plot. On contrary, Balady had the high seed index (weight of 100 seed). No signify-cant difference was noticed with number of seeds per pod between the two varieties. Effects of treat-ments on seed yield indicated that 400 Gy gave the best effect with significant increase than con-trol for all traits in Table (4a), while for pod length

Table 3a. Effect of varieties and seed treatments on chlorophyll and total pigments (mg/100 g F.Wt.) of okra during summer seasons 2006 and 2007.

Character treatments	Chlorophyll "a"		Chlorophyll "b"		Chlorophyll "a+b"		Carotenoids		Total pigments	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2 nd season	1st season	2nd season
Varieties										
Sabahia	8.97 B	8.63 B	5.97 A	5.57 A	14.94 A	14.20 A	4.98 B	5.01 B	19.92 B	19.21 B
Balady	9.54 A	9.15 A	6.37 A	5.54 A	15.91 A	14.69 A	6.81 A	6.68 A	22.72 A	21.37 A
Seed treatments										
control	8.45 D	7.89 C	5.33 C	4.92 C	13.78 D	12.81 D	5.34 D	5.32 C	19.12 E	18.13 E
Water 12h	8.91 C	8.54 B	5.89 B	5.21 C	14.80 C	13.75 C	5.80 C	5.64 B	20.60 D	19.39 D
γ 300 Gy	9.60 B	9.30 A	6.27 B	5.65 B	15.87 B	14.95 B	6.28 A	6.32 A	22.15 B	21.27 B
γ 400 Gy	9.79 A	9.48 A	7.11 A	6.16 A	16.90 A	15.64 A	6.14 B	6.29 A	23.04 A	21.93 A
γ 500 Gy	9.53 B	9.24 A	6.24 B	5.82 B	15.77 B	15.06 B	5.89 C	5.66 B	21.66 C	20.72 C

Values within the same column followed by the same letters are not significantly different, using Duncan's Multiple Range Test at 5% level.

Table 3b. Effect of interaction between varieties and seed treatments on chlorophyll and total pigments (mg/100 g F.Wt.) of okra during summer seasons 2006 and 2007.

Character treatments		Chlorophyll "a"		Chlorophyll "b"		Chlorophyll "a+b"		Carotenoids		Total pigments	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd Season
Sabahia	control	8.30 F	7.86 F	5.17 E	5.08 DE	13.70 E	12.94 F	4.86 H	4.79 D	18.33 I	17.73 G
	Water 12h	8.86 D	8.47 E	5.38 E	5.05 DE	14.24 D	13.52 E	4.93 GH	4.96 D	19.17 H	18.48 F
	γ 300 Gy	9.33 C	9.00 C	6.08 CD	5.62 BC	15.41 C	14.62 C	5.09 F	5.08 D	20.50 F	19.70 E
	γ 400 Gy	9.35 C	9.08 C	6.75 B	6.17 A	16.10 B	15.25 B	5.07 F	5.14 D	21.17 E	20.39 D
	γ 500 Gy	9.01 D	8.73 D	6.49 B	5.91 AB	15.50 C	14.64 C	4.98 FG	5.11 D	20.48 F	19.75 E
Balady	control	8.59 E	7.93 F	5.48 E	4.77 E	14.07 DE	12.70 F	5.82 E	5.85 C	19.89 G	18.55 F
	Water 12h	8.96 D	8.61 DE	6.41 BC	5.38 CD	15.37 C	13.99 D	6.68 D	6.32 B	22.05 D	20.31 D
	γ 300 Gy	9.87 B	9.60 B	6.46 BC	5.69 BC	16.33 B	15.29 B	7.47 A	7.56 A	23.80 B	22.85 B
	γ 400 Gy	10.23 A	9.88 A	7.48 A	6.16 A	17.71 A	16.04 A	7.21 B	7.45 A	24.92 A	23.49 A
	γ 500 Gy	10.05AB	9.75 AB	6.00 D	5.72 BC	16.05 B	15.47 B	6.81 C	6.21 B	22.86 C	21.68 C

Values within the same column followed by the same letters are not significantly different, using Duncan's Multiple Range Test at 5% level.

in second season there is no significant difference between all studied treatments. Interaction between varieties and seed treatments (Table 4b) indicated that 400 Gy treatments for Sabahia seeds gave the higher responses regarding to number of pods/ plant, pod length, weight of seeds/ plant and seed yield/ plot, whereas Balady showed better response to the same irradiation dose and gave high number of seeds/ pod and the

Table 4a. Effect of varieties and seed treatments on seed yield of okra during summer seasons 2006 and 2007.

Character treatments	Number of pods/ plant		Pod length (cm)		Weight of seeds/ plant (g)		Seed yield /plot (g)		Number of seeds/ pod		Weight of 100 seed (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Varieties												
Sabahia	24.35 A	34.00 A	15.46 A	16.22 A	89.5 A	144.2 A	6.05 A	6.38 A	108.2 A	107.7 A	5.19 B	5.23 B
Balady	18.25 B	32.30 A	12.59 B	11.25 B	68.7 B	140.2 A	5.23 B	5.91 B	112.4 A	109.9 A	6.08 A	6.33 A
Seed treatments												
control	18.88 B	24.50 C	13.43 B	13.33 A	53.7 C	100.4 D	4.85 E	5.65 D	100.4 C	96.5 B	5.45 B	5.54 B
Water 12h	20.00 B	32.25 B	13.43 B	13.53 A	61.4 C	125.0 CD	5.21 D	5.78 D	108.5 BC	110.1 A	5.57 AB	5.58 B
γ 300 Gy	22.00 AB	35.13 B	14.23 AB	13.75 A	85. 8 B	155.8 AB	5.91 B	6.46 B	116.0 AB	111.4 A	5.72 A	5.81 B
γ 400 Gy	24.13 A	39.63 A	14.64 A	14.41 A	112.5 A	183.5 A	6.52 A	6.66 A	118.4 A	118.5 A	5.79 A	6.25 A
γ 500 Gy	21.50 AB	34.25 B	14.40 AB	13.65 A	82.2 B	146.4 BC	5.72 C	6.17 C	108.0 BC	107.3 AB	5.66 AB	5.73 B

Values within the same column followed by the same letters are not significantly different, using Duncan's multiple range test at 5% level.

Table 4b. Effect of interaction between varieties and seed treatments on seed yield of okra during summer seasons 2006 and 2007.

Character treatments		Number of pods/ plant		Pod length (cm)		Weight of seeds/ plant (g)		Seed yield /plot (g)		Number of seeds/ pod		Weight of 100 seed (g)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd Season
Sabahia	control	22.25 BCD	27.50 D	14.60 B	15.65 B	55. 5 DE	98.0 E	5.12 F	5.71 E	99.8 E	95.0 D	4.88 C	5.10 F
	Water 12 h	23.75 BC	32.25 C	14.23 B	15.88 B	64.2 CDE	127.5 CDE	5.55 D	5.93 D	108.5 CDE	109.3 ABC	5.12 B	5.13 EF
	γ 300 Gy	24.25 B	35.00 BC	15.78 A	16.13 B	99.1 B	154.5 BCD	6.50 B	6.82 B	113.0 BC	110.5 AB	5.35 B	5.36 EF
	γ 400 Gy	27.75 A	41.75 A	16.53 A	17.33 A	132.3 A	189.3 A	6.94 A	7.02 A	113.8 BC	118.8 A	5.34 B	5.38 E
	γ 500 Gy	23.75 BC	33.50 BC	16.18 A	16.10 B	96.3 B	151.8 BCD	6.15 C	6.40 C	105.8 CDE	104.8 BCD	5.27 B	5.17 EF
Balady	control	15.50 F	21.50 E	12.25 C	11.00 C	52.1 E	102.8 E	4.58 H	5.59 E	101.1 DE	98.0 CD	6.01 A	5.98 D
	Water 12 h	16.25 EF	32.25 C	12.63 C	11.18 C	58. 5 DE	122.5 DE	4.87 G	5.63 E	108.5 CDE	111.0 AB	6.02 A	6.02 CD
	γ 300 Gy	19.75 D	35.25 BC	12.68 C	11.38 C	72. 5 C	157.0 BC	5.32 E	6.10 D	119.0 AB	112.3 AB	6.10 A	6.24 BC
	γ 400 Gy	20.50 CD	37.50 B	12.75 C	11.50 C	92.7 B	177.8 AB	6.10 C	6.30 C	123.0 A	118.3 A	6.25 A	7.12 A
	γ 500 Gy	19.25 DE	35.00 BC	12. C	11.20 C	68.1 CD	141.0 CD	5.29 E	5.95 D	110.3 BCD	109.8 ABC	6.04 A	6.31 B

Values within the same column followed by the same letters are not significantly different, using Duncan's multiple range test at 5% level.

heaviest seed index. Increased number of okra fruit per plant and fruit length as a result of gamma irradiation was recorded by many authors (Dubey et al., 2007; Mishra et al., 2007; Sharma and Mishra, 2007). Obviously, as a result of increased number of fruits per plant it reflected positively onon seed yield. In this connection, enhance ment of seed yield was recorded by Sundaravadivelu et al. (2006) in cotton and Sujaya-Das et al. (2007) in mung bean. These results were further confirmed by those obtained in weight of 100 seeds (Table 4). This agrees with the results obtained by Singh and Singh (2003) in okra and Sujaya-Das et al. (2007) in mung bean.

Soehendi et al. (2007) stated that modification obtained by gamma-ray irradiation of mung bean leaflet type could affect leaf canopy and alter seed yield. Thus, modified mung bean lines which exhibited greater leaf area per plant would have enhanced photothynthetic rate and hence gave greater yield.

The higher dose of gamma irradiation (500 Gy) in this study (Table 4) was less effective than the other two lower doses. This observation was also stated by Artk and Peksen (2006) who found a reduction in faba bean seed yield and harvest index in some varieties when seeds are treated with relatively low doses (25 and 50 Gy) gamma radiation.

On the other hand, soaking seeds in water (hydro-priming) was found to be an effective treatment to increase stand establishment, improved agronomic characters and hence yield of many crops. Data represented in Table 4a, b indicated that hydropriming increased the seed yield traits but this increase doesn't reach significant level. Hydropriming techniques improved germination, yield and quality of directly sown rice (Farooq et al., 2006) and significantly affected seedling establishment, yield and quality of hybrid sunflower (Mubshar-Hussain et al., 2006).

Seed quality

Data presented in Table 5a reveal that there is no clear significant difference between the two varieties in seed quality measurements. However, Balady recorded low values in rate of germination in the second season only (that is, days to complete germination is less) and seedling dry weight in both seasons while, Sabahia had the lower seedling fresh weight. Irradiating okra seeds with 400 Gy had significant and promotional effects on seed quality attributes in terms of germination percent-tage, rate of germination, seedling length and seedling fresh and dry weights (Table 5a). It is clear from the data in the same Table that there is no significant difference between the rest of presowing seed treatments and control.

As regard the interaction between okra varieties and presowing seed treatments on seed quality characters, data in Table 5b indicate that seed quality characters were significantly affected by this interaction. Treating seeds of Balady variety with Gamma irradiation at the dose 400 Gy was the best treatment in almost all studied characters followed by treating Sabahia variety with the same dose. Enhancement of seedling vigor by gamma irradiation was detected by many authors. Thus Nargis et al. (1998) stated that when tomato seeds were treated with 1% vitamin E, 1% vitamin C or hydration and dehydration, then subjected to gamma radiation (10, 20 or 30 kr) the seeds exposed to 10 and 20 Kr (lower dose) showed an increased speed of germination and vigour index, compared with the control and treatment with 30 Kr.

In okra, Arvind-Kumar and Mishra (2004) found that gamma rays at 10 and 20 Kr combined with other mutagens increased the mean seedling vigour index. Rao and Suvartha (2006) found that among the irradiation levels, 30 Kr resulted in the highest seed germination percentage of tomato. Ahmadi et al. (2007) showed that seed soaking of different wheat cultivars in water for 12 h improved speed of emergence, vigour index and seedling dry weight.

SDS-Protein electrophoresis

The SDS- electrophoresis patterns (Figure 1 and Table 6) showed that the number of polymorphic bands among the two varieties under investigation is 15. In Sabahia, different treatments induced changes in protein pattern. There were four new bands having molecular weights 70.75, 67.67, 49.36 and 13.73 kDa that appeared only by the effect of soaking in water compared to control. As a result of gamma irradiation, (300, 400, 500 Gy), three bands disappeared with molecular weights 72.15, 63.12 and 62.01 kDa. Irradiation by 300 Gy induced the appearance of three bands with molecular weights 69.50, 51.61 and 47.38 kDa, 400 Gy induced the appearance of four new bands with molecular weights 67.91, 48.4, 14.05 and 13.41 kDa and irradiation with 500 Gy induced the appearance of four bands with molecular weights 68.8, 47.80, 14.64 and 13.49 kDa. In Balady also soaking in water induced the appearance of five bands with molecular weights 72.80, 70.12, 67.91, 47.97 and 13.97 kDa. Gamma irradiation induced the appearance of one band with molecular weight 68.52 kDa.

Irradiation by 300 Gy induced the appearance of three bands with molecular weights 70.50, 14.35 and 13.65 kDa, also the irradiation by 400 Gy induced the appearance of two bands with molecular weights, 48.66 and 13.90 kDa and irradiation with 500 Gy induced the appearance of four bands with molecular weights 71.13, 53.10, 49.10 and 14.18 kDa. In other work, gamma irradiation was also found to cause changes in protein patterns of seeds of many plants. Thus, dry seeds of common bean (*Phaseolus vulgaris* L. cv. Nebraska) were subjected to 0, 2 and 3 Krad of gamma rays from a cobalt-60 source. The low dose (2 Krad) of gamma irradiation induced stability in the total number of protein

Table 5a. Effect of varieties and seed treatments on seed quality of okra during summer seasons 2006 and 2007.

Character treatments	Germination percentage (%)		Rat of germination (day)		Seedling length (cm)		Seedling root length (cm)		Fresh weight of seedling (g)		Dry weight of seedling (g)	
	1st Season	2nd Season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Varieties												
Sabahia	86.30 A	90.60 A	2.20 A	2.49 A	20.55 A	20.28 A	7.96 A	7.25 A	2.19 B	2.12 B	0.12 A	0.12 A
Balady	86.83 A	89.95 A	2.16 A	2.27 B	22.10 A	22.42 A	8.22 A	7.19 A	2.79 A	2.62 A	0.11 B	0.10 B
Seed treatments												
control	83.81 B	88.56 B	2.22 A	2.44 A	19.55 B	20.44 B	7.44 A	6.76 B	2.31 B	2.23 A	0.101 D	0.096 E
Water 12h	85.00 AB	89.44 AB	2.20 A	2.42 AB	21.39 A	20.65 B	7.54 A	7.00 AB	2.52 AB	2.38 A	0.119 B	0.111 C
γ 300 Gy	87.25 AB	90.13 AB	2.18 A	2.35 AB	21.85 A	22.53 A	8.69 A	7.41 AB	2.51 AB	2.39 A	0.117 B	0.114 B
γ 400 Gy	89.00 A	91.88 A	2.16 A	2.34 B	22.16 A	22.08 AB	8.89 A	7.63 A	2.63 A	2.48 A	0.122 A	0.116 A
γ 500 Gy	87.75 AB	91.38 A	2.13 A	2.34 B	21.68 A	21.05 AB	7.89 A	7.29 AB	2.48 AB	2.36 A	0.107 C	0.103 D

Values within the same column followed by the same letters are not significantly different, using Duncan's multiple range test at 5% level

Table 5b. Effect of interaction between varieties and seed treatments on seed quality of okra during summer seasons 2006 and 2007.

Character treatments		Germination percentage (%)		Rat of germination (day)		Seedling length (cm)		Seedling root length (cm)		Fresh weight of seedling (g)		Dry weight. of seedling (g)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd Season
Sabahia	control	83.50 B	88.50 D	2.24 A	2.56 A	18.55 D	19.48 E	7.50 ABC	6.70 C	2.02 D	2.02 C	0.107 G	0.103 F
	Water 12h	84.50 B	90.00 ABCD	2.24 A	2.57 A	20.58 C	19.55 E	7.88 ABC	7.08 ABC	2.20 CD	2.11 C	0.125 B	0.115 C
	γ 300 Gy	88.00 AB	91.25 ABC	2.21 AB	2.45 B	21.28 BC	21.30 CD	8.25 ABC	7.63 AB	2.19 CD	2.09 C	0.125 B	0.120 B
	γ 400 Gy	88.00 AB	91.75 A	2.17 AB	2.43 B	21.13 BC	21.08 CDE	8.53 ABC	7.68 A	2.35 C	2.23 BC	0.127 A	0.122 A
	γ 500 Gy	87.50 AB	91.50 AB	2.12 B	2.43 B	21.23 BC	19.8 DE	7.65 ABC	7.15 ABC	2.21 CD	2.13 C	0.115 D	0.110 D
Balady	control	84.13 B	88.63 CD	2.21 AB	2.32 C	20.55 C	21.40 CD	7.38 BC	6.83 C	2.59 B	2.44 AB	0.095 I	0.090 H
	Water 12h	85.50 AB	88.88 BCD	2.16 AB	2.27 C	22.20 ABC	21.75 BC	7.20 C	6.93 BC	2.85 A	2.65 A	0.112 E	0.107 E
	γ 300 Gy	86.50 AB	89.00 BCD	2.16 AB	2.25 C	22.43 AB	23.75 A	9.13 AB	7.20 ABC	2.84 A	2.69 A	0.110 F	0.107 E
	γ 400 Gy	90.00 A	92.00 A	2.15 AB	2.25 C	23.20 A	23.08 AB	9.25 A	7.58 AB	2.92 A	2.72 A	0.117 C	0.110 D
	γ 500 Gy	88.00 AB	91.25 ABC	2.13 AB	2.25 C	22.13 ABC	22.13 BC	8.13 ABC	7.43 ABC	2.76 AB	2.58 A	0.100 H	0.095 G

Values within the same column followed by the same letters are not significantly different, using Duncan's multiple range test at 5% level.

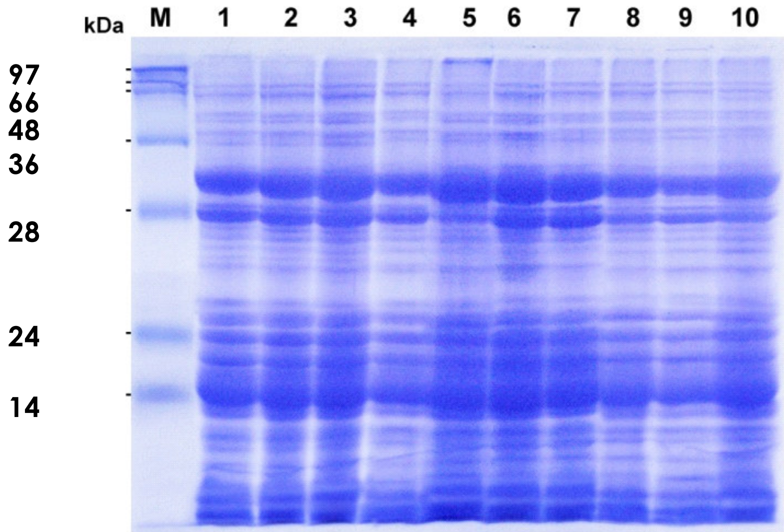

Figure 1. Protein patterns of two okra varieties (Sabahia: 1 - 5 and Balady: 6 - 10) cultivated during summer seasons 2006 and 2007. The control represents dry seeds: 1 and 6. The other groups of seeds are soaked in water (12 h.): 2 and 7 or treated with different doses of gamma irradiation (300 Gy 3 and 8,400 Gy: 4 and 9, 500 Gy: 5 and 10). M = marker.

Table 6. Protein pattern of two okra varieties (Sabahia: 1 - 5 and Balady: 6 - 10) cultivated during summer seasons 2006 and 2007. The control represents dry seeds: 1 and 6. The other groups of seeds are soaked in water (12 h.): 2 and 7 or treated with different doses of gamma irradiation (300 Gy: 3 and 8, 400 Gy: 4 and 9, 500 Gy: 5 and 10).

Band N0.	MW kD	Sabahia					Balady					Polymorphism
		1	2	3	4	5	6	7	8	9	10	
1	72,795	-	-	-	-	-	-	+	-	-	-	Unique
2	72,407	-	-	+	+	-	-	-	-	-	-	Polymorphic
3	72,149	+	+	-	-	-	-	-	-	-	-	Polymorphic
4	71,128	-	-	-	-	-	-	-	-	-	+	Unique
5	70,748	-	+	-	-	+	-	-	-	-	-	Polymorphic
6	70,497	-	-	-	-	-	-	-	+	-	-	Unique
7	70,121	+	-	-	+	-	-	+	-	-	-	Polymorphic
8	69,871	-	-	-	-	-	+	-	-	+	-	Polymorphic
9	69,499	-	-	+	-	-	-	-	-	-	-	Unique
10	68,882	-	-	-	-	+	+	-	-	-	-	Polymorphic
11	68,515	-	-	-	-	-	-	-	+	+	+	Polymorphic
12	67,907	-	-	-	+	-	-	+	-	-	-	Polymorphic
13	67,665	-	+	-	-	-	-	-	-	-	-	Unique
14	67,304	+	-	+	-	-	-	-	-	-	-	Polymorphic
15	63,121	+	+	-	-	-	-	-	-	-	-	Polymorphic
16	62,561	+	+	+	+	+	+	+	+	+	+	Monomorphic
17	62,006	+	+	-	-	-	-	-	-	-	-	Polymorphic
18	61,676	+	+	+	+	+	+	+	+	+	+	Monomorphic
19	58,988	+	+	+	+	+	+	+	+	+	+	Monomorphic
20	56,821	+	+	+	+	+	+	+	+	+	+	Monomorphic
21	53,100	-	-	-	-	-	-	-	-	-	+	Unique
22	52,629	+	-	-	-	-	-	+	-	+	-	Polymorphic
23	52,348	-	-	-	-	-	-	-	+	-	-	Unique
24	52,069	-	-	-	-	-	+	-	-	-	-	Unique

Table 6. Contd.

25	51,884	-	+	-	-	+	-	-	-	-	-	Polymorphic
26	51,607	-	-	+	-	-	-	-	-	-	-	Unique
27	49,358	-	+	-	-	-	-	-	-	-	-	Unique
28	49,095	-	-	-	-	-	-	-	-	-	+	Unique
29	48,659	-	-	-	-	-	-	-	-	+	-	Unique
30	48,400	-	-	-	+	-	-	-	-	-	-	Unique
31	48,227	+	-	-	-	-	+	-	+	-	-	Polymorphic
32	47,970	-	-	-	-	-	-	+	-	-	-	Unique
33	47,800	-	-	-	-	+	-	-	-	-	-	Unique
34	47,375	-	-	+	-	-	-	-	-	-	-	Unique
35	45,230	+	+	+	+	+	+	+	+	+	+	Monomorphic
36	43,028	+	+	+	+	+	+	+	+	+	+	Monomorphic
37	41,670	+	+	+	+	+	+	+	+	+	+	Monomorphic
38	39,783	+	+	+	+	+	+	+	+	+	+	Monomorphic
39	38,185	+	+	+	+	+	+	+	+	+	+	Monomorphic
40	36,004	+	+	+	+	+	+	+	+	+	+	Monomorphic
41	33,586	-	-	-	-	-	+	-	-	-	-	Unique
42	33,288	-	-	+	-	+	-	-	-	-	-	Polymorphic
43	31,499	+	+	+	+	+	+	+	+	+	+	Monomorphic
44	30,126	+	+	+	+	+	+	+	+	+	+	Monomorphic
45	27,216	+	+	+	+	+	+	+	+	+	+	Monomorphic
46	26,263	+	+	+	+	+	+	+	+	+	+	Monomorphic
47	24,984	+	+	+	+	+	+	+	+	+	+	Monomorphic
48	23,641	+	+	+	+	+	+	+	+	+	+	Monomorphic
49	21,587	+	+	+	+	+	+	+	+	+	+	Monomorphic
50	19,782	+	+	+	+	+	+	+	+	+	+	Monomorphic
51	18,23	+	+	+	+	+	+	+	+	+	+	Monomorphic
52	17,15	+	+	+	+	+	+	+	+	+	+	Monomorphic
53	15,44	+	-	-	-	-	-	-	-	-	-	Unique
54	15,39	+	+	+	+	+	+	+	+	+	+	Monomorphic
55	14,64	-	-	-	-	+	-	-	-	-	-	Unique
56	14,35	-	-	-	-	-	-	-	+	-	-	Unique
57	14,18	-	-	-	-	-	-	-	-	-	+	Unique
58	14,1	-	-	-	-	-	+	-	-	-	-	Unique
59	14,05	-	-	-	+	-	-	-	-	-	-	Unique
60	13,97	-	-	-	-	-	-	+	-	-	-	Unique
61	13,9	-	-	-	-	-	-	-	-	+	-	Unique
62	13,73	-	+	-	-	-	-	-	-	-	-	Unique
63	13,65	-	-	-	-	-	-	-	+	-	-	Unique
64	13,61	+	-	-	-	-	-	-	-	-	-	Unique
65	13,49	-	-	-	-	+	-	-	-	-	-	Unique
66	13,41	-	-	-	+	-	-	-	-	-	-	Unique

bands and continued synthesis of certain polypeptides under the highest 3 Krad (Beltagi et al., 2006). Cholakova et al. (2003) observed alterations in the electrophoretic patterns of the soluble seed proteins of isogenic pepper lines developed after gamma irradiation. Moreover, the obtained protein band design using SDS-PAGE method in the standard and mutant durum wheat genotypes were observed to be different in the 300, 400 and 500 gamma ray doses, (Baser et al., 2007).

RAPD-PCR of genomic DNA

RAPD-PCR was used for detection of DNA profile

Table 7. DNA polymorphism using randomly amplifying DNA (RAPD) for two okra varieties (Sabahia: 1 - 5 and Balady: 6 - 10) cultivated during summer seasons 2006 and 2007. The control represents dry seeds: 1 and 6. The other groups of seeds are soaked in water (12 h.): 2 and 7 or treated with different doses of gamma irradiation (300 Gy: 3 and 8, 400 Gy: 4 and 9, 500 Gy: 5 and 10).

No	primers	Polymorphism				Total No.
		Sabahia		Balady		
		Monomorphic bands	Polymorphic bands	Monomorphic bands	Polymorphic bands	
1	OP-B15	7	5	7	5	12
2	OP-B16	0	2	1	1	2
3	OP-B17	5	6	3	8	11
4	OP-B18	6	5	6	5	11
5	OP-B19	2	0	2	0	2
Total		20	18	19	19	38

changes due to treatments (soaking in water for 12 h, gamma irradiation of seeds by 300, 400, 500 Gy) in two varieties of okra (Sabahia and Balady).

All five primers successfully amplified DNA fragments from okra DNA samples. The results indicated occurrence of structural changes in treatment with four out of five primers: OP-B15, OP-B16, OP-B17 and OP-B18 respectively (Table 7). A total of 38 fragments were visualized across the five primers (Table 8). Genomic DNA polymorphisms due to treatments are presented in Figure 2 with primers OP-B15, OP-B16, OP-B17 and OP-B18, respectively (Table 6). Banding patterns for the used five random primers were scored as present (1) or absent (0) (Table 8). In variety Sabahia, the percentage of polymorphism was 47.37%. In primer OP-B15 three bands with molecular size 1379.09, 1163.5 and 469 bp appeared under the effect of gamma irradiation; the first two appeared only at high doses (400 and 500 Gy). The 888.76 bp disappeared at high doses only. In primer OP-B18 a band with molecular size 1289.57 bp disappeared under irradiation and the bands with molecular sizes 785.85 and 721.29 bp disappeared only under irradiation by 500 Gy.

In variety Balady, primers OP-B16 and OP-B19 did not show any polymorphism, the percentage of polymorphism was 50%. The result of RAPD analysis using primer OP-B15 indicted the appearance or disappearance of DNA polymorphic bands with molecular size 5429, 1379.09, 732.07and 469.56 bp the first band present only in Balady variety treated by dose 500 Gy, but the second and third absent in treatment with the same result of RAPD analysis using primer OP-B16 indicted that the band with molecular size 234 bp disappeared only under irradiation by 400 Gy. Gamma irradiation also induced the appearance of a band in primer OP-B17 with a molecular size 689.25 bp and that of a molecular size dose (500 Gy). The fourth (469.56 bp) disappeared in treatment with the all irradiation doses. With primer OP-B17, one band with molecular size 607.2 bp appeared in treatment with the gamma irradiation dose 400 Gy. The result of RAPD analysis using primer OP-B18 indicted the disappearance of DNA polymorphic bands with molecular sizes 1167.46, 912.51 and 785.85 bp. The first disappeared in response to treatments with high doses of gamma irradiation (400 and 500 Gy), the second and third disappeared in treatment with dose 400 Gy. The results agreed with Wendt et al. (2001) who used the RAPD markers to study the effect of gamma radiation on potato cultivar Macaca and concluded that treatment with 500 Gy promoted the highest variation in genetic distances. RAPD-DNA analysis showed that the offsprings of the 5 irradiated *Chamaecrista* spp cultivars were significantly genetically different from the control (GuoZhong et al., 2007). Ganapathi et al. (2008) studied the effect of gamma irradiation on banana using RAPD-DNA analysis. They observed changes in the DNA bands, where the main changes in the RAPD profiles of the present investigation were the appearance or disappearance of different bands with variation in their intensity. These effects might be due to the structural rearrangements in DNA caused by different types of DNA damages.

Thus, the variation in band intensity and disappearance of some bands may correlate with the level of photoproducts in DNA template after radiation which can reduce the number of binding sites for Taq polymerase. Appearance of new bands is usually result from different DNA structural changes (Breaks, transpositions, deletion etc) (Danylchenko and Sorochinsky, 2005).

Conclusion

From the results it was concluded that, pre-sowing treatments either by soaking okra seeds in water (hydropriming) or irradiated them by doses (300, 400, 500 Gy) of gamma rays were effective in improving plant growth, seed yield and seed quality. In this respect, gamma irradiation by 400 Gy gave the highest effect.

These improvements in growth traits were accompanied with a marked modulation in the protein banding pattern and DNA profile of the two okra varieties under investigation. The present work has been devoted to okra as an important crop with a relatively wide consumption rate in Egypt. As a consequence, okra seeds irradiated with

Table 8. DNA polymorphism using randomly amplifying DNA (RAPD) for two okra varieties (Sabahia: 1 - 5 and Balady: 6 - 10) cultivated during summer seasons 2006 and 2007. The control represent dry seeds: 1 and 6, the other groups of seeds are soaked in water (12 h.): 2 and 7 or treated with different doses of gamma irradiation (300 Gy: 3 and 8, 400 Gy: 4 and 9, 500 Gy: 5 and 10).

Primers	M.S (bp)	Sabahia					Polymorphism	Balady					Polymorphism
		1	2	3	4	5		6	7	8	9	10	
OP-B15	5428,02	0	0	0	0	0	Mono.	0	0	0	0	1	Uni.
	4129,5	0	1	1	1	1	Poly.	1	1	1	1	1	Mono.
	3436,7	1	1	1	1	1	Mono.	1	1	1	1	1	Mono.
	2921,45	1	1	1	1	1	Mono.	1	1	1	1	1	Mono.
	2459,66	0	0	0	0	0	Mono.	0	0	1	0	1	Poly.
	2019,05	1	1	1	1	1	Mono.	1	1	1	1	1	Mono.
	1379,09	0	0	0	1	1	Poly.	1	1	1	1	0	Poly.
	1163,5	0	0	0	1	1	Poly.	1	1	1	1	1	Mono.
	732,07	1	0	1	1	1	Poly.	1	1	1	1	0	Poly.
	469,56	0	0	1	1	1	Poly.	1	1	0	0	0	Poly.
	288,76	1	1	1	1	1	Mono.	1	1	1	1	1	Mono.
	236,82	1	1	1	1	1	Mono.	1	1	1	1	1	Mono.
OP-B16	799.4	0	1	0	0	0	Uni.	1	0	1	1	1	Poly.
	234	1	1	1	0	1	Poly.	1	1	1	1	1	Mono.
OP-B17	1245,65	1	0	0	0	0	Uni.	0	1	0	0	0	Uni.
	977,67	1	0	1	0	0	Poly.	0	1	1	0	1	Poly.
	888,76	1	1	1	0	0	Poly.	0	1	0	0	0	Poly.
	778,04	0	1	0	1	1	Poly.	0	1	1	0	1	Poly.
	740,91	1	0	1	1	1	Poly.	1	0	1	1	1	Poly.
	689,25	1	1	0	0	0	Poly.	0	1	0	1	1	Poly.
	607,2	0	0	0	0	0	Mono.	0	0	0	1	0	Poly.
	573,23	1	1	1	1	1	Mono.	1	0	1	0	1	Poly.
	507,49	1	1	1	1	1	Mono.	1	1	1	1	1	Mono.
	420,58	1	1	1	1	1	Mono.	1	1	1	1	1	Mono.
	372,39	1	1	1	1	1	Mono.	1	1	1	1	1	Mono.
OP-B18	1289,57	1	1	0	0	0	Poly.	0	1	1	0	0	Poly.
	1167,46	1	1	1	1	1	Mono.	1	1	1	0	0	Poly.
	912,51	1	1	1	1	1	Mono.	1	1	1	0	1	Poly.
	785,85	1	1	1	1	0	Poly.	1	1	1	0	1	Poly.
	721,29	1	1	1	1	0	Poly.	0	0	0	0	0	Mono.
	632,96	1	1	1	1	1	Mono.	1	1	1	1	1	Mono.
	553,62	0	1	0	0	1	Poly.	1	1	1	1	1	Mono.
	456,72	1	0	1	1	1	Poly.	1	1	1	1	1	Mono.
	417,04	1	1	1	1	1	Mono.	1	1	1	1	1	Mono.
	339,96	1	1	1	1	1	Mono.	1	0	0	0	1	Poly.
	286,44	1	1	1	1	1	Mono.	1	1	1	1	1	Mono.
OP-B19	889,41	1	1	1	1	1	Mono.	1	1	1	1	1	Mono.
	619,35	1	1	1	1	1	Mono.	1	1	1	1	1	Mono.

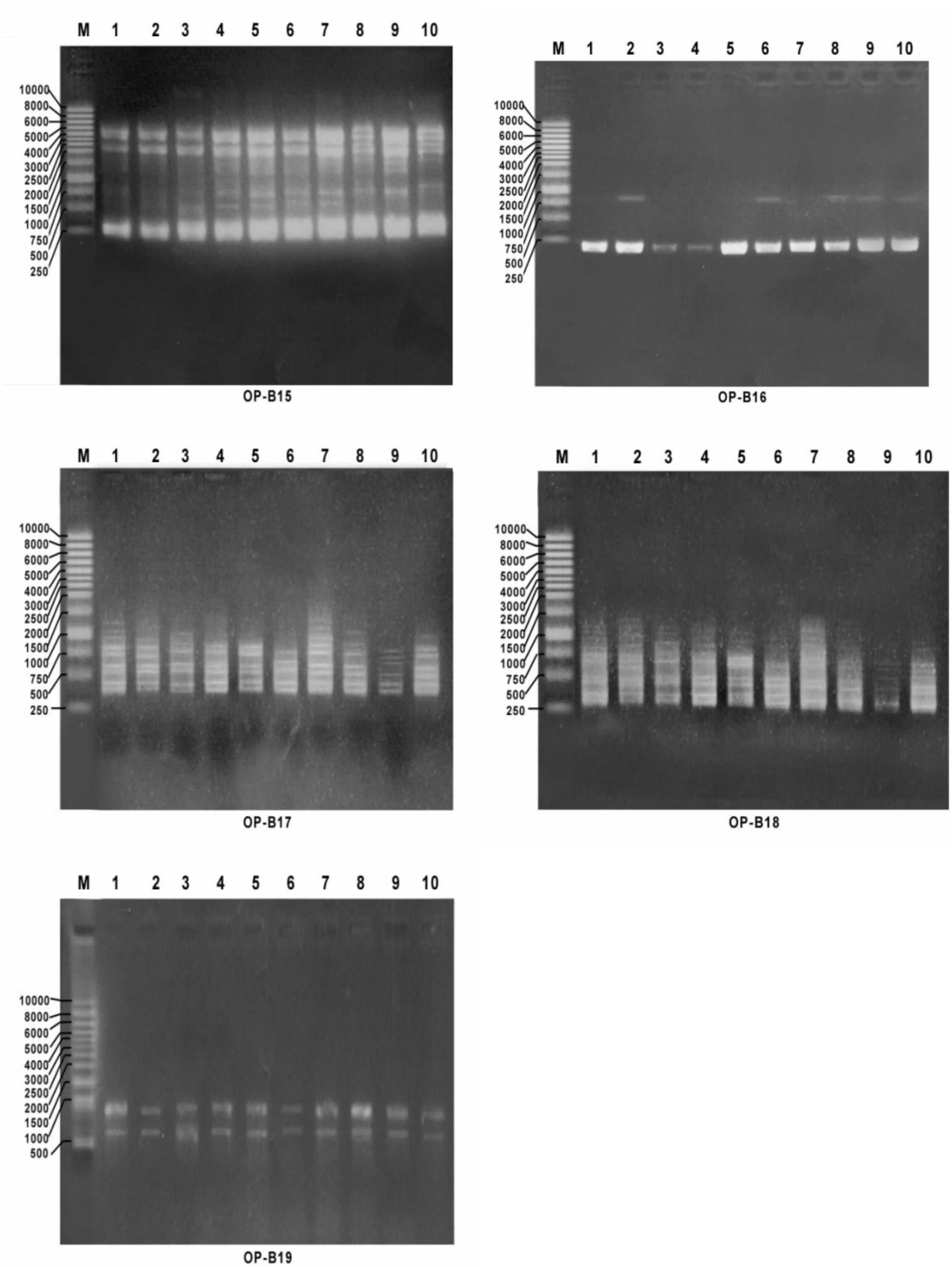

Figure 2. DNA polymorphism using randomly amplifying DNA (RAPD) for two okra varieties (Sabahia: 1 - 5 and Balady: 6 - 10) cultivated during summer seasons 2006 and 2007. The control represent dry seeds: 1 and 6, the other groups of seeds are soaked in water (12 h.): 2 and 7 or treated with different doses of gamma irradiation (300 Gy: 3 and 8, 400 Gy: 4 and 9, 500 Gy: 5 and10).

gamma rays before sowing showed better performance in the field and hence the productivity of plants is greatly enhanced.

REFERENCES

Ahmadi A, Mardeh ASS, Poustini K, Jahromi ME (2007). Influence of osmo and hydropriming on seed germination and seedling growth in wheat (*Triticum aestivum* L.) cultivars under different moisture and temperature conditions. Pak. J. Biol. Sci. 10(22): 4043-4049.

Artk C, Peksen E (2006). The effects of gamma irradiation on seed yield and some plant characteristics of faba bean (*Vicia faba* L.) in M2 generation. Ondokuz-Mays-Universitesi,-Ziraat-Fakultesi-Dergisi, 21 (1): 95-104.

Arvind-Kumar, Mishra MN (2004). Effect of gamma-rays EMS and NMU on germination, seedling vigour, pollen viability and plant survival in M1 and M2 generations of okra (*Abelmoschus esculentus* L. Moench). Adv. Plant Sci. 17(1): 295-297.

Baser I, Bilgin O, Korkut KZ, Balkan A (2007). Improvement of some quantitative characters by mutation breeding in durum wheat. Tarim-Bilimleri-Dergisi, 13(4): 346-353.

Basra SMA, Irfan-Afzal, Rashid RA, Farooq M (2005). Pre-sowing seed treatments to improve germination and seedling growth in wheat (*Triticum aestivum* L.). Caderno-de-Pesquisa-Serie-Biologia, 17(1): 155-164.

Beltagi MS, Ismail MA, Mohamed FH (2006). Induced salt tolerance in common bean (*Phaseolus vulgaris* L.) by gamma irradiation. Pak. J. Biol. Sci. 9(6): 1143-1148.

Cholakova N, Stoilova T, Hadjiiska E (2003). Changes in the seed protein patterns of isogenic pepper lines (*Capsicum annuum* L.) obtained by gamma rays irradiation of the cultivar 'Zlaten medal'. Capsicum and Eggplant Newslett. 22: 91-94.

Danylchenko O, Sorochinsky B (2005). Use of RAPD assay for the detection of mutation changes in plant DNA induced by UV-B and R-rays BMC plant. Biology 5(1).

Dhankhar BS, Dhankhar SK (2003). Effect of gamma rays in okra (*Abelmoschus esculentus* (L.) Moench). Haryana J. Hortic. Sci. 32(1-2): 145.

Dubey AK, Yadav JR, Singh B (2007). Studies on induced mutations by gamma irradiation in okra (*Abelmoschus esculentus* (L.) Monch.). Progressive Agric. 7(1/2): 46-48.

Duncan DB (1965). Multiple Range and Multiple F. Test. Biometrics 11: 1-42.

Dunn MJ (1993). Gel Electrophoresis: Protein. Bios Scientific Publishers pp. 51-53.

Farooq M, Basra SMA, Hafeez-ur-Rehman (2006). Seed priming enhances emergence, yield, and quality of direct-seeded rice. Int. Rice Res. Notes 31(2): 42-44.

Farooq M, Basra SMA, Rehman H, Saleem BA (2008). Seed priming enhances the performance of late sown wheat (*Triticum aestivum* L.) by improving chilling tolerance. J. Agron. Crop Sci., 194(1): 55-60.

Ganapathi TR, Meenakshi Sidha, Suprasanna P, Ujjappa KM, Bapat VA, D'Souza SF (2008). Field performance and RAPD analysis of gamma-irradiated variants of banana cultivar 'Giant Cavendish' (AAA) Int. J. Fruit Sci. 8(3): 147-159.

GuoZhong-Xu, Zheng-XiangLi, Ying-ZhaoYang, Huang-YiBin, Weng-BoQi (2007). Effect of gamma-ray irradiation on *Chamaecrista* spp. nutrient. Zhongguo-Shengtai-Nongye-Xuebao-/-Chinese. J. Eco-Agric. 15(4): 94-96.

Hames BD (1981). An introduction to polyacrylamide gel electrophoresis. IN: Gel Electrophoresis of Proteins. PP. 1-91. B.D. Hames and D. Richwool (Eds.). A Prractical Approach. IRL Press. Oxford Ltd. (Pnb.). UK.

Hamid Eldin NME (2005). Molecular Biological Studies in the effect of gamma rays and mutagenic chemicals on drought resistance in plants. PhD Thesis, Faculty of science, Ain Shams University. Cairo, Egypt.

Jawardena SDL, Peiris R (1988). Food crop breeding in Srilanks-Archivements and challenges. Biol. News, 2:22-34.

Laemmli UK (1970). Clearage of structural proteins during the assembly of the head bacteriophage T4. Nature 227: 680-685.

Maniatis T, Frictsch EF, Sambrook J (1982). Molecular cloning. A laboratory manual. Cold Spring Habor Laboratory Publisher, New York. USA.

Mishra MN, Hina-Qadri, Shivali-Mishra (2007). Macro and micro mutations, in gamma-rays induced M2 populations of Okra (*Abelmoschus esculentus* (L) Moench). Int. J. Plant Sci. Muzaffarnagar 2(1): 44-47.

Mokobia CE, Anomohanran O (2005). The effect of gamma irradiation on the germination and growth of certain Nigerian agricultural crops, J. Radic. Prot. 25(2): 181-188.

Mubshar-Hussain, Muhammad-Farooq, Basra SMA, Ahmad N (2006). Influence of seed priming techniques on the seedling establishment, yield and quality of hybrid sunflower. Int. J. Agric. Biol. 8(1): 14-18.

Nargis S, Gunasekaran M, Lakshmi S, Selvakumar P (1998). Effect of gamma irradiation on seed germination and vigour of tomato (*Lycopersicon esculentum* Mill). Orissa J. Hortic. 26(2): 47-49.

Norfadzrin F, Ahmed OH, Shaharudin S, Rahman DA (2007). A preliminary study on gamma radiosensitivity of tomato (*Lycopersicon esculentum*) and okra (*Abelmoschus esculentus*). Int. J. Agric. Res. 2(7): 620-625.

Raisheed MS, Asad S, Iqbal MJ, Mukhter Z, Zaffar Y, Malik KA (2001). Polymorphic studies employing RAPD analysis in stress- induced variants of sugarcane developed through *in-vitro* techniques. Pak. Sugar J. 16(6): 15-26.

Rao PK, Suvartha C (2006). Effect of gamma rays on *in vivo* and *in vitro* seed germination, seedling height and survival percentage of *Lycopersicon esculentum* cv. Pusa Ruby. Adv. Plant Sci. 19(2): 335-339.

Rashed MA, Fahmy EM, Sallam MA (1994). Embryo culture, protein and isozyme electrophoresis as selectable markers to predict salt tolerance in wheat. 5^{th} Conf. Agricultural Development Research Faculty of Agriculture, Ain Shams Univ. Cairo, Egypt 1: 469-490.

Rejili M, Telahigue D, Lachiheb B, Mrabet A, Ferchichi A (2008). Impact of gamma radiation and salinity on growth and K^+/Na^+ balance in two populations of *Medicago sativa* (L.) cultivar Gabès. Prog. Nat. Sci. 18(9): 1095-1105.

Senthamizh Selvi B, Ponnuswami V, Kavitha PS (2008). Use of RAPD assay for the detection of mutation changes in aonla (*Emblica officinalis* Gaertn.). Adv. Nat. Appl. Sci. 2(3): 129-134.

Sharma BK, Mishra MN (2007). Micro-mutations for fruit number, fruit length and fruit yield characters in gamma-irradiated generation of ANKUR-40 variety of okra [*Abelmoschus esculentus* (L.) Monech]. Int. J. Plant Sci. Muzaffarnagar 2(2): 208-211.

Sharma DK, Rana DS (2007). Response of castor (*Ricinus communis*) genotypes to low doses of gamma irradiation. Indian J. Agric. Sci., 77(7): 467-469.

Singh AK, Singh KP (2003). Induced micromutation through gamma rays and EMS in okra *Abelmoschus esculentus* (L.) Moench. Environ. Ecol. 21(1): 20-27.

Singh AK, Singh KP, Singh RB (2000). Seedling injury, reduced pollen and ovule fertility and chlorophyll mutations induced by gamma rays and EMS in okra [*Abelmoschus esculentus* (L.) Moench]. Vegetable Sci. 27(1): 42-44.

Soehendi R, Chanprame S, Toojinda T, Ngampongsai S, Srinives P (2007). Genetics, agronomic, and molecular study of leaflet mutants in mungbean (*Vigna radiata* (L.) Wilczek). J. Crop Sci. Biotech. 10(3): 193-200.

Sujaya-Das, Anirban-Maji, Puspendu-Singha, Sarkar KK (2007). Selection of some useful mutants of mungbean *Vigna radiata* (L.) Wilczek in generation. Environ. Ecol. 25S(Special 2): 258-260.

Sundaravadivelu K, Ranjithselvi P, Reddy VRK (2006). Induced genetic variability in cotton (*Gossypium hirsutum* L.) for yield and its components. Crop Res. Hisar. 32(3): 442-446.

Vinod, Mishra, JP (1999). Response of okra to gamma-rays. Nat. Acad. Sci. Lett. 22(5/6): 84-85.

Wendt SN, Peters JA, Oliveira AC, Bobrowski VL, Cosa ELC, Madruga CS, Vighi IL (2001). Plant regeneration and molecular characterization of potato cultivar Macaca, obtained from gamma irradiation explants. J. New Seeds, 3(2): 17-37.

Yoko K, Aya M, Hiromi I, Takashi Y, Kukio S (1996). Effect of gamma irradiation on cereal DNA investigated by pulsed-field gel electrophoresis. Shokuhin-Shosha 31: 8-15.