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EFFECTS OF IRRADIATION ON PLANT GROWTH AND SOME PESTS INCIDENCE IN: COTTON AND KIDNEY BEANS

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ABSTRACT

The effects of low doses of gamma irradiation on cotton, *Gossypium barbadence* kidney beans, *Phasolus vulgaris* were investigated. Seeds for each crop were irradiated with 4 doses of gamma radiation, 15, 25, 35 and 45 Kilo rad for cotton and 5, 10, 20 and 30 Kilo rad for kidney beans. Plants of the two crops were used to determine growth parameter. Since, kidney beans plants were negatively affected in the most of its growth parameter as a result of gamma radiation, and cotton plants were highly affected and clearly activated, therefore, the effects of gamma radiation on phenolic compounds and plant tolerance to pests were took place on cotton plants only. Increasing radiation dose obtained increase in number of phenolic compounds; eight different phenolic plants were detected in irradiated cotton plants. Feeding *Spodoptera littoralis* (Boisd.) larvae on irradiated cotton leaf, induced larval mortality with 100, 100, 73.3 and 85 % for the 15, 25, 35 and 45 Kilo rad treatments, respectively, compared with 20% for the larvae feed on control plants. On the other hand, irradiated cotton plants attract aphids compared with its abundance on control plants.

INTRODUCTION

Very early in the last century, gamma-rays were discovered by a New Zealand-born British physicist, Ernest Rutherford that emitted in the decay of radioactive substances. Gamma-rays were the smallest wavelengths and the most energy of any other wave in the electromagnetic spectrum. These waves are generated by radioactive atoms and in nuclear explosions. Gamma-rays can kill living cells, a fact which medicine uses to its advantage, using gamma-rays to kill cancerous cells.

In the 1960s- 1980s there were numerous attempts for inducing genetic variability by irradiation, to serve breeding objectives in food, feed and ornamental plants. Many workers subjected some important crops to low doses of irradiation by gamma rays to obtain an increase in the yield through growth promotion and/or high tolerance of some pests. Low irradiation dose can be used to enhance potato tuberization without fear of genetic changes in the used cultivars (Bassam *et al.,* 2000). Gamma irradiation using to mutate some crops (e.g. cotton and chili) to obtain high abilities to tolerate high temperature and high osmotic pressures (Sheng *et al.,* 2003).

Some workers noticed that gamma irradiation causes significant changes in the pest biology concerning reproduction, irradiation at low

irradiation dose eliminated most Alternaria, Fusarium and Epicoccum sp (Ramakrishna and Lacey, 1991). Also, correlation between irradiation by gamma rays and abundance of some pests in cotton plantations was studied. It was recorded that irradiated plants showed moderate resistance to the leafhopper in age of 45 days after germination (Hormchan *et .al.,* 2001)

This work aims to investigate the effect of gamma radiation in low doses on plant growth and pest tolerance in cotton and kidney beans.

MATERIAL AND METHODS

Seeds of two crops: cotton, *Gossypium barbadence* and kidney beans, *Phasolus vulgaris* were subjected to irradiation by gamma rays. The seeds of each crop were divided into five similar, mature and equal size groups, first group was kept as a control without any treatment, while the other four groups irradiated with gamma rays in dose of 15, 25, 35 and 45 Kilo rad for cotton and 5, 10, 15 and 20 Kilo rad for kidney beans. Irradiation was conducted in the Middle Eastern Regional Center for Arab Countries in Cairo, using Cobalt 60 as a source of radiation. Irradiation process during March 2006 lasted 9 minutes and 34 seconds per each Kilo Rad (Hussein *et al*., 1999 and Hussein *et al.,* 2005).

These steps were carried out to define the following:

1. Determination of plant growth parameter:

Plants of the two crops from each treatment were used to determine, germination %, no. leaves/plant, leaf area (cm^2), no. flowers/plant, plants height (cm), no. pods/plant, pod weight (gm) and pod long (cm).

2. Determination of Phenolic compounds:

Leaf samples of cotton per each treatment was used to determine the phenolic compounds according to Gertz 1990.

3. Determination of plant tolerance:

I. Rearing of *Spodoptera littoralis* on irradiated plants:

The strain of cotton leafworm *Spodoptera littoralis* was established; the eggs were maintained at 27 ± 1 ºC and 65 – 70% RH until hatching. Newly hatched larvae were transferred to glass jars. They were provided with fresh caster oil leaves until reached the second instar larvae.

In order to study the larval development, 15 of 2^{nd} instar larvae for each treatment were transferred to 3 glass jars (5 larvae/ replicate) and provided with fresh pieces of treated (radiated) or untreated (as control) cotton leaves. The larvae were left in the glass jars. Daily observations were recorded regarding larval mortality, larval duration, pupation percentage, pupal duration, pupal mortality and emergence percentage.

II. Pest incidence:

The abundance of some insects and pests which recorded through direct count and / or microscopic investigation of the leaves samples.

RESULTS AND DISCUSSION

1. Determination of plant growth parameter:

1.1. Cotton:

Table (1) and Figs. (1 and 2) showed that the effect of different doses gamma rays on cotton growth parameters in different ages. Results showed that 5 days germination of the treated seeds 25 and 35 Kilo rad of gamma radiation were highly affected and clearly activated with the irradiation as they recorded 34.3 and 22.8 % respectively, while control germination (seeds without irradiation) recorded only17.2 %. Charbaji and Nabulsi. (1999) showed that low doses of gamma rays increased the number of roots in two varieties of grapevine.

The same table showed the no. leaves/plant, there were more leaves in control compared with the other treatments.

Table (1) showed that the plant height was stimulated by the dose 15 Kilo rad, as it recorded average of 28 and 30 cm compared with 21 and 29 cm for control plants, at age of 25 and 32 days, respectively. Shamsuzzamen *et.al.,* (2003) improved the cotton in Bangladesh through mutation breeding using gamma rays; they reported that irradiation and subsequent selections resulted in 12 desirable mutants. Some mutants had the highest, others showed earliness and other mutants had highest fiber length and strength.

Leaf area (cm^2), was presented in the same table, leaf area was wider in control than in all tested doses of gamma rays.

Survivability, (number of survival plant at the age of 45 days) were higher for doses 15 and 25 Kilo rad as it recorded 31 and 28 % compared with 25 % for control. Susan (1976), indicated that gamma rays increase in survival of haploid tobacco *Nicotiana tabacum* L, in addition to malformation in leaves growth were noticed in these doses. Generally, the other growth parameters were reversely affected with increasing doses of irradiation.

Generally, majority of cotton growth parameters was affected by low doses of gamma , Sheng *et al.,* (2003) proved that the dry weight and available P and K of the cotton plant increased in the treated plants compared with the control, which means that the mutations could include potential plant growth promotion.

Table (1) : **Effect of irradiation by different doses of gamma rays on cotton growth parameters.**

Plant growth Parameter	Plant age (days)	Control	Irradiation Treatments (Kilo rad)			
			15	25	35	45
Germination %	5	17.2	11.4	34.3	22.8	5.7
No. leaves/plant	9	12.2	12	9	8.5	6.5
	11	17	15.5	15	11	7.5
	25	68	61	47	36	24
Plant height (cm)	25	21	28	18	11	7.5
	32	29	30	20	12	8
Leaf area(cm^2)	40	30.66	22.54	13.03	8.36	Na*
Survivability %	45	25	31	28	22	5
Malformation	30	0	0	0	+	++

***Na: not available**

Fig. (1): Effect of irradiation by different doses of gamma rays on cotton

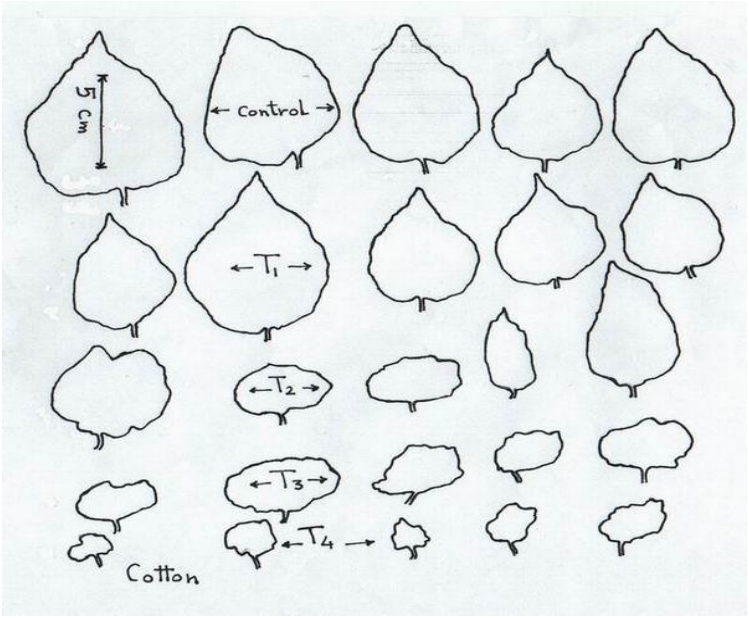

Fig. (2): Effect of irradiation by different doses of gamma rays on cotton leaf area (cm^2)

1.2. Kidney beans:

Table (2) and Figs. (3 and 4) show that the plant growth parameters in Kidney beans for both control and irradiated plants. Data indicated that the highest dose of 30 Kilo rad inhibited seed germination completely.

All growth parameters e.g. germination percentage, number of leaves per plant, leaf area, Plant height, number of flowers were negatively affected as a result of gamma radiation. However slight stimulation for some growth parameters were observed. The 5 Kilo rad irradiation treatment

caused an increase as the average number of pods/ plant (at age of 70 and 86 days) recorded 32 and 86.4 higher than of the control 30 and 65.5 respectively.

Table (2): Effect of irradiation by different doses of gamma rays on kidney beans growth parameter.

Growth Parameter	Plant age (days)	Irradiation Treatments (Kilo rad)				
		Control	5	10	20	30
Germination %	9	50	16.6	10.7	8.9	no data found because 30 Kilo rad inhibited seed germination completely
	17	51.78	26.78	25	8.9	
No. leaves/plant	17	10	8	4	3	
	30	23	20	16	5	
	70	89	81	64	24	
	86	111	95.5	94	42	
Leaf area(cm^2)	86	37.25	29.43	40.83	28.21	
No. flowers/plant	70	82	60	66	9	
	86	56.7	46.7	42.5	21.8	
Plant height (cm)	17	15	13	9	5	
	30	20	16	12	5	
	70	28.7	25.2	24.3	14.3	
	86	29	26	25	16.5	
No. Pods /plant	70	30	32	20	4	
	86	65.5	86.4	60.9	11.4	
Pod weight (gram)	70	2.25	2.2	2.25	1	
	113	2.88	3.16	2.96	1	
Pod long (cm)	113	10.19	10.46	9.54	7.6	

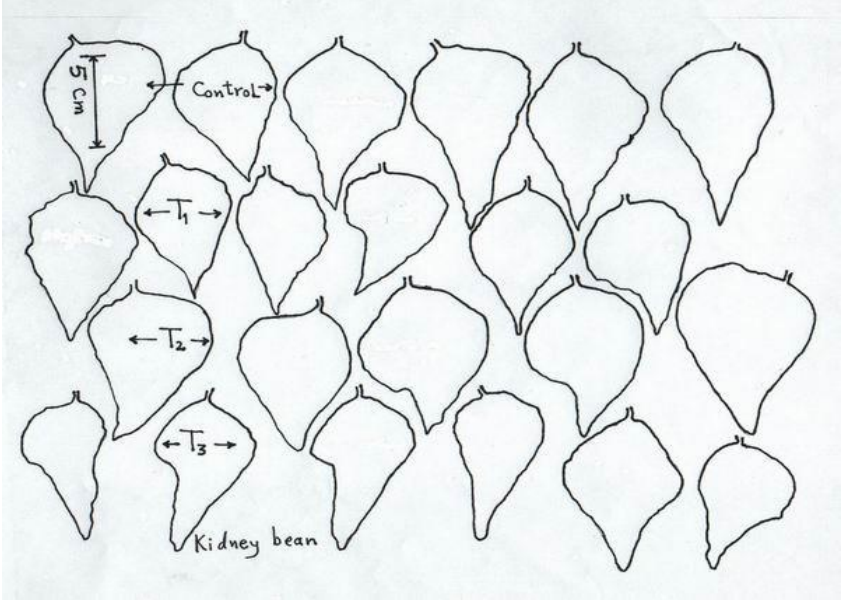

Fig. (3): Effect of irradiation by different doses of gamma rays on kidney beans leaf area(cm^2)

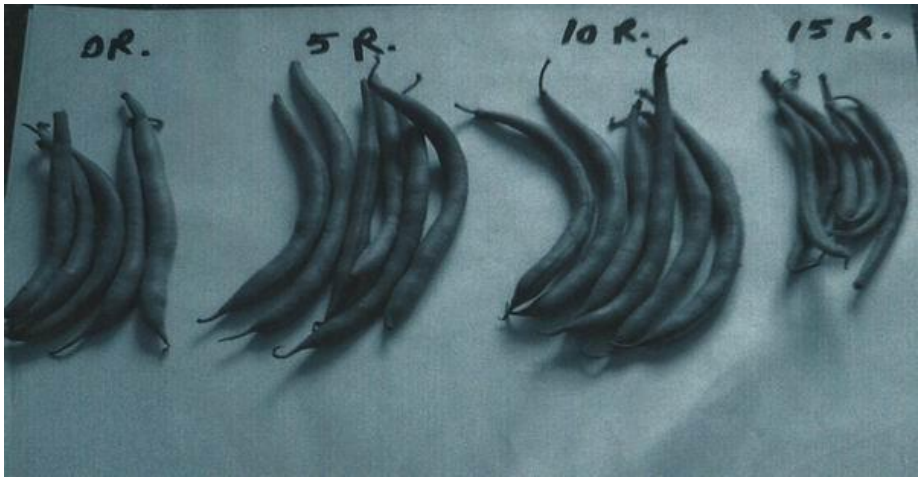

Fig. (4): Effect of irradiation by different doses of gamma rays on kidney beans Pods

The same dose (5 Kilo rad) increased the pod length and weight 10.46 cm and 3.16 gram (at age of 113 days) against 10.19 cm and 2.88 gram, respectively. The dose 10 Kilo rad also stimulated the plant growth in respect of leaf area (at age of 86 days) and pod weight (at 113 days) as they recorded 40.83 cm and 2.96 gram Against 37.25 cm and 2.88 gram for the control plants.

2. Determination of Phenolic compounds:

Chemical characteristics of irradiated crops were studied before, Youssef *et al.,* (1985) obtained that radiation of soybean seeds induce inhibition of 71% of lipoxygenase activities, 25.4% trypsin inhibitor activities, and 16.7% chymotrypsin inhibitor activities were found when the soybean seeds. Also, Zareena *et al.,*(2001) indicated that gamma irradiation caused a decrease in glycosides and an increase in glycol content in saffron crop, *Crocus sativus*. Dar and Ihsanullah (2003) showed that the ascorbic acid decrease in tomato plant as a result of seed radiation by low doses of gamma rays.

Data in Table (3) presents the results of HPLC analysis for determination phenolic compounds in cotton leaves. It indicated that control included only 2 phenolic compounds (Benzonitrile and Diethyl Phthalate), while increasing radiation dose obtained increase in number of phenolic compounds. As, plants treated with 15, 25 and 35 Kilo rad recorded 5 different phenolic compounds, while, the plants treated with 45 Kilo rad 8 different phenolic plants were detected.

Table (3): Determination of phenolic compounds in cotton plants samples

Doses	relative concentration of phenolic compounds %									No. of phenols detected (NPD)
	Benzyl alcohol	Phenol	P- Cresol	Benzonitrile	Dimethyl Phthalate	3-4 dimethyl phenol	2-4 dimethyl phenol	Benzene	Diethyl phthalate	
Control	-	-	-	26.864	43.557	-	-	-	-	2
15	-	4.175	3.332	19.231	42.648	10.942	-	-	-	5
25	-	4.595	11.964	23.591	-	4.247			16.798	5
35	4.071	5.308	10.035	30.590	-	16.869	-	-	-	5
45	14.440	4.062	22.295	12.617	7.504	5. 010	3.172	8.395	-	8

3. Determination of plant tolerance:

I. Effect of feeding *Spodoptera littoralis* **larvae on irradiated cotton leaf:**

Table (4) conducted the influence of feeding cotton leafworm *S. littoralis* larvae on irradiated cotton leaves. Data showed that larval duration recorded 21 days for larvae reared on irradiated plants with 35 Kilo rad compared with 19 days for larvae reared on non irradiated leaves. Larval mortality recorded 100, 100, 73.3 and 85 % for the 15, 25, 35 and 45 Kilo rad treatments respectively. On, the other hand, pupation percentage recorded 80 % for control, while the dose 35 and 45 Kilo rad recorded only 26.7 and 15 % respectively. In the same time, pupal mortality % was 100 % for both 35 and 45 kilo rad doses compared with zero percentage for the control. This disturbance of larvae biology may be due to the new phenolic compounds had formed in the leaves Table (4).

Table (4): Effect of irradiation by low doses of gamma rays on some biological aspects of cotton leafworm and aphid abundance.

Pests	Insect parameters bioaspects	Control	Irradiation treatments (Kilo rad)			
			15	25	35	45
Cotton leafworm	Larval duration (days)	19	0	0	21	19
	Larval mortality %	20	100	100	73.3	85
	Pupation %	80	0	0	26.7	15
	Pupal duration (days)	10.12	0	0	Na	Na
	Emergence %	100	0	0	0	0
	Pupal mortality %	0	0	0	100	100
Aphid	No .of winged aphids/ leaf	0.55	0.2	7.15	1.75	*Na
	No. of non winged aphids/ leaf	3.6	2.55	3.75	4	*Na

***Na: not available**

II. Pest incidence:

The same table shows results of numbers of both winged and non-winged aphids in addition of numbers of moulting skins on cotton leaves. It was noticed that the dose 35 Kilo rad recorded the highest values for the 3 items as they recorded 7.15, 3.75 and 7.55 compared with 0.55, 3.60 and 2.20 for control respectively this results may be due to the different phenolic compounds which formed in tissues of leaves (Table 4), which could attract the aphids, especially the winged form for their ability to move.

REFERENCES

Bassam, A. S.; Z. Ayyoubi and D. Jawdat. (2000). The effect of gam irradiation on potato microtuber production in vitro. *Plant Cell, Tissue and Organ Culture*ma*. 61(3):* 183-187*.*

Charbaji, N. and I. Nabulsi. (1999). Effect of low doses of gamma irradiation on in vitro growth of grapevine. *Plant Cell, Tissue and Organ Culture. 57(2): 129-132*.

Dar N. G.; T. N. Ihsanullah and Khattak A. D. (2003): Effect of radiation on the physico-chemical characteristics of tomato during storage. *Pakistan J. Sci. Indust. Res. 46: 5, 383-388.*

Gertz, C. H. (1990). HPLC tips and tricks with over 1000 applications. *Great Britain, Add. Press, Oxford. pp. 608.*

Hormchan, P.; A. Wongpiyasatid; and A. S. Piyapuntaw (2001): Observation of gamma irradiated cotton populations on trend of cotton leafhopper resistance using hopper burn index. *Natural Sci. 35(4): 386-391*.

Hussein, A. M; Fatma S. Ali and A. A. Siliman (1999): Utilization of gamma rays to control the two spotted spider mite *Tertanychus uriticae* Koch Minufiya J. Agric.Res., 26, (1):157-168.

Hussein, A. M; Fatma S. Ali; S. A. Allam and H. M. Nenaey (2005): Irradiation and new aspects crop pests control: *Tertanychus uriticae* Koch Minufiya J. Agric.Res., 30, (6):1835-1842.

Ramakrishna N.; J. Lacey; J. Smith. (1991). Effect of surface sterilization, fumigation and gamma irradiation on the microflora and germination of barley seeds. *Int. J. Food Microbiol. 13(1):47-54.*

Shamsuzzaman, K. M.; M. A. Hamid; M. A. K. Azad; M. Hussain and M. A. Majid (2003): Varietals improvement of cotton *Gossypium hirsutum* through mutation breeding. *Int. Atomic Energy Agency Tech. Doc., IAEA TECDOCs, (1369): 81-94.*

Sheng, X. F.; J. J. Xia and J. Chen. (2003): Mutagenesis of the *Bacillus edaphicus* strain NBT and its effect on growth of chili and cotton. *Agric. Sci. China. 2(4): 409-412.*

Susan E. (1976). Effect of gamma- and ultraviolet-irradiation on survival and totipotency of haploid tobacco cells in culture. *Protoplasma. 89(1): 149-155*

Youssef S. H.; A. Mohamed; G. SINGH and F. M. Hewedy. (1985). Effects of Gamma Irradiation on Proteins and Fatty Acids of Soybean. *J. Food Sci. 50 (5), 1271–1274.*

Zareena A.V.; P. S. Variyar; A. S. Gholap and D. R. Bongirwar (2001): Chemical investigation of gamma irradiated saffron *Crocus sativus* L. *J. Agric. Food Chem. 49(2): 687-691.*

تـأثير الإشـعاع علـى نمـو النباتـات وتواجـد بعـض الآفـات فـي محصـولي القطـن والفاصوليا

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تم دراسة تأثير استخدام الجرعات المنخفضة من أشعه جاما لتشعيع بذور نباتات القطن و الفاصوليا، تم التشعيع بأربعة جرعات مختلفة ١٥ و ٢٥ و ٣٥ و ٤٥ كيلو راد و ٥ و ١٠ و و٢٠ و ٣٠ لكل من بذور القطن و الفاصوليا، علي التوالي. تم تقييم قياسات النمو لكل نبات، أعطت النتائج تأثيرا سلبيا علي كلا النباتين في الجرعات العالية ، بينما أدت الجرعات المنخفضة إلي تنشيط بعض قياسات النمو الخاصة بالمجموع الخضري والمحصول . تم الكشف عن تأثير الإشعاع علي وجود المواد الفينولية و مدي مقاومة النباتات للإصابة بكل من دودة ورق القطن و المن.

أدت زيادة الجرعة المستخدمة من الإشعاع إلي زيادة المواد الفينولية حيث زادت إلي ثمان مواد إضافية في النباتات المشعة عن المقارنة والتي كان بها مادتين فقط . أوضحت النتائج إلي ارتفاع نسب الموت اليرقى نتيجة تغذية يرقات دودة ورق القطن علي أوراق القطن المشع إلي ١٠٠ و ١٠٠ و ٧٣,٣ و ٨٥ و ٢٠ % لكل من الجرعات ١٥ و ٢٥ و ٣٥ و ٤٥ كيلو راد و المقارنة، علي التوالي. علي الجانب الآخر اجتذبت نباتات القطن المشعة حشرات المن مقارنة بالنباتات غير المشعشعة.