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Combined Effect of Gamma Irradiation and Ten Plants on Potato Tubermoth *Phthorimaea operculella* (Zeller) Larval Mortality

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Abstract: The combined effect of ten plants (from eight different families) and gamma radiations were tested on larvae of potato tubermoth (P. T. M.), *Phthorimaea operculella* (Zeller). The insecticidal effect of different plants and mortality percentages were recorded on third larval instar. Results indicated that *Matricaria chamomilla* scored the higher mortality percentage followed by *Lupinus termis*. Newly hatched larvae were used to evaluate the effect of ten plants on the percentages of infestation, pupation, emergence and sex ratio. *Matricaria chamomilla* and *Lupinus termis* were completely toxic to (P. T. M.) larvae, followed by *Anethum gravelones* and *Apium graveolens*. The other plants succeeded to minimize the hazards and reduced viability of *P. operculella*. When potato tubers were irradiated (100 Gy) the lethal effect of the ten plants was increased and it inhibited the sprouting. Data showed that *Trigonella foenum*, unexpectedly, did not have toxic effects on (P. T. M.) larvae and it helped the larvae to complete the life cycle normally as control and to tolerate the radiation effect.

Key words: Gamma radiations, *Phthorimaea operculella*, botanical powder.

Introduction

The potato tubermoth, *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae) is a serious pest for solanaceous crops and caused damage to potato plants, leaves and tubers in field and storage (EL-Sinary, 1995).

Chemical control is the common method for tuber disinfestation but its extensive use has led to many problems such as the presence of undesirable residues, which are considered as potential health hazards, development of insect resistance or tolerance to chemicals and chemical fumigations fail to kill the larvae that live inside the stored tubers (Haiba, 1990).

There is thus an urgent need for safe but effective biodegradable pesticides with no toxic effects on non-target organisms. This has created a world wide interest in the development of alternative strategies, including the search for new types of insecticides and the re-evaluation and use of age-old, traditional botanical pest control agents (Heyde *et al.*, 1983). Botanical insecticides have broad spectrums in pest control, and many are safe to apply, unique in action and can be processed and used easily. Locally available plants and minerals have been widely used in past to protect stored products against damage by insect infestation (Golob and Webley, 1980). The ability of some plants to control, *P. operculella* on potato tubers at storage, in the form of repellents or insecticides has been described by many authors (Alawas and Colting, 1986; Raman *et al.*, 1987; Ewell *et al.*, 1990; Doss *et al.*, 1994; Hany, 1998; Haiba, 2000 and EL-Sinary and Rizk, 2001). The main advantage of botanicals is that they are easily produced by farmers at small-Scale industries and are potentially less expensive.

Gamma-irradiation looks more effective and safer (Ahmed *et al.*, 1993), as well as cheap. The application of gamma-irradiation for the extended commercial storage of potatoes was carried out by Nouami *et al.* (1987) ; Ahmed *et al.* (1989); Haiba (1994) and Saour *et al.* (1997). The present study, was designed to investigate the toxicity of ten plants and the combined effect of gamma-irradiation and the used plants on the larvae of *P. operculella* (P. T. M.).

Materials and Methods

Rearing technique: The potato tubermoth, (P. T . M.) were reared mainly on potato tubers in the laboratory of Entomology, in National Center for Radiation Research and Technology. Potato tubers were cleaned from dust and parasites by washing and drying with clean towels or tissue papers.

A thin layer of clean sand (exposed to high temperature in oven to kill other insects or parasites) was distributed on the bottom of the rearing cages to allow the pupation (Hemeida, 1976).

Irradiation technique: The irradiation source was the Gamma Cell Irradiation Unit (^{60}Co source) located at National Center for Radiation Research and Technology, Atomic Energy Establishment, with a dose rate of 2.1 rad/sec.

Potato tubers were exposed to gamma-radiation dose of 100 Gy. This dose was chosen according to Haiba (2000) who proved that the doses 100, 150 and 200 Gy inhibited the sprouting of potato tubers.

Preparation of plants: Plant parts used were air dried and then ground in an electric grinding machine.

Biological effects of different plants on newly hatched larvae of P. T. M: About 50 grams of each ground plant was spread over non-irradiated and irradiated potato tubers. Fifty newly hatched larvae (neonate) of P. T. M. / 500 gm potato tubers were introduced to each cage and the cages were observed daily. The percentages of infestation, pupation, emergence and sex ratio were computed. The experiments were triplicated.

Plants maintenance: Ten available plants which are common in Egypt are maintained in Table 1.

Table 1: Plants being maintained for experiment

Scientific name	Family name	Part of plant used
Matricaria chamomilla	Astraceae	Flowers
Lupinus termis	Fabaceae	Seeds
Piper nigrum	Piperaceae	Fruits
Mentha spicata	Lamiaceae	Leaves
Anethum graveolens	Apiaceae	Leaves
Apium graveolens	Apiaceae	Leaves
Trigonella foenumgraecum	Fabaceae	Seeds
Lantana camara	Verbinaceae	Flowers and leaves
Nicotiana tabacum	Solanaceae	Leaves
Poinciana regia	Ceasalpineaceae	Leaves

Evaluation of susceptibility of the third instar larvae to the toxicity of different plants: All potato tuber slides had 15 larvae in third instar (for each replicate). Mortality was recorded after 24, 48 and 72 hr. after treatment for each plant and control. The experiments were triplicated. Percent mortality was calculated in larvae for different plants and were corrected by Abbott's formula (1925), when control mortality was between 5 and 20%.

Statistical analysis: The results were statistically analyzed and the values of L. S. D. were determined, whenever, the calculated "F" values were significant at 5% and 1% level (Snedecor and Cochran, 1980).

Results and Discussion

Table 2 shows the insecticidal activity of different plants. Mortality was recorded after 24, 48 and 72 hrs for each plant and for the control. From Table 2 we notice that *Matricaria chamomilla* caused the highest percentage of mortality being (60.0, 71.42 and 92.85) at 24, 48 and 72 hrs respectively, while the lowest percentage of mortality was recorded in *Trigonella foenum* being zero at 24, 48 and 72 hrs. The others have intermediate or moderate values for percentage mortality.

Anethum graveolens caused 46.67% mortality at 24 hrs. that increased to 57.14% at both 48 and 72 hrs. *Apium graveolens* also caused 33.33, 49.99 and 64.29% mortality at 24, 48 and 72 hrs. Both *Lantana camara* and *Nicotiana tabacum* caused 13.33% mortality at 24 hrs increasing to 21.42 and 35.71 at 48 hrs and to 35.71 and 49.99% at 72 hrs. Finally *Poinciana regia* caused (40.0, 57.14 and 78.57) at 24, 48 and 72 hrs, respectively. Statistical analysis showed highly significant difference between, *Matricaria chamomilla*, *Lupinus termis*, *Anethum graveolens*, *Piper nigrum*, *Poinciana regia* and *Apium graveolens* as compared with control.

Table 3 shows the effect of ten plants on infestation, pupation, emergence and sex ratio percentages of *P. operculella* (P. T. M.). It was clearly noticed from Table 3 that *Matricaria chamomilla* and *Lupinus termis* caused no infestation to the tubers, while *Trigonella foenum* and the control caused 100% infestation.

Mentha spicata and *Apium graveolens* caused 50% infestation, 25% infestation was occurred in case of treatment with *Piper nigrum*, *Anethum graveolens* and *Poinciana regia* while *Lantana camara* and *Nicotiana tabacum* caused 80% and 10% infestation, respectively. Statistical analysis showed that *Matricaria chamomilla* and *Lupinus termis* caused no infestation (0.0%), while in all other plants the differences were highly significant except *Trigonella foenum*, which caused 100% infestation as in case of control.

Percentage of pupation was 88.0 in control, 86.67 in *Trigonella foenum* and decreased sharply to 15.33, 9.33, 6.6 and 6.0 in *Lantana camara*, *Apium graveolens*, *Mentha spicata* and *Piper nigrum*, respectively, while in case of treatment with *Anethum graveolens*, *Nicotiana tabacum* or *Poinciana regia* the percent of pupation was 4.0% only. Statistical analysis showed that highly significant percent pupation was occurred in case of treatment with all plants except *Trigonella foenum*.

Percent emergence was zero in case of treatment with *Apium graveolens* and *Anethum graveolens* while the highest percent of emergence was observed in treatment with *Trigonella foenum* being 96.15% compared to 95.45% in control. The percent emergence were 19.33, 40.0, 34.78, 50.0, and 50.0 for *Piper nigrum*, *Mentha spicata*, *Lantana camara*, *Nicotiana tabacum* and *Poinciana regia* respectively. Percent emergence was significantly high in all treatments with different plants with the exception of *Trigonella foenum*.

The number of emergence males, as shown in Table 3 exceeded significantly as compared with the number of females in all treatments, except in *Trigonella foenum* again. All the previous results were in agreement with many authors on other insects. Lichtenstein *et al.* (1974) stated that the *Anethum graveolens* plant contains insecticidal components. Su (1977) and Scott and Mickibben (1978), proved that ground *Piper nigrum* were highly toxic to rice weevil, and boll weevil, respectively. Pandy *et al.* (1986) tested neem, *Lantana camara* against the stored product pest *Callosobruchus chinensis* by mixing them with seeds of *Phaseola awreus* and *Vigna radiate* and concluded that plants were highly toxic repellents to this pest. Ismail *et al.* (1996) examined the antifeeding activity of five plant extracts namely *Anethum graveolens*, *Matricaria chamomilla*, *Lupinus termis*, *Mentha spicata* and *Apium graveolens* against the fourth instar larvae of the black cutworm, *Agrotis ipsilon* and concluded that *Mentha spicata* and *Apium graveolens* had the least deterrent action while, *Anethum gravelones* and *Matricaria chamomilla* followed by *Lupinus termis* possessed the highest positive antifeeding effect. Similar findings were carried out on the potato tubermoth *P. operculella*. Haiba (1996), who found that the exposure of potato tubermoth (P. T. M.) to vapours of 0.1 ml oil of *Apium graveolens* and *Anethum gravelones* led to highly significant decrease in the percent pupation from 50 to 24.3%. Hany (1998), proved that the treatment of *P. operculella* with dry leaves of *Lantana camara* decreased significantly the infestation rate of (P. T. M.) and thus effectiveness can be explained by the repellent effect of these leaves, in addition to its possible role as an antifeedant to this pest. EL-Sinary and Rizk (2001) reported that when neem extract was applied to (P. T. M.) larvae, the pupation, emergence, successive infestation percentages decreased as the concentration of neem extract increased.

When potato tubers irradiated with 100 Gy, besides treatments with different plant powders, it was noticed that the percent infestation decreased comparing to that treatments with plants only in case of *Mentha spicata*, *Anethum gravelones*, *Lantana camara* and *Poinciana regia* (Table 4). Infestation percentage was zero in case of *Matricaria chamomilla* and *Lupinus termis* and 10% in case of *Anethum gravelones* and *Nicotiana tabacum* and become 25% in *Piper nigrum*, *Mentha spicata* and *Poinciana regia*. In case of *Apium graveolens* and *Lantana camara* the infestation was 50%, while infestation was 100% in case of *Trigonella foenum* just like control. It was clearly noticed that, while *Matricaria chamomilla* and *Lupinus termis* caused no infestation (0.0%), all the other plants exhibited highly significant effect as compared to control except *Trigonella foenum* .

Percent pupation was decreased being 0.0, 0.0, 4.0, 4.67, 3.33, 8.00, 73.33, 12.67, 3.33, 2.0 and 76.0 in *Matricaria chamomilla*, *Lupinus termis*, *Piper nigrum*, *Mentha spicata*, *Anethum gravelones*, *Apium graveolens*, *Trigonella foenum* , *Lantana camara*, *Nicotiana tabacum*, *Poinciana regia* and control, respectively when compared with larvae exposed to plants powders and non-irradiated potato tubers (Table 4). All plants had highly significant effect than control except *Trigonella foenum*, which always gave non-significant results in comparison with control.

Effect of gamma-irradiated potato tubers besides the effect of plants decreased the percentage of emergence than results obtained with the effect of plants only. Percent emergence became zero in case of *Matricaria chamomilla*, *Lupinus termis*, *Anethum gravelones* and *Apium graveolens* and increased

Table 2: Effect of different plants used on third instar larvae of (P. T. M.) *P. operculella* (Zeller).

Plants	Hours					
	24 Hrs		48 Hrs		72 Hrs	
	% Average mortality	% Corrected mortality	% Average mortality	% Corrected mortality	% Average mortality	% Corrected mortality
Matricaria chamomilla	60.0	60.0	73.33	71.42	93.33	92.85
Lupinus termis	53.33	53.33	60.67	57.86	86.67	85.71
Piper nigrum	40.0	40.0	60.0	57.14	73.33	71.42
Mentha spicata	20.0	20.0	33.33	28.57	33.33	28.57
Anethum graveolens	46.67	46.67	60.0	57.14	60.0	57.14
Apium graveolens	33.33	33.33	53.33	49.99	66.67	64.29
Trigonella foenum	0.0	0.0	0.0	0.0	6.67	0.0
Lantana camara	13.33	13.33	26.67	21.429	40.0	35.71
Nicotiana tabacum	13.33	13.33	40.0	35.71	53.33	49.99
Poinciana regia	40.0	40.0	60.0	57.14	80.0	78.57
Control	0.0	0.0	6.67	0.0	6.67	0.0
L.S.D. 0.05		4.4		9.8		129
0.01		15.3		13.0		17.3

Table 3: Effect of the ten plants on percentage of infestation, pupation, emergence and sex ratio of (P. T. M.) *P. operculella* (Zeller).

Plants	% Infestation	% Pupation	% Emergence	Sex ratio	
				Male	Female
Matricaria chamomilla	0	0	0	0	0
Lupinus termis	0	0	0	0	0
Piper nigrum	25.0	6.0	19.33	100.0	0.0
Mentha spicata	50.0	6.67	40.0	75.0	25.0
Anethum graveolens	25.0	4.0	0.0	0.0	0.0
Apium graveolens	50.0	9.33	0.0	0.0	0.0
Trigonella foenum	100.0	86.67	96.15	51.2	48.8
Lantana camara	80.0	15.33	34.78	62.5	37.5
Nicotiana tabacum	10.0	4.0	50.0	100.0	0.0
Poinciana regia	25.0	4.0	50.0	100.0	0.0
Control	100.0	88.0	95.45	52.38	47.62
L. S. D.		3.7	9.8	4.4	6.3
		4.9	13.7	5.9	8.4

Table 4: Combined effects of the ten plants and gamma radiation on percentage of infestation, pupation, emergence and sex ratio of (P. T. M.) *P. operculella* (Zeller).

Plants	% Infestation	% Pupation	% Emergence	Sex ratio	
				Male	Female
Matricaria chamomilla	0.0	0.0	0.0	0.0	0.0
Lupinus termis	0.0	0.0	0.0	0.0	0.0
Piper nigrum	25.0	4.0	0.0	0.0	0.0
Mentha spicata	25.0	4.67	28.57	100.0	0.0
Anethum graveolens	10.0	3.33	0.0	0.0	0.0
Apium graveolens	50.0	8.00	0.0	0.0	0.0
Trigonella foenum	100.0	73.33	90.9	55.0	45.0
Lantana camara	50.0	12.67	31.58	66.67	33.33
Nicotiana tabacum	10.0	3.33	40.00	100.0	0.0
Poinciana regia	10.0	2.0	33.33	100.0	0.0
Control	100.0	76.0	78.95	60.0	40.0
L.S.D. 0.05		15.6	0.0	0.0	0.0
0.01		20.8	0.0	0.0	0.0

to 28.57, 90.91, 31.58, 40.0, 33.33 and 78.95 in case of *Mentha spicata*, *Trigonella foenum* , *Lantana camara*, *Nicotiana tabacum*, *Poinciana regia* and the control, respectively (Table 4). It was regarded that *Trigonella foenum* scored higher percentage of emergence than control i.e. *Trigonella foenum* reduced the lethal effect of gamma rays on (P. T. M.) at different developmental stages.

Irradiation of potato tubers with 100 Gy decreased the number of emerged females as compared to males i.e. the number of males exceeded that of the females significantly than control in all treatment with whole the used plant powders (Table 4). These results agreed with those obtained by Rizk (1991), who stated that the combined treatments of some insecticides and radiation to *Spodoptera littoralis* caused great reduction in percentage of pupation and emergence as compared to the effect of radiation alone.

Also Rizk (1998) found that gamma radiation and plants extracts of *Azadirachta indica* and *Thevetia merifolia* and their combination lead to an increase in the percentage of sterility in *Corcyra cephalonica*, however the combined effect was more pronounced. Also, results go in line with those of Haiba (2000), who proved that the integration of plants (rice straw and cotton stem) and gamma-irradiation (70 and 100 Gy) gave better results than the use of plant alone, for controlling the *P. operculella*; disinfest the potatoes from the natural attack by this pest after the harvest and before storage and protect the

disinfested tubers from reinfestation during storage.

Generally, it was concluded that, the most effective plants were *Matricaria chamomilla* and *Lupinus termis* which gave 100% mortality to P. T. M. larvae. All the other plants were effective, and caused lethality to P.T.M. larvae in different ratios and increased males: females ratios which decrease the progeny of P. T. M. for their long run usage (except *Trigonella foenum*). Irradiation, besides its role in stopping the sprouting during potato tubers storage, it increased the lethal effect of the plants (except *Trigonella foenum*). The best results were obtained when the potato tubers were irradiated with 100 Gy of gamma rays followed by dusting the plants powder on tubers.

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