STUDIES ON POTATO TUBER MOTH,
PHTHORIMAEA OPERCULELLA (ZELLER)
(GELECHIIDAE: LEPIDOPTERA)
AND IT'S CONTROL

By

Maha Sabry Mohamed El-Ghanam

B.Sc. Faculty of Agric. Moshtohor Zagazig University

1999

DISSERATATION

Submitted in partial fulfillment of the

Requirements

For

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Studies on potato tuber moth, Phthorimaea operculella (zeller) (Gelechiidae: Lepidoptera) and its control.

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INTRODUCTION

INTRODUCTION

Potato (*Solanum tuberosum* L.) is an important vegetable crop in Egypt, which is seriously infested by the potato tuber moth, *Phthorimaea operculella* (Zell.) (Lepidoptera : Gelechiidae) especially, in the field and in stores (Abd El-Salam *et al.,* 1972), Shaheen (1979), Heeder (1983), Doss (1984), Iskander (1985); Khalil *et al.* (1987), Ahmed (1991), Dawood (1999) and Abd El-Wahab (2003). Infested tubers become completely unmarketable. Chemical control of this potato tuber moth is a costly input that contaminated the environment, increase resistance to insecticides and can also cause health hazards for the humans.

Recently, natural plant products are presently in the focus of research efforts because of their mammalian safety and their efficacy against pests. Much research has been conducted on the effectiveness of plant products for insect control in stored potato (Gomaa, 2002). Promising results against stored product pests with plant extracts, dust sand oils as pest control agents were reported by several investigators (Su, 1985 & 1989; El-Lakwah *et al.,* 1992; 1993, 1995, 1996 and 1998; Shemais and Al-Moajel 2000, Eid 2001; Fatoh 2003).

The present study aims to investigate the following items for the potato tuber moth, *P. operculella.*

1. Estimation of *P. operculella* larvae population on the different potato cultivars (Diamont, Sponta and Karo) and their relative susceptibility to infestation by the potato tuber moth in the field.
2. Effect of three temperatures (20, 25 and 30°C and 70 ± 5 R.H.) on certain biological aspects of the potato tuber moth in the laboratory using two potato varieties (Diamont & Sponta).
3. Effectiveness of the petroleum ether extracts of cumin seeds (*Cuminum cyminum* L.), dill seeds (*Anethum graveolens*) and castor bean leaves (*Ricinus communis*); the water extract of garlic (*Allium sativum*), the bioinsecticides-Protecto and the powders of Black pepper seeds (*Piper nigrum*), clove flowering buds (*Syzygium aromaticum*), santonica flowers (*Matricaria chamomillia*) were tested against *P. operculella* in the laboratory .

REVIEW OF LITERATURE

REVIEW OF LITERATURES

1. Susceptibility of potato cultivars on potato tuber moth, *Phthorimaea operculella* (Zeller) infestation:

In Egypt, **Assem (1966)** studied the varietals resistance to infestation with *Phthorimaea operculella* in tubers resulting from both shallow and deep cultivations in case of shallow tubers, the least infested varieties were Alphaa, King Edward, Lori, Alpha B and Modor (4-7% infestation), while the heaviest infested ones (39-55%) were Perviosnck, Gevoont and Kerpondy. In case of Deep tubers; alpha A, Clivia, King Edward and Perviosnek showed lowest infestation level (1%), while Kerpondy, Up-To-date and Gevont were the heaviest infested (11-14%). The same author concluded that in both Shallow and deep Tubers; the lightly infested varieties were Alpha A, Alpha B, Condea, Daroli, Fina, King Edward, Lori and Mador. Most of the tested varieties were categorized as moderately infested, irrespective to the tubers position, while pervious snek, Aran Banner, Claudia, Kers pink and Majestic varieties were found severally infested in the shallow tubers and highly infested in the deep tubers.

Abd El-Salam *et al.* (1972) conducted four experiments in Egyptian field and in storage to evaluate the susceptibility of the potato variety Alpha (A), Alpha (B), alpha (E), Aran Banner, Claudia Gevont (Pol) Seinge, Patrones, Pervisonik and Up-To-attack by *P. operculella.* Cludia proved as the least susceptible variety followed by Alpha A, while Seinge was the most susceptible.

In New Zealand, **Foot (1976)** tested the susceptibility of twenty potato cultivars to *P. Operculella* and stated four relative levels of foliar and tuber infestation by its larvae, none showed and evidence of resistance varieties with a prolonged upright growth habit and few leaves close to the soil surface sustained low leaf mining populations. Light tuber infestation was associated with growth habits such as deeper tuber set.

Fenemore (1978) in New Zealand also, found that large surface depressions and hairy substrates on tubers were much more attractive to the tuber moth for egg lying than smoth ones. The author suggested that mechanical stimulation of tactile hairs on the oviposition may account for these effects.

In Chile, **Guglielmetti (1978)** found that 20 cultivars of potato were significantly different in percentages of damaged tubers at harvest due to *P. operculella* this difference was attributed to tolerance to attack rather than to true resistance.

Harris (1978) in Australia studied *P. operculella* larval feeding on the foliage of five potato varieties. Early Carmen variety was found the most severaly damaged and the variety Snow Falk was the least damaged. Cultivation of deep tuber varieties prevented worms to attack tubers.

Temerak (1978/79) tested three potato varieties (Alpha; Claudia and King Edward) to evaluate the potato tuber moth infestation at different level soft soil moisture. The author found that the differential response of tested potato varieties to infestation was insignificant.

Shaheen (1979) stated that the less susceptible potato varieties to infestation with *P. operculella* are characterized by moderate size tubers which develop deeper down in the soil beside being compact to stem of eight tested varieties, Knebec proved to be the most susceptible followed by Desiree and Baraka.

Raman and Palacois (1982) in Peru, Screened 3747 accession of primitive cultivars and 452 wild potato species for resistance to *P. operculella* and investigated 22 primitive and 21 wild accession resistant to the insects attack. They found that the resistance was attributed to antibiosis.

El-Sayed (1983) in Egypt, studied the susceptibility of ten potato varieties, in Kafr El-Zayat, (Garbia Governorate). The author found that in summer season, the potato tuber moth infestation on the foliage and tubers was severe during late plantation, while the infestation was lighter through early one. Symptoms appeared firstly on the foliage at the second half of March. Potato plants of the winter season were nearly free from infestation, while the infestation was higher in tubers during late plantation an early one. The differences among the tested potato varieties in tuber worm infestation on the foliage were insignificant. However, there was a significant difference among them in tubers infestation. The same author recorded three varieties (Monitor; King Edward and Dunja) as lightly infested, Alpha, Aula, Osatara and Blanka were categorized as of moderate infestation level, while Desiree; Atica and Granola were severally infested.

Heeder (1983) studied the relative susceptibility of 26 potato varieties infestation with the potato tuber moth, the light infestation varieties were Jaerla; Alpha; Explera; Patrone and Desiree. The moderate infestation varieties were Renova; Fundy; Kennbes and King Edward; while Culba; Sintje; Marion; Cosima; Grate and Aron varieties were heavily infested. Susceptibility was related to the vegetative growth where the less susceptible plants were relatively poored.

Doss (1984) studied the relative susceptibility of 17 potato varieties to infestation by *P. operculella* in tubers at harvesting Kalubia and Minia Governorate. Sponta and Diamont were the least susceptible varieties. The author also mentioned that stored potato tubers were lightly infested by *P operculella* in June but the level of infestation steadily increased in July and August, reaching a peak in

September and was greater in Minia than Kalubia from field studies on five potato varieties (Kondor, Garcia, Renska, Monalisa and Vulkano) at Kalubia, Egypt.

In Egypt, **Iskander (1985)** found that Monalisa variety was most susceptible; Kondor and Garcia varieties were less susceptible as foliage infestation. As for tubers infestation; moderate rates occurred in Vulkano and Renska varieties, while light infestation levels were recorded on Kondor, Monalis and Garcia varieties. The authors also found that the density of leaf hairs, leaf moisture and protein content had no correlation with infestation, whereas, a slight positive correlation was evident between insect abundance and length of hairs.

Ghalla and Chandla (1986) in India, screened sixty potato cultivars in the laboratory for their resistance to *P. operculella* of the tested cultivars, QB/Q21-29 was defined as resistant, while Kufri Red, Kufri Shakti, QB/A 16-43 and VB/A 92 were tolerant.

Khalil *et al.* (1987) carried out field studies in Egypt on the susceptiblility of 4 varieties of potato (Arran Banner, Cosima, Draga and Claudia) to *P. operculella* infestation. Their results indicated insignificant differences between the varieties. However, insect population was greater in the summer season than in the "Nili" season.

Suriaatmadja (1988) in Indonesia, studied the effect of five potato varieties (Draga, Raban 106, Katella, Desiree and Thung 151), 2 bed heights (20 and 40 cm) and treatment with orthene 75 sp (Acephate) at 1% on the incidence of damage by *P. operculella.* Katella variety had the lowest incidence of damage and the highest yield. Treatment with 1% Acephate gave complete control after 30 days.

Gyawali (1989) mentioned that, the local potato variety Red Round was highly preferred by females of *P. operculella* for oviposition as compared with improved varieties, difference in preference between the varieties Nil 108, NPI 106, Cardinal and Kufri Jyoti.

Field studies were carried out in Bangladesh by **Ahmed *et al.* (1990)** to determine the susceptibility of five potato varieties (Patrones, Cardinal, Multa, Diamont and Lalpakhi) to *P. operculella.* Lalpakhri was the least susceptible variety both in the field and storage (15.67 and 23.30% damage, respectively), whereas, Cardinal was the most susceptible variety in the field (46.67% damage), and Multa the most susceptible in storage (46.60% damage).

Ahmed *et al.* (1991) studied in Bangladesh the susceptibility of the potato varieties Patrones, Cardinal, Multa, Diamont and Lalpakhi to *P. operculella.* Lalpakhri was the least susceptible variety both in the field and storage (15.67 and 23.30% damage, respectively), whereas, Cardinal was the most susceptible variety in the field (46.67% damage), and Multa the most susceptible in storage (46.60% damage).

In Egypt, **Iskander (1992)** tested twelve imported varieties of potato (Monalisa, Obelix, Vital, Famosa, Mondial, Kondor, Lesita, Morene, Timate, Gigant, Diamont, and Alpha) but none of these varieties proved resistant to *P. operculella* infestation. However, there was a significant difference in the rate of susceptibility. The study also, indicated that leaves of certain potato varieties could be highly susceptible to infestation, meanwhile the tubers are lightly infested such as the case with Obelix, Mondial, and Gigant varieties (1990 season) and Vital and Thimate varieties showed light leaf infestation and high tuber infestation.

Khattab *et al.* (1995) carried a study in Egypt during the summer and winter seasons to evaluate the susceptibility of 10 potato varieties to infestation by *Phthorimaea operculella.* The results revealed that plants were free from infestation by *P. operculella* during the winter seasons. There was no correlation between leaf and tuber infestation by *P. operculella* but the "Van Goch" variety had heavily infestation level on leaves and tubers, whereas "Obelix" had heavily infested leaves and tubers. The "Van Goch" and "Gigant" varieties were infected leaves and tubers. The

"Van Goch" and "Gigant" varieties only slightly infested whereas the "Mondial" variety was heavily infested.

Mikhael (1995) studied the potato tuber moth, *P. operculella* in Egypt. Results showed that 10 potato varieties were cultivated. The infested varieties were "Draga; Sponta; Van Goch; Morene; Diamont; Gigant moderately; Baraka; Obelix; Jaerla and Mandoial". Jaerla variety was the most infested than Draga was the least and Sponta was the least. According to the whole mean percentages of infestation of two years: Draga; Sponta; Van Goch and Morese were considerd as least infested varieties; Diamont and Gigant moderately infested, while Mondial, Oblex, Baraka and Jaerla were the severest infested varieties.

Soliman (1997) mentioned that as respect to number of larvae/100 tubers, the most susceptible variety to PTM infestation was Sponta variety followed by Draga, Diamont and Alpha variety, while Cara variety is the less susceptible one. As respect to number of larvae/100 leaves, Draga variety is the most susceptible variety followed by Diamont, Sponta and Alpha varieties, but Cara variety was the less susceptible one.

Dawood *et al.* (1999) studied the relative susceptibility of 18 potato varieties to tuber moth, *P. operculella* (Zeller) infestation and found that the low susceptible varieties including : Nicola, Draga, Sponta, Diamont and Van Gauche and high susceptible varieties including : Grata, Baraka, Kondor, Ajax, Oblix, Kara, King, Edward, Mondial, Vital and Monalis.

Stein and Vendramin (2000) reported that the potato tuber moth, *Phthorimaea operculella* is a common species in almost all regions where the potato is cultivated, causing several damage under both field and storage conditions. Wild species and primitive cultivars of potato tuber in breeding program has been shown the possibility to obtain resistant cultivars to attack of this tuber moth. Potato tubers of the cultivars chat, Aracy, Itarae and Apua.

2. Population fluctuation of *Phthorimaea operculella* (Zeller):

Traynier (1975) in Australia found that the eggs of *P. operculella* were more prevalent around the bases of potato plants than between rows or 2m outside the plot, the few eggs on the plants were on the leaves.

Bacon *et al.* (1978) found that the most pests of potato were: *Phthorimaea operculella.* The damage caused by potato tuber moth with information on their distribution, population dynamics. Determination of economic thresholds and pest management.

El-Borolossy *et al.,* (1984) studied the population densities of the immature stages of the potato tuber moth. Date at 15-day intervals was selected, representing early, normal and late in winter and summer plantation. Results of the experiments could be summarized as follows potato plants become more attractive to the adults of each insect when they attain a certain stage of growth or age at which they become more susceptible to infestation. Tubers were infested with *P. operculella* during the two seasons. High level of *P. operculella* infestation occurred in late plantation of summer season.

Jabirri (1984) studied in laboratory rearing of the potato pest *Phthorimaea operculella* in Iraq; the thermal development threshold was calculated to be 10◦C. An average of 437.8 effective day-degrees was found to be required for the appearance of peak populations causing severe economic damage to potato. Comparison of the data obtained in these observation with the accumulated day-degrees (3304.61) for 214 days between April and October in Mosul indicated that 7 complete generations and a partial 8^{th} generation per year were likely to have occurred in that region.

Youssef *et al.* (1986) reported that population density of the potato tuber moth, *P. operculella* was recorded in summer plantation, 1981 and the peak of infestation was in May. Also, in Nili plantation, 1984 the peak of infestation occurred during August and September.

Popova (1986) indicated that the potato tuber moth, *P. operculella* did not cause significant damage to Solanaceous crops due to low temperatures pertaining during winter storage.

Shyaeva *et al.* (1986) found the potato tuber moth *Phthorimaea operculella* on a farm in the Southern Ukraine. Where tobacco is the main crop but other Solanaceous. the population peaks occurring around the end of August and (the higher one) mide-September.

Omelyuta and Kuba Ichuk (1987) found that accumulations of *P. operculella* developed in May-June from a part of the population over wintering on Solanaceous weeds and on unharvested tubers remaining in the field, and also as results of planting of larvae infested tubers. Numbers and also damage to Solanaceoae increase in the second half of summer (August) reaching a maximum by autumn (September-October).

Siddig (1988) mentioned that the damage by *P. operculella* increased steadily on potatoes sown successively on 15 November (the optimum sowing date to 5 and 25 December in Sudan; yields of marketable tubers declined correspondingly increasing sowing depth from 1 to 3 inches reduced damage and increased yield, but the application of nitrogen and re-riding during tuber formation were not effective. Delay in harvesting increased infestation and reduced yield. Post-harvest trials indicated that infestation of harvested potatoes took place if the tubers were left unprotected in the field for more than 2 days. However, spraying harvested tubers with neem extracts and bagging them in Jute sacks, effectively protected them from damage.

Lal (1990) investigated insect pests of potato and found that PTM caused a major. He found that 50% plants investigation and 70% tubers damage under indigenous storage conditions were detected.

Lakshman (1991) recorded that the population dynamics of *Phthorimaea operculella* on potatoes were the main cause of reinfestation of the winter crop.

Habib and Hesanl (1992) showed that under the environmental conditions of Kara, Iran, *Phthorimaea operculella* a pest of potatoes, had 5 generations per year with an average longevity of 33 days the insect over wintered a larvae insides the tubers. The maximum number of adult damaged from tubers at a soil depth of 10-20 cm. potato tuber moths was also found to damage other Solanacecous species.

Das *et al.* (1993) reported that a total of 21 potato genotypes was screened against the gelechiid *Phthorimaea operculella* at 3 population densities in storage at 27-35◦C eyes on tubers and the number of holes made by the gelechiid at all 3 population pressures and after 2 and 4 months of storage. Variations were found among the genotypes, especially after 2 months of storage, in terms of infested tubers, infested eyes and the number of holes, with cica being the most resistant genotype and Huayro the most susceptible. Sprouts of all genotypes were equally infested after 2 and 4 months of storage.

Kroschel and Koch (1994) observed that the development of *P. operculella* in Yemen was strongly determined by climatic factors reproduction took place in the summer between June and August and there were 8 generations with one year.

Chernii *et al.* (1994) studied the population of *Phthorimaea operculella* in Ukraine. Numbers of *P. operculella* were maximal during development of the 3rd generation (in September) larvae of the 4th generation over wintering.

Debnath and Khound (1994) studied the population fluctuation of *Phthorimaea operculella* in stored potatoes over a period of 8 months are described.

Ibrahim (1996) studied the derived PTM from different localities of potato production in Egypt. Results indicated that Menufia moths lived longer than others of inspected strains. The duration of life cycle differed in the four studied strains collected from Alexandria, Beheira, Gharbia and Menufia.

Gomaa (1998) stated that, the most severe damage induced by *Phthorimaea operculella* proved to occur in plantation cultivated in February and harvested in late May and June. Potato tuber moth had annually ten generations, the fourth, fifth and sixth generations were the largest in size and could be considered the most dangerous generations, which attack potato and cause serious damage to both plants and tubers during the period extended from April to August. It causes serious damage in the fields. A high infestation in the late plantation of summer seasons. Infestation (on foliage was found negligible) in winter season while it highly appeared during summer season. The insects attack tubers in both summer and winter seasons.

Eid (2001) carried out field studies on PTM in winter and summer seasons from 1996 till 1998. The obtained data revealed that the rate of infestation began in January in low rate 10-16% and increased to reach its maximum55-61% during February in winter seasons.

Fetoh (2003) reported that *P. operculella* population density showed high positive correlation with each of temperature, photo period and plant age; but fairly high negative correlation with each of relative humidity and wind velocity.

3. Biology of *Phthorimaea operculella* Zeller:

3.1. Effect of temperature and host plant on the biology of *P. operculella:*

El-Sherif (1961) mentioned some biological observations on potato tuber moth in laboratory. He declared that at 28-31◦C the duration periods of oviposition, egg incubation, larval, prc pupal, pupal and adult stages lasted from 4-6.3, 3-4, 10-15, 2-3, 6-9 and 5-12 days, respectively. The development from oviposition till emergence of the adult was attained in 21 to 28 days in summer. The average of deposited eggs per one female was about 90 eggs.

Staven and Kaitazova (1962) observed seven generations for potato tuber moth in laboratory, which lasted 63, 36, 30, 25,, 34, 96 and 115 days; and five generations in the field late 61, 41, 31, 47 and 190 days, respectively. Poring took 10-12 h after emergence in the worm moths and 24-28 h in cooler ones. Oviposition began after 10-72 h and lasted 2-8 days. The eggs were laid at the rate of 39-146 eggs per female on the lower surface of the leaves, on potato tubers, singly or in group of 2-025 eggs. The eggs hatched after 4-5 days in July-august and 14-18 days in October-November. Larval stage lasted about14 days, while the pupal period varied from 6 to 90 days.

El-Sherif (1966) in Egypt, recorded that egg, larval and pupal stages of *Phthorimaea operculella* lasted for 3.1-19.4, 9.9-47.5 and 5.9-32.4 days, respectively.

In India, **Verma (1970)** studied the bionomics of *Phthorimaea operculella* in laboratory and found that ovipositor took place on the eye buds of potato. About 50-80 eggs were laid/female. The eggs hatched in 3-7 days according to the season. The larval stage lasted 16-18 days in August and 20-24 days in December. The pupal stage lasted 5-9 days. The duration of the complete life cycle varied from 23 to 27 days in August on September and 31-41 days in November-December.

Abou El-Nasr *et al.,* (1972) mentioned that *Phthorimaea operculella* had been raised in 9 continues generations throughout year under laboratory conditions. Complete life cycle averaged 22, 21, 26, 30, 42, 63, 84, 26 and 24 days, respectively.

In India, **Cubbaiah Thontadarya (1977)** observed that the eggs of *Phthorimaea operculella* lasted 5 days, larval stage 15 days and pupal stage 5-6 days on tuber in laboratory. The post oviposition periods lasted 1-1.5, 4-7 and 1-2 days. The number of laid eggs per female averaged 72.5 eggs; and the Gelechiidae could complete 13 generations in year in laboratory.

In Iraq, **Al-Ali *et al.,* (1978)** studied the life –history of *Phthorimaea operculella* under laboratory conditions. It was shown, that the egg stage lasted 2.3-7.2 days, the larval stage 6.2-29.5 days, the pupal stage 4.1-7.9 days and pre oviposition period 1.6-7.9 days. A single generation lasted 17.5 days in summer and 57.2 days in winter. Whereas 8 generations developed between 22 November, 1973 and 29 July, 1974 and the nine the one failed to developed beyond the larval stage.

In New Zealand, **Foot (1979)** stated that under laboratory conditions durations of consequent stages of *Phthorimaea operculella* lasted as follows: egg stage 5-25 days, larval stage 18-60 days, pre pupal period 2.5-18 days, pupal stage 8-23 days and adult pre oviposition period 2-23 days.

In Korea, **Choe *et al.*, (1980)** studied the life history of *Phthorimaea operculella* on potato tuber in the laboratory. The moth under winter had 7 generations in a year and development from egg to adult averaged 49.4 days in spring at 18.2◦C, 21.2 days in summer at 26.9◦C and 39 days in autumn at 19.6◦C. the female laid an average of 101 eggs, with a maximum of 242. the adult lived an average of 17.6 in spring at 15.1◦C, 8.1 days in May-September at 25.3◦C and 13.3 days in autumn at 16.8◦C.

Abd El-Karim *et al.* (1985) studied the effects of temperature and food plant on larval development and mortality of the Gelechiidae *Phthorimaea operculella*. Potato tuber was the most suitable substrate for larval development with the shortest duration of the immature stages, the lowest mortality and the highest rate of adult emergence.

Nawal and Rokia (1985) studied the biology of the potato tuber moth *Phthorimaea operculella* under laboratory conditions throughout different months of one complete year. The shortest and longest incubation periods of the eggs were 3.1±0.4 days in June and 5.2±0.8 days in February, respectively. The optimum range of temperatures ranged from 20.9 to 31.5◦C with in which the egg mortality percentages did not exceed 7%. The relative humidity had very little effect either on the incubation period or on the mortality percentage. The shortest duration for the whole larval stage was 6.3±0.2 days during October (at average temperature of 29.8◦C and 73.9% RH) the longest duration was 12.1±0.3 days during January (at average temperatures of 22.7◦C and 57.8% RH). The shortest duration of the pre-pupal stage was 1.2±0.1 days during October (average temperature 29.8◦C and 73.9% RH). The longest during was 3.7±0.1 days during February (average temperature 21.3◦C and 69.8% RH). The relative humidity appeared to have no clear effect on the pre-pupal stage. The shortest duration of the pupal stage was 5.3±0.4 days during April at average temperature of 33.6◦C and February at average temperature of 21.3◦C and 69.8% RH). The rate of development in this stage was mainly correlated with temperature but the relative humidity did not show any appreciable effect.

Chaudan and Verma (1985) mentioned that, the mergence of adult moth mortality takes place during early hours of the day with peak period between 0.700 and 0.900 hour, and 0.900 and 11.00 hour for male and female moths, respectively in summer and is delayed by two hours for both sexes in winter.

In Saudi Arabia, **El-Atrouzy and Awoad (1986)** reared potato tuber moth from collected infested potatoes in the laboratory. They stated that 13 generations per year produced at temperatures 20.5-33.0◦C and 52.1-66.0% RH. Nine generations occurred during the first 6 months, 4 in the last 3 months and no generations were completed between early August and late October when the highest temperatures were recorded. Increase in temperature shortened the duration of the life cycle, but relative humidity had no effect.

El-Atrouzy and Awoad (1986) reported , the effect of feeding on oviposition of summer and winter broods of *Phthorimaea operculella* was studied in the laboratory at 32◦C and 76% RH and 25.4◦C and 62.5% RH, respectively. Using cultures initiated from insects collected from potatoes in Saudi Arabia. Starvation of the winter brood reduced the life span of most of females and reduced egg production of both broods. Longevity was increased by the decrease in temperature during the winter.

Abdel-Wahab *et al.*, (1987) studied the biology of the Gelechiidae potato pest *Phthorimaea operculella.* He found that this pest had 10 generations in the year. Potato tuber moth has 4 larval instars; the 4th instar occupied 37% of the total larval period. Adult longevity increased during winter. The number of laid eggs varied from 24-70 eggs/female during winter and summer, respectively.

Ali and Hussein (1988) mentioned that the egg stage of *P .operculella* lasted 7.4, 5.8 and 4.3 days at 20, 25 and 30◦C respectively in the laboratory.

In Philippine **Das (1989)** mentioned that there were 10 overlapping generations of potato tuber moth in the year. The larva went through 4 instars. Adult longevity was 24.25±11 days for mated males and 17.35±8.35 for mated females. Mean fecundity was 72.48 eggs per female. Moreover, it was stated that the means duration of the different developmental stages in days at 15, 20, 25 and 30◦C were 17.4, 9.76, 5.43 and 4.0 days for egg; 97.47, 47.89, 26.55 and 17.71 for larvae to adult, respectively. No development took place at temperature >11.8◦C.

Gelz (1989) showed that ten potato moth *Phthorimaea operculella* has 2 to 6 generations a year, depending on the climatic conditions.

Gomboa and Notz (1990) determined the durations of the developmental stages of *Phthorimaea operculella* reared on potatoes. The calculated period ranged between 4 & 4.5 for egg; 9 & 10 for larvae.

Chauhan and Verma (1991), studied the life cycle of the Gelechiidae *Phthorimaea operculella* using a laboratory maintained colony. It was reported that five following stages of pupal development could be identified on the basis of eye pigmentation. Moreover, male and female adults differ morphologically and also in their longevity (14±1.28 days and 9.1±2.71 days, respectively. The life cycle of the Gelechiidae was completed in 21 days.

Das *et al.,* **(1993) mentioned** that, the growth and development of the Gelechiidae *Phthorimaea operculella* were studied on 23 potato genotypes in the laboratory at 26-28◦C and 50-55% RH. The biological parameters differed between genotypes, indicating that antibiosis in operation.

Khan and Ahmed (1996) reported that *Phthorimaea operculella* eggs were exposed to 40◦C for 0.5, 1.0, 1.5, 2.0, 2.5 or 4.0 h. egg viability, larval and pupal duration, adult emergence and sex ratio were significantly reduced compared with the controls not specificity.

Daoud ***et al.*** **(1999)** reported that, the estimated thermal thresholds of different developmental stages were 9.62, 9.32 and 8.5 for egg, larval and pupal stages, respectively, and 11.91: 9.91 (male: female) for the adult sex ratio. The corresponding value for the thermal units needed foe development of these stages were 87.55, 201.75, 172.25 and (115.95 : 143.0) degree-days, respectively in laboratory.

Mariy *et al.*, (1999) mentioned that, the biology of *Phthorimaea operculella* was studied in the laboratory using the potato cultivar Diamond. The incubation period of *Phthorimaea operculella* eggs varied greatly from 16.27 days at 15◦C to 3.45 days at 35◦C. the corresponding values of hatchability were 56.75 and 75.24%. The larval durations was 35.41 days at 15◦C and 7.8 days at 35◦C. the mean pupation percentage was 55.54, 48.56, 54.88, 57.13, 52.63 and 60.95% and the mean pupal stage duration was 26.5, 14.2, 9.23, 7.82, 6.50 and 7.96 days at 15, 20, 25, 30, 35 and 27±2◦C, respectively. The percentage adult emergence was 76.98, 70.86, 73.86, 74.43, 78.36 and 69.92% and the mean pre-oviposition period was 6.6, 2.6, 2.8, 2.2, 2.1 and 2.4 days at the same respective temperatures. The mean oviposition period was 14.3, 8.0, 6.3, 3.1, 2.4 and 4.6 days while the post-oviposition period was 7.2, 2.1, 1.6, 2.5, 1.2 and 2.0 days at 15, 20, 25, 30 35 and 27±2◦C, respectively. Female longevity in days was 28.1, 12.7, 10.2, 7.5, 5.7 and 9.0 days, while male longevity was 36.4, 28.9, 12.5, 5.7, 5.0 and 7.0, 5.0 and 7.0 days at 15, 20, 25, 30, 35 and 27±2◦C, respectively. The mean numbers of deposited eggs/female were 68.3, 121.9, 142.1, 84.7, 26.9 and 87.3 at the tested temperatures were 15, 20 and 27±2◦C, while at 25, 30 and 35◦C the corresponding sex ratio was 1:1.7, 1:142 and 1.158, respectively.

The mean generation's duration was 84.78, 46.22, 32.09, 22.1, 19.9 and 21.43 days, respectively.

4. Toxicity of plant extracts and powders against *P. operculella*

Shelke *et al.*, (1985) tested the effect of seven vegetable oil or extracts against the adults of the potato tuber moth on potato tubers in the laboratory. They found that 0.05 and 0.1% neem oil (*Azadirachta indica*) and 0.1% oils or extracts of mohwa (*Bassia catifolia*), karnj (*Pongamia globra* or *P. pinnata*), ratnajot (*Jatropha circas*) and dodi (*Leptodenia reticulata*) caused 91.6-100% oviposition deterrent.

Setiawati *et al.*, (1986) concluded that dry leaves of *Lantana* sp. and rice husk were effective for the control of *Phthorimaea operculella*, either alone in combination with Methomyl 25 WP or Carbaryl 85 S. *B. thuringiensis* WP reducing the number of sprout damage due to *Phthorimaea operculella.*

Alawas and Colting (1986) reported that the effectiveness of pine tree products using fresh and dry needless at 50 g/kg tuber applied by top freezing, fresh needle extract at 50 g/l water applied by tuber soaking fresh wood chipping at 50 g/kg tuber applied by dressing and needle ash and sawdust at 25 g/kg tuber applied by dusting were tested against larvae of *Phthorimaea operculella* damaging potato tubers ml/l were used as standard. Fresh pine needle as top dressing. Ash, and wood chippings were effective up to 15 days after storage (DAS); dry needle up to 30 (DAS); and ash and sawdust up to 45 DAS. These were comparatively effective as the standard insecticides.

Siddig (1986) studied the effect of neem extracts at different growning dates on insect pests of potatoes. Other cultural means for control were evaluated against soil pests. The control of the infestations post-harvesting by the Gelechiidae *Phthorimaea operculella* by neem sprays and other means was also studied the application of neem controlled foliage pests, spraying tubers with neem and then placing them in jute sacks reduced post harvest loss.

Lal (1987) investigated the effects of the leaves of *Ambrosia artiemisiifolia, Anemone elongate, Eupatorium odoratum* (*Chromolana odortat*) *Eucalyptus globules* and *Lantana aculeate* on the Gelechiidae *Phthorimaea operculella.* The results indicated that the leaves of *Lantana aculaeata* provided the most protection, reducing tuber damage to below 3% compared with 70% and 45%, respectively. In the untreated control, the next most effective treatment was *E. globulus* followed by *B. thuringiensis.* None of the treatments had an adverse effect on germination or on the yield of subsequent crop.

Shelke *et al.,* (1987) tested seven plant oils or/and extracts against *Phthorimaea operculella* in stored seed potatoes. It was found that neem oil at 0.03-0.1% concentrations as well as the extracts of *Pongomia glabra, Jatropha cureas* and ipomoea carnea leaves at 0.05 and 0.1% concentrations were the most effective.

Raman *et al.*, (1987) stated that *L. camara* and the other repellent from plant foliage significantly reduced sprout damage when compared with the untreated control and with those covered with rice straw.

Lal (1988) in India mentioned that the rates of *Phthorimaea operculella* infestation in summer and autumn was 54 and 43% of plants, respectively. Under indigenous storage conditions, the estimated losses were 18-84%. Leaves of *Lantana camara* and *Eucalyptus globules* were repellent to *Phthorimaea operculella* and reduced tubers damage to 5 and 8%, respectively, compared to 99% damage in untreated potatoes. Covering stored tubers with leaves of *Eupatorium odoratum, Ambrosia artemissifolia* or *Anemon elongate* reduced tubers damage to 26.50, 29.50 and 39.00%, respectively.

CIP (1988) published a paper on collecting lantana plants, drying and placing them in jute bags; and then were beaten into a powder. This powder was spread over stored potatoes with thickness of 2.5 cm. This treatment acted as a barrier and as an oviposition repellent which portected the potatoes against pests, especially PTM. This protection lasted for over 120 days.

Siddig (1988) stated that spraying harvested tubers with neem extracts and bagging them in jute sacks, effectively protected them from damage.

Sharaby (1988) investigated the effect of orange peel oil on reproduction in the Gelechiidae *Phthorimaea operculella* a pest of potato. Newly emerged males and females were exposed for 30, 60 or 120 min to the vapor of organ peel oil emanating from filter paper discs impregnated with 40, 80, 160 and 220ul. After the required exposure, males and females subjected to identical or differ treatments were paired singly to facilitate mating and subsequent oviposition by the females reproduction was significantly reduced when either males or females were exposed to the oil vapour. The effect increased with an increase of oil dose and exposure time. Egg hatch ranged from 0 to 30% when the moths were exposed to 160 ul of oil for 30-120 min. A further pronounced were exposed to 160 ul of oil for 30-120 min. A further pronounced reduction in egg production and egg viability occurred when the moth were exposed to the vapour arising from paper discs treated with 220 ul.

Reddy and Urs (1989) treated eggs, larvae and pupae of *Phthorimaea operculella* with 0.10-1.25% weed extracts of (the weed) tribulusterrestris. Egg hatchability decreased with increase in conc. of the extract, from 82% with 0.10% to 10% with 1.25% extract. Mortality in larvae and 40% mortality in pupae.

Islam *et al.*, (1990) in Bangladesh found that the crushed dried leaves of *Lantana camara* and 0.1% Elsan 50% EC (Phenthoate) protected seed tubers for up to three months (6.72 and 2.35% infestation, respectively) compared with 91.38, 66.37, 95.86 and 94.86% infestation of potatoes treated with Sevin 10% dust at 1.0 gm/2 kg potatoes, granulose virus at 4.0 larval equivalents/20 liters water, dried rice straw and untreated potatoes, respectively. Infestation of ware house potatoes treated with 0.1% Decis 0.5% EC (Deltamethrin) plus CIPC (Chlopropham) at 2.0 gm/kg potatoes or covered with *L. camara* leaves plus chlorpropham were lower 19.79 and 21.88%, respectively after 2 months than those treated with granulose virus plus chlorpropham or chlorpropham alone (35.28 and 72.28% infestation, respectively).

Wahundeniya (1990) in Sri-Lanka evaluated the effectiveness of the locally a viable plants foliage and insecticides against *Phthorimaea operculella* on stored potatoes. Effective control of *Phthorimaea operculella* was achieved with foliage of *Lantana camara* and chenopodium, ambroides and primiphos methyl.

Salem (1991) compared neem seed extract at 20, 40, 60, 80 and 100 ppm with sevin 10% (Carbaryl) for control of *Phthorimaea operculella* on potatoes stored covered with arice hill in a store in Egypt, in summer. Storage losses after 6 months in potatoes treated with 100 ppm neem oil and carbaryl were 25% and 10% respectively. In laboratory experiments, 100 ppm neem oil and carbaryl caused 78.57% and 88.1% mortality of larvae, respectively, and both allowed 10% successful. Pupation, all adults emerging from pupae of larvae treated with 100 ppm neem oil were deformed.

Islam *et al.* (1991) in Bangladesh reported that crushed dried leaves of the repellent plant *Lantana camara* afforded significant protection of seed potatoes for up to 3 months. *L. camara* afforded significant reduction infestation in ware potatoes for up to 2 months.

Nasseh and Al-Furassy (1992) in Yemen found that Sumithioin (fentrothion 40 EC) at, 0 ml, 10 liters and aqueous extract of the outer pulp of *Melia azedarach* and *Allium sativum* (garlic) at 100 g/10 liters gave good control of *Phthorimaea operculella* larvae in the laboratory at 26◦C, 45% RH and LD 12: 12 mortality percentage were 100, 91 and 85% for the three treatments, respectively.

Kashyap *et al.*, (1992) studied the efficacy of powdered dry leaves of *Vitex negundo, Ageratum houstonianum. Mentha longifolia, Cinnamomum tamala, Cannabis sativa, Lantana camara, Murraya koenigii* and *Eucalyptus* sp. and sand in controlling *Phthorimaea operculella* on stored potatoes. 2 cm thick layers of *A. haustonianum* or *V. negundo* and *M. longifolia* were equally effective and only 6% infestations was observed after 120 days.

Doss *et al.*, (1994) studied the effect of *Lantana camara* leaves; rice strum and chemical control against the adults of the potato tuber moth on potato tubers in Newalla. They found that powdered leaves of *L. camara* 3% resulted in pronounced decrease in PTM infestation.

Das (1995) mentioned that a survey of literature on the plants used for the control of the potato pest *Phthorimaea operculella* revealed that the preparations from 35 plant species are effective against the pest either in storage or in the laboratory. In some studies chopped and dried leaves were used, while in others leaf seed extracts, fruit peel, bulb, root and rhizome were used. Plant preparations are effective in reducing pest damage or killing at different stages of the pest.

Kroschel and Koch (1996) reported that, effects of seed extracts of chinaberry (*Melia azedarach*), neem (*Azadirachta indica*), garlic (*Allium sativum*), covering the tubers with leaves of the tree species *Schinus molle* and *Eucalyptus* sp. were evaluated to determine their potential control to *Phthorimaea operculella* in bioassay tests on tubers. Products were tested when the potatoes were inoculated in the tubers. The effectiveness of the water extract of neem and garlic were 93.8% and 61.3%.

Sharma *et al.*, (1997) conducted a study to determine the ovicidal and oviposition deterrent properties of acetone, alcohol, benzene, petroleum ether and distilled water extracts of plant species against the Gelechiid *Phthorimaea operculella.* The results showed that the efficacy of alcohol extracts was superior to of other solvents in reducing egg hatch and oviposition. The order of efficacy was *pinus roxburghii* >Achook > (a neem –based formulation) > *Eucalytus globules* > *Murraya koenigii* > *Lantana* sp. > *Cannabis sativa* > *Nictotina tabacum* > *Melia azedarach* > *Uitex negundo.*

Eden (1999) stated that extracts of *Azadirachta indica* tree, can influence nearly 200 species of insects. It is an insect growth regulator and a feeding deterrent. Neem products work by intervening at several stages of the life of an insect. They may not kill the pest instantly but in capacitate it in several other ways. The use of neem products does not give, immediate results like chemical insecticides, as some patience is required after application. Neem products affect insects like flies.

Sabbour and Ismail (2002) tested the effect of plants extracts of *Solanum nigrum, Atropa belladonna* and *Hyscyamus niger* against the potato tuber moth (PTM) *Phthorimaea operculella* (Lepidoptera: Gelechiidae) under laboratory conditions. The toxicity of the three plant extracts were evaluated at 5% and 2.5% concentration. The results showed that *H niger* and *A. belladonna* were the most toxic against the potato tuber moth *Phthorimaea operculella.*

5. Efficacy of some bacterial preparations against *Phthorimaea operculella:*

Ali (1978) in Iraq reported that laboratory tests on insecticides used to dip piecewise of potato showed that *Phthorimaea operculella* was suitable to Monocrotophos (Nuvacron), Diazinon and primiphos-methyl (Actellic), and also Tothuricide- HP (a preparation of *Bacillus thuringensis* (Berliner) with a potency of 16000- IU or 30 X 10^6 viable spores/mg). The LC_{50} of the three chemical insecticides after 48 hours were 0.0096, 0.029 and 0.076%, respectively. And the corresponding LC_{90}'s were 0.045, 0.08 and 0.23%. The LC_{50} of thuricide-HP was $70X10^6$spores/ml, after 48h and $33x10^6$ spores after 168h, and the corresponding LC_{90}'s were 1000x106 and $27x10^6$ spores/ml.

Amonkor *et al.*, (1979) in India, studied the microbial control of potato tuber moth infesting potato seedlings in pots and potato tubers in laboratory. Effective control could be achieved by using the crystalliferous bacteria, *B. thuringiensis var icautella* (Walker). The pathogen retained potency against the pest for up to 60 days.

Heeder and El-Sherif (1987) in Egypt, applied two commercial preparation of *B. thuringiensis* (Diple and thuricide) at rate of 1.0 kg/feddan, on *Phthorimaea operculella* a population on potato plants, and also two chemical insecticides Sevin 85% WP at the rate of 0.4% as well as Gusathion 50% WP at the rate of 0.25%. Diple thuricide and Gusathion were effectiveness in reducing moth infestation and that led consequently to a high potato yield.

Arx *et al.*, (1987) investigated the relationship between the dynamic of field populations, the harvest date, the economic damage in the field and the subsequent damage stores under Tunisian conditions. Emphasis was given to the agricultural practices that allowed reduction of pesticide applications and to replacements of the commonly used parathion with less toxic products. The studies showed that tubers damage by *Phthorimaea operculella* could be avoided by an early harvest date (to reduce initial tuber infestation) and the application of *B. thuringiensis* or synthetic pyrethroid (premtehrin) at the beginning of the storage period.

Baklanova *et al.*, (1990) reported that, the effects of major ecological factors on the development and physiology of the potato pest *Phthorimaea operculella* revealed its very high viability in southern areas of the Ukraine, USSR. Lepidocide (*Bacillus thuringiensis* sub sp. *Kurstaki*) and Bioxibacllin *(B. thuringensis sub* sp. *thuringiensis*) were highly effective against the pest when applied at 10-25◦C treatment of larval with these preparation at 9-

12◦C showed that they were at least as actives. Diple (another formulation of *B. thuringiensis* sub sp *kurstaki*) and chemical insecticides.

Iskander (1992) in Egypt studied the effectiveness of three commercial products of *B. thuringiensis* (Bactospeine, Delfin, and Diple) and Fenitrothion against *Phthorimaea operculella* in the laboratory. Data indicated that all tested insecticides were effective against newly hatched larvae of *Phthorimaea operculella* flowed by second instar, while third and fourth instars were less susceptible to different treatments. Latent effects on pupae and moths produced from surviving larval after treatment was also indicated. The three bioinsecticides gave better results against the four instars than Fenitrothion.

Das *et al.*, (1992) investigated the effectiveness of different control treatments against tuber moth *Phthorimaea operculella* infesting stored potatoes over periods of 2 and 4 months. Four potato cultivars were tested, revolucion, Moro-Bole, Cica Huayro, Classi feed, respectively. Having low, moderate and high resistance and susceptibility to infestation by *Phthorimaea operculella*. A granulosis virus (GV) preparation at 5 kg/ton of tubers was effective against *Phthorimaea operculella* for up to 2 months of storage, i.e., up to sprouting.

Salama *et al.*, (1995) investigated the susceptibility of PTM larvae after exposing to various strains of *B. thuringiensis.* First instar larvae were susceptible to some varieties of *Bacillus* e.g. *kurstaki, thuringiensis, tolworthi, gallerial, kenyae* and *aizawai.*

Kroschel (1995) stated that mixture of Diple and fine sand was effective and suitable to control the PTM on storage, even for periods of more than three months.

Salama *et al.*, (1996) mentioned that, treatment of the host larvae, *Phthorimaea operculella*, with *Bacillus thuringiensis* did not change their susceptibility to being parasitized by either Bracon in stabiles or *Apanteles litae* (*Dolichogenidea litae*). The longevity of adults of both parasitoids as well as their egg production, were not markedly affected As a result of the treatments but the duration of immature stages was prolonged. Also, emergence of the adult parasitoids was significantly reduced. The longevity of emerged adult parasitoids was significantly shortened when fed on honey containing *B. thuringiensis* and the fertility of the resultant females was significantly reduced.

Bekheit *et al.*, (1997) found in a field experiment in Egypt, that the application of *Bacillus thuringiensis, granulosis virus* or trapping with a sex pheromone reduced infestation by *Phthorimaea operculella* in potatoes by 82.5-95, 69.5-91.8% and 74.8-91.6%, respectively.

Das *et al.*, (1998) reported that, in controlling *Phthorimaea operculella* in stride potatoes, Deltamethrin, *Granulosisi virus* and *Bacillus thuringiensis* were equally effective in reducing pest damage. After three months, storage the treatments showed significant effect on sprouting.

Rico *et al.*, (1998) mentioned that two populations of *Phthorimaea operculella* one of them presumed to be resistant to Diple (a commercial preparation of *Bacillus thuringiensis* delta end toxins) and other susceptible, were grown on four cultivars of potatoes, two of them a first generations of transgenic plants, expressing the *Bacillus thuringiensis* cry 11 Ab delta endotoxinpriyiene, and the other two untrans formed. The moth population which was reported to be resistant, proved to have less mortality than the susceptible one, but it was not really resistant to cry a Ab. The transgenic potatoes were partially protected against the attack of the moth. The adult survival of the two strains of *Phthorimaea operculella,* reared on transgenic potatoes was less than half their survival on untrans formed potatoes, so that cry 1 Ab expressing potato tubers proved to be protecting partially against attack of the moth.

Fetoh (2003) mentioned that, two bacterial isolates could be isolated from diseased PTM larvae. They were identified as *Bacillus thuringiensis* and an *Actinomycete bacterium.* Laboratory bioassay of these isolate bacteria showed increased reduction in PTM larval population within increasing periods after application. The actinomycete bacterium appeared more potent than either *B.t.* or mixture of both bacteria, and the mixture was more potent than *B.t.* alone.

MATERIALS AND METHODS

MATERIALS AND METHODS

I. Field experiment:

Population fluctuation of the *Phthorimaea operculella* (Zeller) larvae on three potato cultivars under field conditions:-

The susceptibility of three potato cultivars to the potato tuber moths, *Phthorimaea operculella* infestation was studied throughout two successive seasons during 2002 and 2003. Experiments were carried out at Giza Governorate. The planting dates were at 5 and 7 January for 2002 and 2003 seasons, respectively.

An area of about 1/3 feddan was divided into 12 plots, each 120 m^2 containing 30 rows. The summer plantation was chosen for conducting the field experiments as the most affected one with potato tuber moth (PTM) infestation. It was harvested on 19^{th} and 29^{th} May for 2002 and 2003 seasons, respectively.

Three imported potato varieties were cultivated in the in a randomized complete block design including four replicates each. The tested potato varieties were: Diamont, Sponta and Karo varieties. All the usual agricultural practices were followed on all the experimental plots except for the factors under study. Cultivation of the tubers was at depth of 10-15 cm.

Estimation of plant infestation by the larvae was carried out as follows:

Samples of 25 plant leaves were weekly picked randomly from three levels of the plants in each plot. Leaves were examined using a binocular microscope and the total number of *P. operculella* larvae per sample was recorded and tabulated.

At harvest infestation was estimated on potato tubers. From each replicate, 100 tubers were taken randomly from the yield of every plot. Thus 400 potato tubers represented for each tested potato variety. The effect of certain weather factors on the insects with three potato varieties was investigated. Temperature,(max. Temp.; min. Temp. Mean. Temp.), and relative humidity were recorded by the Metrological Station of the Ministry of environmental affairs. The yield (Kg/plot) of each plot was evaluated at the harvesting time.

Statistical analysis of data, was carried out by using a computer soft ware package "a Costat" a product of cohort soft ware Icu., Barkeley, California, USA. Duncan's multiple range test (Duncan, 1955) was used to differentiation between means.

II. Laboratory experiments:

2.1. Stock culture and rearing conditions:

The stock culture of *P. operculella* was reared in the laboratory as described by Fenemor (1977), on potato tubers (Diamont and Sponta varieties) in cages, the front and back walls of the cage were protected and covered with fine wire gauze, and the top of each cage was a plate glass.

Infested potato tubers were placed in the breeding cages and after the emergence of moths; fresh tubers were placed for oviposition. The moths were fed on molasses supplied as small droplets a 5% sugar solution, under laboratory condition. When pupation was completed, the cocoons were carefully collected, to be used for starting the experimental cultures.

3. Biological studies:

3.1. Effect of different temperatures on certain biological aspects of *P. operculella:*

Three incubators running constant temperatures of 20, 25 and 30°C.The relative humidity was 70±5% R.H. were used for the tests.

One hundred eggs placed in 10 glass jars were taken for each temperature. Hatched eggs were counted daily until no more eggs hatched and the incubation period of the eggs was estimated.

At the previously mentioned temperatures i.e. 20, 25 and 30°C, Ca. 100 larvae were used. One/kg of the potato tuber was taken from the Diamont and Sponta cultivars in the tests. The larval, pupal periods, adult longevity and the life cycle were assessed during this study.

Toxicological studies:

Effectiveness of certain bioagents against *P. operculella*:-

1-Plant extracts:

- Petroleum ether extract of castor bean leaves (*Ricinus communis*) Fam.: Euphorbiaceae; dill seeds (*Anethum graveolens*) Fam.: Umbelliferae and cumin seeds (*Cuminum cyminum* L.) Fam.: Umbelliferae and water extract of garlic (*Allium sativum) Fam.: Liliaceae*. Were investigated.

2-Plant dusts:

- Powders of black pepper seeds (*Piper nigrum*) Fam. : Piperaceae; clove flower (*Syzygium aromaticum*) Fam.: Mytaceae; and santonica flower (*Matricaria chamomillia*) Fam. : Compositae were used also during the experiments.

3-Bioinsecticides:

Protecto (10% W/P) is a commercial product (*Bacillus thuringensis* Var. Kurstaki Berliner potency : 32000 IU/mg) and registered by the Insect Pathology Unit (IPU) at Plant Protection Research Institute (PPRI), Agriculture Research Center, Ministry of Agriculture and Land Reclamation, Cairo, Egypt.

Preparing of the plant extracts:

A-Petroleum ether extract of the plants:

500 g from each material were ground in electric mill into fine powder. The ground plant material was soaked in the solvent (petroleum ether) in a large flask for 72 hours, then the flask shacked for half hour in shaker and its content was filtered. The solvent was evaporated at 45°C in an evaporator as described by Su (1985). The extract which in the form of a crude gum, was weighed and redissolved in the solvent to give 10% (W/V) stock solution.

Concentrations of 0.625; 1.25;2.5, 5 and 10% (W/V) were prepared from the stock solution for the extracts of castor bean leaves, dill seeds and cumin seeds for conducting the experiments.

B-Water extract of garlic *(Allium sativum):-*

The globes of *Allium sativum were* cut into small pieces, then soaked in water (1g: 1m1).the mixture was mixed in a household grinder. The extract was kept in glass stoppered bottles in refrigerator and its concentration was considered a 100%w/v.

Different concentrations were prepared by adding different quantities of the water to a constant volume of the initial extract. Following concentrations;10,40,60,80,100%(w/v),were prepared by diluting the liquid formulation in distilled water. The water used for the tests control.

Bioassay test:

The efficacy of the previously mentioned plant extracts and bioinsecticide were investigated against *P. operculella* as follows:

Potato tubers were treated using various concentrations of the different plant extracts in cages. Three replicates were used for each concentration. The treated potato tubers were infested in each replicate with 4 pair moths, while in the other one the treated potato tubers were infested with 100 eggs and another treated potato tubers were infested with the pupae of *P. operculella.* Besides, three replicates were used as control. Experiments were carried out at 28±2◦C and 65±5% R.H. Then the numbers of emerged moths were recorded for one week from the initial moth emergence.

Percent reduction of the emerged moths from the pupae and eggs were calculated using the following equation:

$$\% \textbf{ Inhibition} = \frac{\text{No. of emerged moths in control} - \text{No. of emerged moths in treatment}}{\text{No. of emerged moths in control}} \times 100$$

The inhibition rates of emerged moths were considered as percent reduction of the emerged moths from the eggs; the pupae and moths of *P. operculella* after treatment.

Bioassay test of the plant powders:-

The following powders of these plants were tested:-

Black pepper seeds (*Piper nigrum*) piperaceae, cloves flowering buds (*Syzygium aromaticum*) Mytaceae, and santonica flowers (*Matricaria chamomillia*) Compositae were bought from the local market.

These plant materials were ground well in an electric mill. The sieved powder was used in the testes. Potato tubers were covered with three concentrations (25, 12.5, 6.25 gm/kg.) of the plant powder to study its effect on *P. operculella* moths. Untreated potato tubers were used as control in each treatment, each replicate was 10 kg. Three replicates were used in each concentration for each variety.

Statistical analysis:

The dosage mortality response was determined by probit analysis (Finny, 1971).

The mortality was corrected using Abbott's formula (1925):

$$\text{Corrected } \% = 100 \text{ X } 1- \left(\frac{\text{n in T after treatment}}{\text{n in Co after treatment}} \right)$$

n = insect population

T = treated,   Co = control

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Field study:

I. Population fluctuation of the potato tuber moth larvae *Phthorimaea operculella* (Zeller.) on some potato cultivars:

1.2. Season 2002:

The data illustrated in Table (1) and Fig. (1) showed that infestation by *Phthorimaea operculella* stated at 45 days after sowing on February 19^{th} (3.8, 0.3 and 0.8 larva/25 leaves) on Diamont, Sponta and Karo cultivars, then increased gradually to reach its maximum (12.8, 6.2 and 12.3 larva/25 leaves) 108 days after sowing on April 23^{rd} on Diamont, Sponta and Karo cultivars.

After that the population decreased gradually to reach (5.0, 0.0 and 2.0 larva/25 leaves) 122 days after sowing on May 7^{th} on Diamont, Sponta and Karo. Meanwhile, data indicated also that incidence of larval stage increases sharply with the increase of potato plants age to reach its maximum incidence at 108 days on three potato cultivars (Karo, Sponta and Diamont). Such infestation drops sharply to reach minimum rates at ages of more than 122 days. This result indicates that young fresh plants having highest biological activities with turgid fully nourished cells are very suitable for the reproduction of the insect pest.

1.3. Season 2003:

Data in Table (2) and Fig. (2) showed that infestation by *P. operculella* stated at 58 days after sowing on March 6th (3.2, 0.0 and 0.2 larva/25 leaves) on Diamont, Sponta and Karo cultivars, then increased gradually to reach its maximum (12.9, 6.1 and 6.7 larva/25 leaves) 121 days after sowing on May 8th on Diamont, Sponta and Karo cultivars.

Table (1): Mean larval numbers of the potato tuber moth *P. operculella* in relation to certain ecological factors and plant age for some potato cultivars at Giza Governorate during summer plantation of 2002.

Date of inspection	Plant age (day)	Mean larval numbers /25 plant leaves			Ecological factors			
		Karo	Sponta	Diamont	Min. Temp.	Max. Temp.	Mean	R.H.(Mean)
15/1/2002	10	0.0	0.0	0.0	4.7	15..34	10.02	62.4
22/1	17	0.0	0.0	0.0	4.63	17.47	11.05	66.0
29/1	24	0.0	0.0	0.0	6.64	18.48	12..56	61..9
5/2	31	0.0	0.0	0.0	12.16	21.67	16..91	64..3
12/2	38	0.0	0.0	0.0	9.66	20.78	15..22	58..9
19/2	45	0.8	0.3	3.8	9.32	23.48	16.40	51.88
26/2	52	1.3	1.1	4.2	13..35	28.18	20.76	52.8
4/3	59	1.5	1.3	4.5	10.8	25.46	18.13	56.0
11/3	66	2.1	2.0	5.2	10.7	23.74	17..22	54..9
18/3	73	3.6	2.3	6.3	12.74	27.07	19.90	57..3
25/3	80	3.9	3.4	7.4	17..32	32.83	25.07	58.1
2/4	87	4.2	4.0	8.0	13.69	25.84	19.76	59.0
9/4	94	5.1	4.9	9.6	16..51	32..21	24..36	50.0
16/4	101	5.2	5.8	10.2	16..95	32.6	24.60	54..5
23/4	108	12.3	6.2	12.8	19.05	32.71	25.88	51.8
30/4	115	3.0	0.0	7.65	18.06	35.4	26.73	54..9
7/5	122	2.0	0.0	5.0	20.19	36..55	28.37	54..3
14/5	128	0.0	0.0	0.0	20..50	36.25	28.73	58.1
Mean±S.E.of actual values		**3.75±0.848**	**3.13±0.616**	**6.67±0.76**	**18.7**	**26.9**	**22.8**	**60.2**

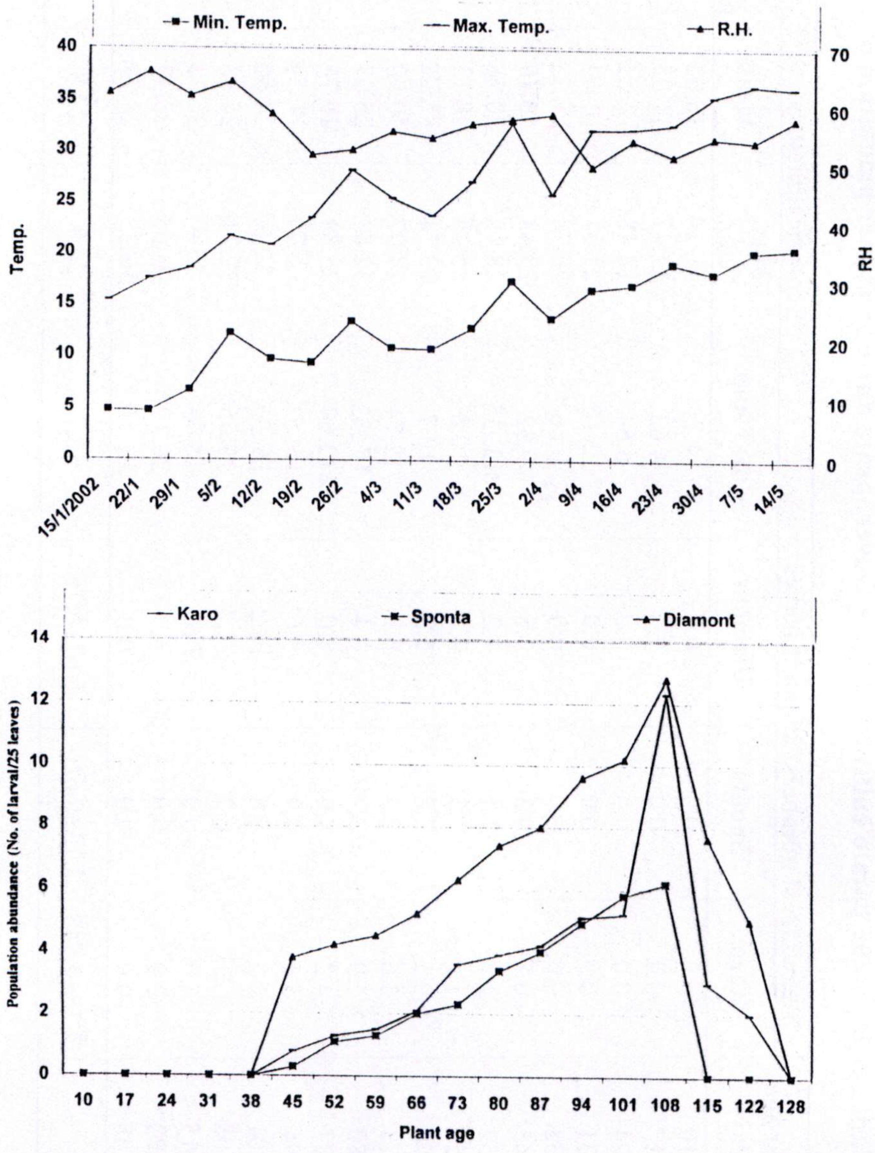
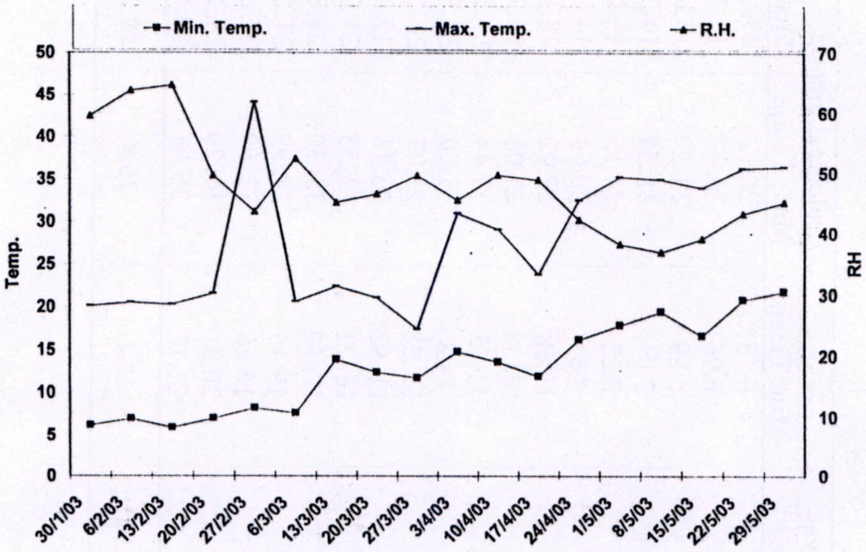


Fig.(1): Mean larval numbers of the potato tuber moth *P. operculella* in relation to certain ecological factors and plant age for some potato cultivars at Giza Governorate during summer plantation of 2002.

Table (2): **Mean larval numbers of the potato tuber moth *P. operculella* in relation to certain ecological factors and age plant for some potato cultivars at Giza Governorate during summer plantation of 2003.**

Date of inspection	Plant age(day)	Mean larval numbers 25/ plant leaves			Ecological factors			
		Karo	Sponta	Diamont	Min. Temp.	Max. Temp.	Mean	R.H.(Mean)
30/1/2003	23	0.0	0.0	0.0	6.16	20.12	13.14	59..5
6/2	30	0.0	0.0	0.0	6.96	20..53	13.74	63.7
13/2	37	0.0	0.0	0.0	5.89	20..29	13.09	64.6
20/2	44	0.0	0.0	0.0	7.01	21..57	14.29	49.6
27/2	51	0.0	0.0	0.0	8.22	24.15	16.18	43.7
6/3	58	0.2	0.0	3.2	7.63	20.63	14.13	52..37
13/3	65	1.1	1.0	3.7	13.88	22.42	18.15	45..2
20/3	72	1.4	1.3	4.6	12..38	21.08	16.73	46.6
27/3	79	2.0	2.0	5.2	11.75	17.44	14..59	49.6
3/4	86	2.3	2.2	6.1	14.8	31.00	22..90	45.6
10/4	93	3.4	3.1	7.2	13..58	29.07	21..32	49.7
17/4	100	4.1	4.0	8.1	11..93	23.78	17.85	48..9
24/4	107	5.2	5.0	9.5	16..21	32..55	24..38	42..3
1/5	114	6.0	5.9	10.1	17..92	35..30	26.61	38..2
8/5	121	6.7	6.1	12.9	19.46	34..99	27..22	36..9
15/5	128	0.0	0.0	12.2	16.66	33..99	25..32	39.1
22/5	135	0.0	0.0	0.0	20.81	36..29	28..55	43..3
29/5	142	0.0	0.0	0.0	21.77	36.46	29.11	45..2
Mean ±S.E. of actual values		**3.24±0.66**	**3.4±0.60**	**7.92±0.95**	**13.1**	**26.8**	**19.95**	**48**



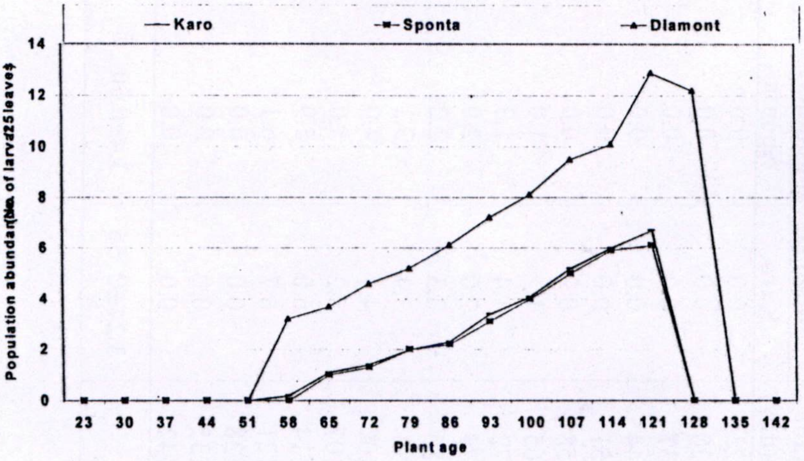


Fig.(2): Mean larval numbers of the potato tuber moth P. operculella in relation to certain ecological factors and age plant for some potato cultivars at Giza Governorate during summer plantation of 2003.

After that the population decreased gradually to reach (12.2, 0.0 and 0.0 larval/25 leaves) 128 days after sowing on May 15th on Diamont, Sponta and Karo cultivars the end of the season on May 29th.

Data show also that incidence of infestation by *P. operculella* as expressed by counts of larvae stage increases sharply with the increase of potato plants age to reach its maximum incidence at 121 days, on the three potato cultivars (Diamont, Sponta and Karo). Such infestation dropped to reach minimum rates at ages of more than 128 days on the three potato cultivars (Diamont, Sponta and Karo).

Data in Tables (1 and 2) revealed that infestation rate by *P. operculella* during summer plantation of 2002 and 2003 years, was very high for Diamont than Sponta and Karo Varieties.

The obtained data are in agreement with those of Mikhael (1995); Dawood *et al.* (1999); Stein and Vendramin (2000) and Gomma (2002).

2. Effect of the main climatic factors and plant age on the population fluctuation of *P. operculella:*

The data presented in (Tables 3, 4 and 5) showed the simple correlation and regression values, as well as the partial regression values with their significant levels (P) and the percentage of explained variance for the combined effect of these main climatic factors on the insect population/leaf in both seasons during 2002 and 2003 years.

2.1. Effect of daily mean temperature:

The data of statistical analysis of simple correlation for the three potato varieties (Tables 3, 4 and 5) showed a positive and significant correlation between the daily mean temperature and insect population on various cultivars in 2002 and 2003 ("r" values = 0.548, 0.859, 0.841, 0.804 and 0.451, 0.863 for Diamont, Sponta and Karo cultivars on the 1st and 2nd seasons, respectively, While the real effect of this factor which appears from the partial regression on larval population values of *P. operculella* indicated insignificant negative effect during the two seasons (b. reg. = -0.38, -0.66, -0.92, -0.16 and -0.12, -0.93) for the 1st and 2nd seasons, respectively.

2.2. Effect of plant age:

The effect of plant age on the larvae of *P. operculella* activity during the two seasons was significant positive (r = 0.99, 0.628 and 0.512) and (r = 0.98, 0.98 and 0.99), with the three potato cultivars (Sponta, Diamont and Karo).

The real effect of this factor which appears from the partial regression values showed insignificant effect (b. reg. = 0.746, 0.93 and 0.619) and (b. reg. = 0.923, 0.98 and 0.94) during 1st and 2nd seasons with the potato cultivars (Diamont, Sponta and Karo) , respectively (Tables 3, 4 and 5).

2.3. Effect of daily mean relative humidity:

The results of statistical analysis of simple correlation, showed a negatively significant correlation during 2002 and 2003 seasons, the "r" values in the two seasons were (-0.771, -0.509 and 0.501) and (-0.789, 0.704 and 0.79) with the three potato cultivars (Diamont, Sponta and Karo), respectively.

The partial regression values emphasized negative and insignificant relation (b. reg. = -0.16, -0.25 and -0.20) and (b. reg. = -0.15, -0.2 and -0.16) between the daily mean relative humidity and larvae of *P. operculella* in both seasons for the three potato cultivars (Diamont, Sponta and Karo), respectively.

Table (3): Effect of main climatic factors and plant age on population fluctuation of *P. operculella* on potato cultivar(Diamont) during summer plantation of two successive years of 2002&2003 under climatic, conditions at Giza Governorate.

year	Factor	Simple correlation and regression values					Partial regression values				Analysis of variance		E.V.%
		r	b	S.E.	T	P	b. reg	S.E.	T	P	F	P	
2002	Plant age	0.628	+0.814	±0.0065	3.22	0.05	0.746	±0.060	1.242	0.05	31.94	0.05	76.2
	Daily mean temp.	0.548	-0.0952	±0.00415	2.621	0.05	-0.38	±0.060	-0.299				
	Daily mean R.H.%	-0.771	-0.0017	±0.0028	-0.694	0.05	-0.166	±0.0277	-0.601				
2003	Plant age	0.982	+0.355	±0.019	20.702	0.05	0.923	±0.013	6.83	0.05	66.56	0.05	81.5
	Daily mean temp.	0.859	-0.043	±0.012	6.700	0.05	-0.66	±0.018	-0.358				
	Daily mean R.H.%	-0.789	-0.093	±0.088	-5.133	0.05	-0.15	±0.014	-1.05				

b: Simple regression coefficient.

b. reg. : partial regression.

E.v.: Explained variance.

Table (4): **Effect of main climatic factors and plant age on population fluctuation of *P. operculella* on potato cultivar (Sponta) during summer plantation of two successive year of 2002&2003 under climatic conditions at Giza Governorate.**

year	Factor	Simple correlation and regression values					Partial regression values				Analysis of variance		E.V.%
		r	b	S.E.	T	P	b. reg	S.E.	T	P	F	p	
2002	Plant age	0.99	0.91	±0.062	28.001	0.05	0.93	±0.064	14.612	0.05	29.41	0.05	59.2
	Daily mean temp.	0.841	0.36	±0.036	6.214	0.05	-0.92	±0.065	0.96	0. 3			
	Daily mean R.H.%	0.509	-0.48	±0.025	-0.438	0.05	-0.25	±0.037	-1.74	0. 1			
2003	Plant age	0.988	0.10	±0.077	19.6	0.05	0.98	±0.076	12.88	0.05	61.63	0.05	63.4
	Daily mean temp.	0.804	-0.73	±0.046	5.45	0.05	-0.16	±0.010	-1.561	0.01			
	Daily mean R.H.%	-0.704	-0.93	±0.093	-3.962	0.05	-0.20	±0.081	-2.551	0.03			

b: Simple regression coefficient.

b. reg. : partial regression.

E.v.: Explained variance.

Table (5): **Effect of main climatic factors and plant age on population fluctuation of *P. operculella* on potato cultivar (Karo) during summer plantation of two successive years of 2002&2003 under climatic conditions at Giza Governorate.**

Season	Factor	Simple correlation and regression values					Partial regression values				Analysis of variance		E.V.%
		r	b	S.E	T	P	b. reg	S.E.	T	P	F	p	
2002	Plant age	0.512	0.75	±0.080	2.383	0.05	0.619	±0.065	1.939	0.05	21.16	0.05	62.1
	Daily mean temp.	0.451	-0.97	±0.05	2.02	0.05	-0.12	±0.066	-0.193	0.8			
	Daily mean R.H.%	-0.501	-0.23	±0.034	-0.854	0.05	-0.20	±0.030	-0.68	0.5			
2003	Plant age	0.991	0.98	±0.085	29.545	0.05	0.94	±0.081	11.59	0.05	85.46	0.05	68.4
	Daily mean temp.	0.863	-0.42	±0.051	6.822	0.05	-0.93	±0.011	-0.83	0.4			
	Daily mean R.H.%	-0.79	-0.70	±0.037	-5.153	0.05	-0.16	±0.087	-1.86	0.09			

b: Simple regression coefficient.

b. reg. : partial regression.

E.v.: Explained variance.

Table (6): The yield of the potato cultivars during summer plantation of two successive years.

Year	Mean yield (ton/feddan)		
	Diamont	Sponta	Karo
2002	9.8	10.7	10.2
2003	9.9	10.9	10.4

The combination effect of daily means of temperature and R.H. and plant age on the population fluctuation of *P. operculella:*

The partial regression values were carried out for obtaining the influence of the three factors (i.e. the daily mean temperature plant age and R.H.) on the larvae of *P. operculella* activity during 2002 and 2003 seasons. The obtained data revealed that the calculated "F" values were (31.94, 29.4 and 21.16) and (66.56, 61.63 and 85.46) for the 1st and 2nd seasons of 2002 and 2003 for the three potato cultivars (Diamont, Sponta and Karo), respectively.

The percentage of variance explained by the three tested factors during the 1st and 2nd seasons of 2002 and 2003 were (62.1, 59.2 and 76.2%) and (68.4, 63.4 and 81.5%), for the three potato cultivars, (Karo, Sponta and Diamont), respectively (Tables 3, 4 and 5).

Results in Table 6 indicated the yield of the three potato cultivars, showed that Sponta variety gave the highest yield, followed by Karo and then Diamont varieties. The obtained yield was 10.7, 10.9; 10.2, 10.4and 9.8, 9.9 tons/feddan, during 2002 and 2003 years.

Biological studies:

Effect of temperature and kind of food on the biology of *Phthorimaea operculella:*

Some biological aspects of *P. operculella* were investigated on two potato varieties (Diamont and Sponta) at three constant temperatures of 30, 25 and 20°C and 70±5% relative humidity.

Effect of temperature on egg stage:

Data in Table (7) and Fig. (3) showed that the mean incubation periods were 3.45±0.71, 4.2±0.53, 7.6±0.65 and 4.2±0.63, 5.6±0.9, 8.9±0.73 days at 30, 25 and 20°C on Diamont and Sponta potato varieties, respectively.

This means that the incubation period of eggs was affected by the degree of temperature and the two potato cultivars (Diamont and Sponta).

The effect of different temperatures on eggs hatching rates presented in the same table revealed that the highest rate of hatching rates (81.9%) was recorded at 25°C when *P. operculella* was reared on potato variety Diamont, while the lowest value (49.27%) was registered at 20°C on Sponta cultivar.

Data indicated also that the optimum temperature for eggs hatching seems to be between 25°C and 30°C for the two potato varieties. The obtained results are in agreement with Marriy *et al.* (1999).

Effect of temperature on larval stage:

The duration of *Ph. operculella* larval instars were 7.89±1.96, 23.5±2.73 and 32.6±2:93 days on Diamont potato variety and 9.10±2.11, 25.2±2.30 and 33.4±2.56 days on potato Sponta variety at 30ºC, 25ºC and 20ºC, respectively.

The obtained results showed clearly that the total larval period of *P. operculella* at various temperatures was significantly longer on Sponta variety than Diamont.

Also, results clarified that, the duration of the larval stages increased with the decease of temperature and this result is in line with the finding of Marriy *et al.* (1999). In this respect, Iskander (1992) indicated that the duration of the larval stage decreases when *P. operculella* reared on Diamont than Oblisc variety.

Effect of temperature on pupal stage:

As for the developmental period of the pupal stage presented in Table (7) data indicated that these periods were 7.82±0.50, 9.23±0.69 and 14.2±0.28 days on potato variety (Diamont) at 30, 25ºC and 20ºC, but these periods were 8.25±0.80, 10.65±0.93 and 16.1±0.55 days on potato variety Sponta at the same temperatures, respectively. The longest periods were recorded at 20ºC on both potato varieties and pupal duration lasted longer time on Sponta variety than on potato Diamont variety at various temperatures. Also, it noticed that the duration of the pupal stage was decreased markedly by increasing of temperature.

In this respect, El-Atrouzy and Awoad (1986) concluded that *P. operculella* at high temperatures become more active and restless, which resulted in rapid expenditure of their energy and according shorter longevity.

Effect of temperature on total developmental period:

The total developmental period was longer when *P. operculella* reared on potato variety Sponta than on Diamont at all temperatures, i.e. a higher survival from egg to adult estimated on potato variety Sponta than on Diamont variety. There are large numbers of literatures on *P. operculella* but most deals with Diamont variety other than Sponta variety and temperatures different from that used in this work Haydeer (1983), Ahmed *et al.* (1990), Dos *et al.* (1993) and Khattab (1995).

The duration of the whole life cycle was varied greatly according to the prevailing temperatures (Table 7).

Effect of temperature on adult stage:

The longevity of adult stage under different conditions of 30, 25 and 20°C was varied from 5.7±1.2, 10.2±1.4 and 13.7±0.85 days on potato variety Diamont but these values were 5.8±0.52, 9.9±0.4 and 13.4±0.5 days on potato variety Sponta and there are slight differences between the two potato at all tested temperatures. Also, *Ph. operculella* adults had the shortest longevity at 30°C.

Pre-oviposition and post-oviposition periods:

The effect of various temperatures on pre-oviposition, oviposition and post-oviposition periods is given in Table (8). and Fig. (4) Results indicated that slight difference between the effect of different temperatures and different potato varieties on the pre-oviposition, oviposition and post-oviposition periods of *P. operculella* female. On the other hand, the oviposition period was markedly longer at 20 and 25°C than at 30°C. Results showed that at 20°C, females began laying eggs after 3.9±0.2 and 3.6±0.19 days from emergence, while at 30°C they started laying their eggs after 2.6±0.5 and 2.1±0.4 days, i.e. the longest pre-oviposition period were recorded at 20°C, while the shortest period were at 30°C. When *P. operculella* was reared on potato Sponta variety and Diamont variety.

Egg laying activity:

Data revealed that the mean number of eggs laid per female at 20, 25 and 30°C was 115.8±13.2, 121.9±15.3, 126.3±11.3, 142.1±12.9 and 77.6±8.1, 84.7±7.6 eggs when *P. operculella* was reared on potato Sponta and Diamont varieties, respectively.

The highest number of eggs was recorded at 25°C, while, the lowest number was shown at 30°C, when the insect was reared on the two varieties. From the above results it could be concluded that a decrease in the temperature below 30°C causes a high laying in number of eggs laid per female. In this respect, Abd El Wahab *et al.* (1987) mentioned that, the number of eggs lay per *P. operculella* female was 24, 70 eggs, female during winter and summer, respectively. Also, Mariy *et al.* (1999) reported that *P. operculella* female laid the greatest numbers of eggs 142 at 25°C.

Statistical analysis of the data proved that the host plants had significant effect on the total developmental periods of the larvae and pupae of *p. operculella* as well as the total life cycle of this insect species at the various tested aemperafunes.

Data showed also that the host plant Diamont variety was more suitable for rearing *P. operculella* than Sponta variety.

Table (7): Effect of various temperatures on the developmental periods of different stages and hatchability of potato tuber moth *P. operculella* reared on two potato cultivars (Diamont and Sponta) at 70±5% R.H.

Temp.	Potato cultivars	Incubation period of eggs (days)	Larval period (days)	Pupal period (days)	Total developmental period (days)	Adult longevity (days)	Total life cycle (days)	Hatching%
30∘C	Diamont	3.45 ±0.71	7.89* ±1.96	7.82 ±0.5	18.6* ±0.98	5.7 ±1.2	24.3** ±1.1	75.24
25∘C	Diamont	4.2* ±0.53	23.5* ±2.73	9.23* ±0.69	37.2* ±1.4	10.2 ±1.4	47.4** ±1.4	81.92
20∘C	Diamont	7.6 ±0.65	32.6 ±2.93	14.2** ±0.28	53.1** ±1.3	13.7 ±0.85	65.8** ±1.2	56.75
30∘C	Sponta	4.2 ±0.63	9.1* ±2.11	8.25 ±0.8	21.55* ±1.2	5.8 ±0.52	27.35** ±0.86	55.96
25∘C	Sponta	5.6* ±0.9	25.2* ±2.3	10.65* ±0.93	41.45* ±1.4	9.9 ±0.46	51.35** ±0.93	61.32
20∘C	Sponta	8.9 ±0.73	33.4 ±2.56	16.1** ±0.55	58.4** ±1.28	13.4 ±0.5	71.8** ±0.89	49.27
F value		156.48	173.17	131.81	168.6	0.219	34.081	
$LSD_{0.05}$		1.465	1.045	0.926	2.99	0.0	0.872	
$LSD_{0.01}$		2.429	2.412	1.53	4.96	2	2.0123	

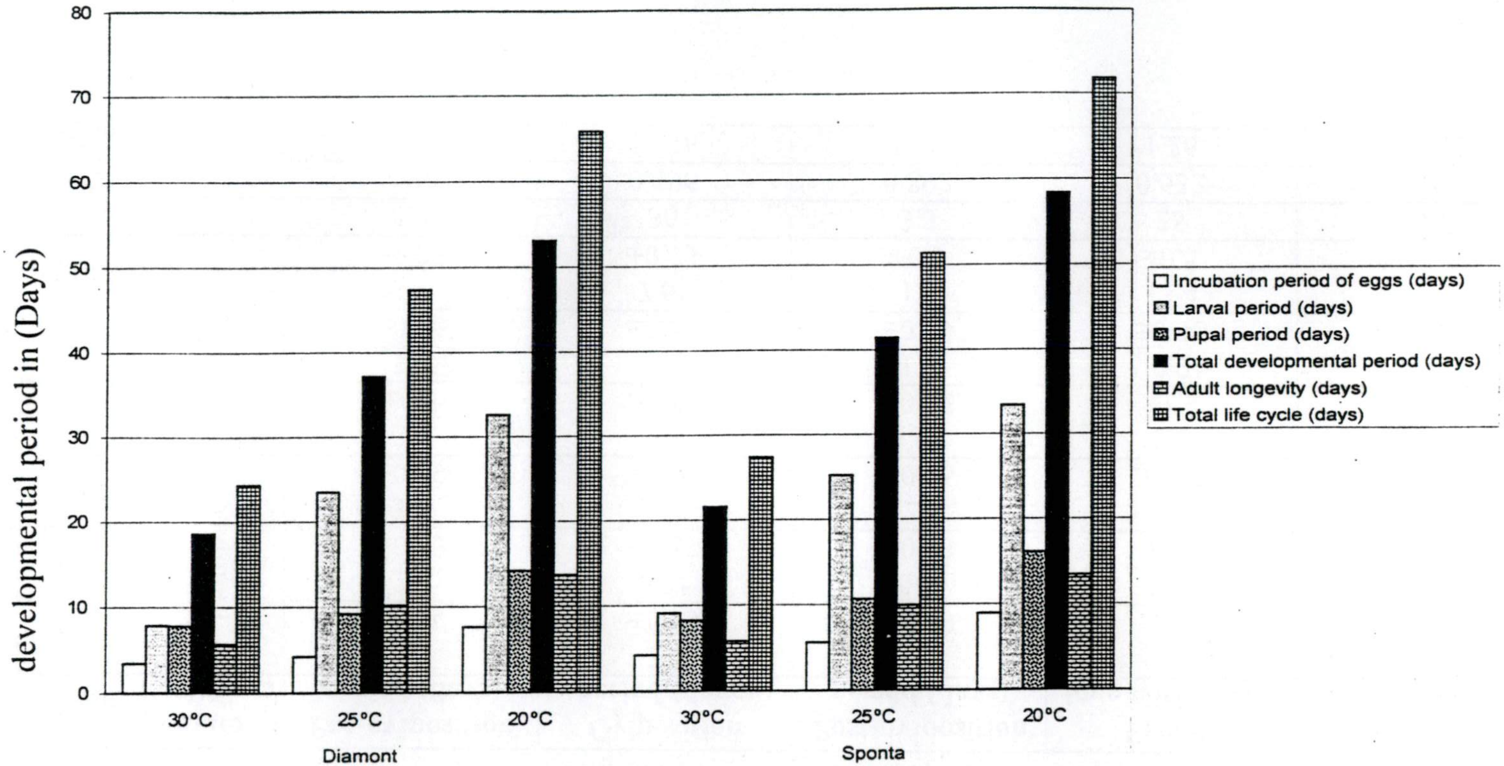


Fig.(3): Effect of various temperatures on the developmental periods of different stages and hatchability of potato tuber moth *P. operculella* reared on two potato cultivars (Diamont and Sponta) at 70±5% R.H.

Table (8): Effect of different temperatures on the longevity and number of eggs laid per female of, *P. operculella* reared on two potato cultivars (Diamont and Sponta) at 70±5% R.H.

Temp.	Potato cultivars	Pre-oviposition period (days)	Oviposition period (days)	Post-oviposition period (days)	Female longevity (days)	No. of eggs laid/female
30∘C	Diamont	2.1 ±0.4	2.4 ±0.23	1.2 ±0.59	5.7 ±1.2	84.7* ±7.6
25∘C		2.8 ±0.53	6.3* ±0.57	1.6 ±0.03	10.2 ±1.4	142.1** ±12.9
20∘C		3.6 ±0.19	8.0* ±0.5	2.1 ±0.16	13.7 ±0.85	121.9* ±15.3
30∘C	Sponta	2.6 ±0.5	2.2 ±0.46	1.05 ±0.62	5.8 ±1.2	77.6* ±8.1
25∘C		3.0 ±0.36	5.6* ±0.63	1.3 ±0.29	9.9 ±0.46	126.3** ±11.3
20∘C		3.9 ±0.27	7.6* ±0.73	1.9 ±0.5	13.4 ±0.5	115.8* ±13.2
F value		4.9	36	3.3	25	184.18
$LSD_{0.05}$		1.6	0.496	0.892	0.632	5.216
$LSD_{0.01}$		1.95	1.146	1.39	1.26	12.033

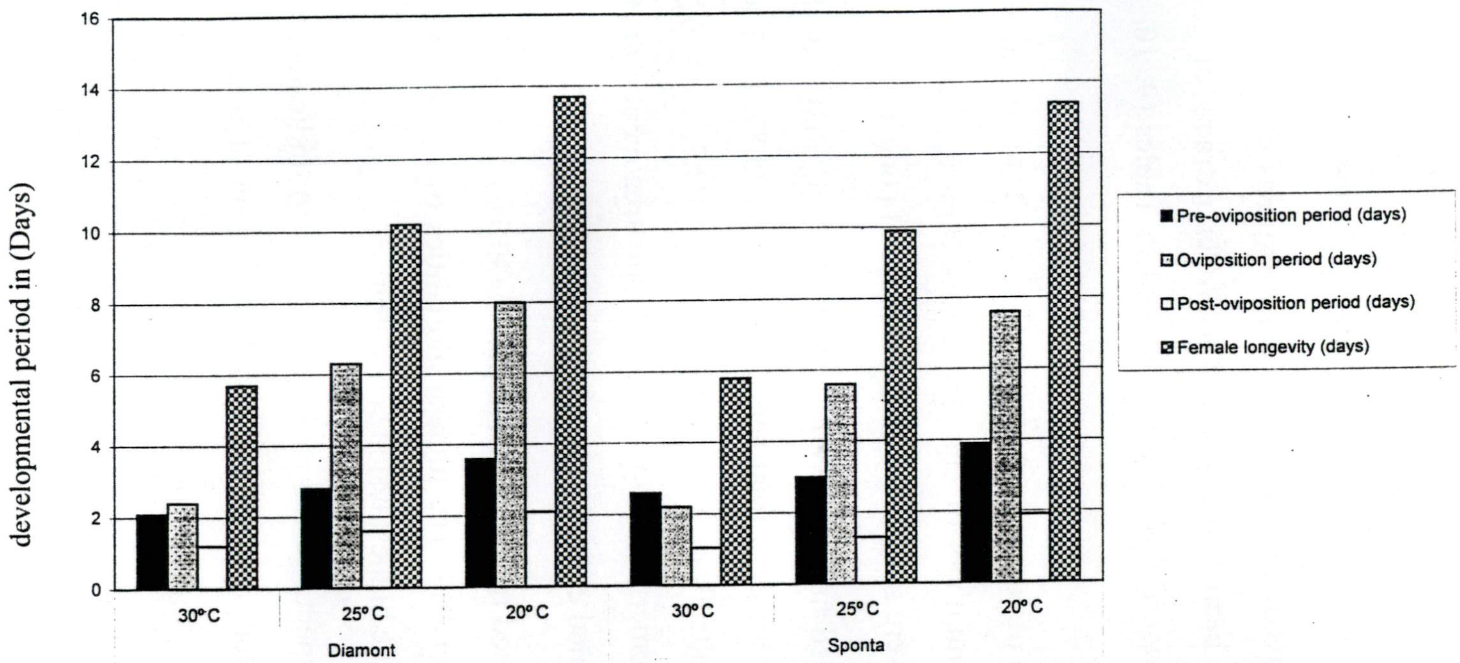


Fig.(4): Effect of different temperatures on the female longevity of, *P. operculella* reared on two potato cultivars (Diamont and Sponta) at 70±5% R.H.

Toxicological studies:

Toxic activity of some plant extracts against *P. operculella:*

The effectiveness of petroleum ether, extracts of cumin, dill seeds and castor bean leaves as well as water extracts of garlic globs against *P. operculella* is demonstrated in Tables (9, 10, 11, 12, 13 and 14).

The results of cumin seed extracts given in Table (9) showed that the average numbers of emerged adults from egg, pupa and moth treatments were reduced with the increase of concentration.

The recorded numbers were 94.2, 85.7, 75.5, 60.0 and 28.9 emerged adults from eggs treatments, 88.0, 80.0, 75.87, 61.2 and 23.5 emerged adults from pupae treatments and 72.7, 71.4, 62.2, 46.4 and 18.6 emerged adults from moth treatments at the previously mentioned concentrations, respectively.

The obtained results revealed that the efficacy of agent was concentration-dependent. The highest mortalities of the treatments were observed at the highest tested concentration.

In this respect, El-Lakwah *et al.,* (1996) indicated that mortalities of acetone and petroleum ether extracts of were some what higher at the highest concentration of 10%, to some stored product insects.

Response of *P. operculella* to petroleum ether extract of seeds is given in Table (10). The results indicated that inhibition rates of moths resulted from eggs, pupae and moth treatments are concentration dependent. The highest inhibition rates of moths emerged were 61.4, 81.39% and 87.3% to eggs, pupae and moths treatments at the highest used concentration (10% W/V) of petroleum ether extract of dill seeds for treated eggs, pupae and moths, respectively, while the lowest reduction rates of moth emergence (13.8, 17.46 and 24.3%) were recorded at the lowest concentration (0.625% W/V).

A result of the response of P. operculella to petroleum ether of castor bean leaves was given in Table (11). Data showed the same phenomenon as presented with the extracts of dill seeds.

The number of emerged moths was gradually reduced with increasing the concentration at all treatments when compared with control. Consequently, the inhibition rates of moth emergence increased with increasing the concentration at all treatments, reaching between 3.72-71.0%, 7.4-76.6% and 10.0-77.5% in egg, pupa and moth treatments for petroleum ether extract of castor bean leaves.

Response of *P. operculella* to water extracts of garlic globs is given in Table (12). The results indicated that inhibition rates of moths resulted from eggs; pupae and moths treatments are concentration dependent. The highest inhibition rates of moth's emergence were 63.54, 68.4 and 77.78% to eggs, pupae and moth treatments at the highest used Concentration (100%) , respectively. While, the lowest reduction rates of moth emergence (2.08, 5.26 and 11.1%) were recorded at the lowest concentration (10%). The obtained results are in complete harmony with that obtained by Kroschel and Koch (1996). Who studied that the toxicity of three plant extracts, namely chinaberry *(Melia azedarch)*, neem *(Azadirachta indica)* and garlic *(Allium sativum)* on the reduction of *P. operculella.* The effectiveness of the water extract of neem and garlic were 93.8 and 61.3%.

The lethal concentrations of petroleum ether extracts of the seeds and leaves of the tested plants on *P. operculella* are summarized in Tables (13, 14). The results showed that the lethal concentration values to eggs (LC_{90}, LC_{95}) were slightly greater than those obtained to pupae and moths for various plant extracts.

Results indicate that the tested plant extract were slightly more effective in moths and pupae treatments than eggs treatment and showed promising results at the highest used concentrations of the different tested materials. Thus, these plant seed and leaves extracts could be used as tuber protectants against this species frame of an integrated pest management program (IPM).

Based on the (LC_{90}, LC_{95}) results revealed that seed extracts of dill was the most effective followed by cumin and castor bean leaves, while the extracts of garlic globs was the least effective against *P. operculella* infestation. Effect of these plant extracts may be due to the fact that these plants contain some compounds which possess antifeedant or toxic activity or lead to a moulting disturbance which is often lethal to insects (Champagne *et al.*, 1989).

Also, the obtained results coincide with the findings of other investigators (Reddy and Urs., 1989; Salem, 1991, Sabbour and Ismail, 2002).

Table (9): Response of *Phthorimaea operculella* (Zeller) to the petroleum ether extract of cumin seeds *Cuminum cyminum.*

Conc. (% w/v)	Average no. of emerged moths from eggs treatment	Inhibition rates of moths emergence (%)	Average no. of emerged moths from pupae treatment	Inhibition rates of moths emergence (%)	Average no. of emerged moths from moths treatment	Inhibition rates of moths emergence (%)
10	28.9±3.1	69.4	23.5±2.2	75.66	18.6±2.8	79.0
5	60.0±2.9	36.5	61.2±3.4	37.42	46.4±3.6	47.7
2.5	75.5±2.6	20.1	75.87±2.5	22.4	62.2±3.1	29.9
1.25	85.7±3.2	9.3	80.0±2.9	18.2	71.4±2.4	19.6
0.625	94.2±1.2	0.31	88.0±3.6	10.02	72.7±2.2	18.1
Control	94.5	-	97.8	-	88.8	-

Table (10): **Response of *Phthorimaea operculella* (Zeller) to the petroleum ether extract of dill seeds *Anethum graveolens*.**

Conc. (% w/v)	Average no. of emerged moths from eggs treatment	Inhibition rates of moths emergence (%)	Average no. of emerged moths from pupae treatment	Inhibition rates of moths emergence (%)	Average no. of emerged moths from moths treatment	Inhibition rates of moths emergence (%)
10	36.6±2.6	61.4	18.0±2.1	81.39	11.1±2.3	87.3
5	41.2±3.4	56.6	40.6±2.5	58.0	33.9±1.9	61.4
2.5	56.1±3.2	40.9	54.6±2.3	43.53	48.5±1.8	44.8
1.25	66.6±1.9	29.9	70.4±2.7	27.19	62.2±2.7	29.3
0.625	81.8±2.1	13.8	79.8±1.8	17.46	66.6±3.6	24.3
Control	95	-	96.7	-	88	-

Table (11): Response of *Phthorimaea operculella* (Zeller) to the petroleum ether extract of castor bean leaves *Ricinus communis.*

Conc. (% w/v)	Average no. of emerged moths from eggs treatment	Inhibition rates of moths emergence (%)	Average no. of emerged moths from pupae treatment	Inhibition rates of moths emergence (%)	Average no. of emerged moths from moths treatment	Inhibition rates of moths emergence (%)
10	28.1±2.6	71.0	22.0±1.1	76.6	22.2±3.2	77.5
5	70.2±2.3	27.5	63.6±1.5	32.55	65.3±2.6	34.0
2.5	82.0±1.9	15.37	68.9±2.1	26.93	71.4±1.3	27.8
1.25	89.7±1.5	7.43	79.1±1.9	16.1	81.8±2.2	17.37
0.625	93.3±1.4	3.72	87.3±1.7	7.4	89.1±1.9	10.0
Control	96.9	-	94.3	-	99	-

Table (12): Response of *Phthorimaea operculella* (Zeller) to water extract of garlic globs *Allium sativum.*

Conc. (% w/v)	Average no. of emerged moths from eggs treatment	Inhibition rates of moths emergence (%)	Average no. of emerged moths from pupae treatment	Inhibition rates of moths emergence (%)	Average no. of emerged moths from moths treatment	Inhibition rates of moths emergence (%)
100	35±1.2	63.54	30±1.3	68.4	20±0.9	77.78
80	46±1.3	52.08	40±1.5	57.8	32±2.7	64.44
60	67±1.5	30.2	60±2.1	36.84	51±1.5	43.33
40	80±2.3	16.6	75±3.1	21.05	62±1.3	31.11
20	89.0±4.1	7.29	85±2.9	10.52	71±1.1	21.11
10	94.0±3.2	2.08	90±2.6	5.26	80±2.5	11.1
Control	96	-	95	-	90	-

Table (13): Lethal concentration of petroleum ether extracts of certain plants against *Phthorimaea operculella* (Zeller).

Plant extracts	Treated stage	Lethal concentration (w/v) and their 95% confidence limits			Slope±SD	R
		LC_{50}	LC_{90}	LC_{95}		
Cumminum cyminum	Egg	6.77 (4.4-7.2)	195.4 (14.2-45.5)	391	1.203 ±0.17	0.995
	Pupa	5.53 (3.6-21.6)	36.73 (52.6-1544.7)	62.8 (105.7-550)	1.56 ±0.16	0.995
	Moth	4.25 (2.4-14.0)	33-76 (45-143.5)	60.75 (95-576)	1.42 ±0.15	0.998
Anethum groveolenus	Egg	4.3 (3.4-5.9)	60.7 (31.4-177.9)	28.2 (57.5-497.2)	1.12 ±0.14	0.875
	Pupa	3.0 (2.5-3.7)	22.6 (15.2-39.9)	39.8 (24.6-80.3)	1.47 ±0.14	0.972
	Moth	2.5 (2.1-3.0)	19.1 (13.1-33.1)	34.8 (21.3-67.2)	1.46 ±0.148	0.986
Ricinus communis	Egg	7.07 (5.0-19.6)	35.3 (49.8-122.6)	60.3 (48.9-81.1)	2.0 ±0.19	0.993
	Pupa	5.59 (3.6-4.0)	33.13 (30.9-328.9)	54.8 (98.3-407.7)	1.66 ±0.16	0.984
	Moth	5.3 (5.1-7.3)	30.6 (30.9-328.9)	46.4 (49.9-758)	1.56 ±0.16	0.983

R = correlation coefficient of regress line **SD = Standard deviation of the mortality regression line**

Table (14): **Lethal concentration of water extracts of certain plant garlic *Allium sativum against Phthorimaea operculella* (Zeller).**

Plant extracts	Treated stage	Lethal concentration (w/v) and their 95% confidence limits			Slope ±SD	R
		LC_{50}	LC_{90}	LC_{95}		
Allium sativum	Egg	81.81 (72.8-94.5)	259.8 (199.4-381)	388.6 (289.4-1307.5)	2.55 ±0.25	0.991
	Pupa	71.95 (63-83.1)	266.1 (201.8-8394.3)	385.6 (276.9-619.7)	2.25 ±0.21	0.993
	Moth	53.3 (39.5-77.0)	250.6 (191.9-679.4)	360.5 (263.2-570.3)	1.9 ±0.17	0.993

R = correlation coefficient of regress line **SD = Standard deviation of the mortality regression line.**

Effect of bio-insecticide and powder plants against *p. operculella* on three potato tuber cultivars under laboratory conditions:

Larvae were fed on potato tubers treated with three concentrations of Black pepper (*Piper nigrum*) seeds; Santonica (*Matricaria chamomillia*) flowers; Clove (*Syzguim aromaticum)* flowers; Protecto (Bacillus thuringiensis) and control (untreated).

The results obtained in Tables (15,16 and 17) and Figures (5, 6 & 7) showed that the corrected mortality percentage of larvae 2,4,6 and 8 weeks after treatment with three potato tuber cultivars ,(Karo, Diamont and Sponta).

Data indicated that the larvae of *P. operculella* were susceptible to bio-insecticidal treatment. The mortality in case of after two weeks, on treated potato tuber (Karo Variety) with the lowest concentration (6.25gm) was 44.59 %, 51.52 % and 52.77 % with Black pepper, Santonica and Clove, while 62.74 %,73.40%,86.14% and 95% for the higher concentration 25gm. With three powder plants, Black pepper, Santonica, Cloves and Protecto compared with control. The mortality after 4,6and 8 weeks showed nearly the same trend as indicated with after two weeks. However, all powder plants caused a significant in the general mean of larvae as compared with the control. Also, the Protecto was relatively the most efficient compound in protecting potato tubers against *P. operculella* (Table 15).

The results in Table (16) revealed that the powder plants Santonica, Clove and Protecto were relatively the most efficient compound in protecting potato tubers against *P. operculella* 73.1 % ,82.68% and 95.29% for the higher concentration 25gm. after two weeks compared with control. The mortality case of after two weeks on treated potato tubers (Diamont variety) with the lowest concentration (6.25gm.) was 43.21%, 49.44% and 51.52% with the powder plants, with three powder plants.

The results in Table (17) the mortality in case of after two weeks on treated potato tubers (Sponta variety) with the lowest concentration (6.25gm.) were 45.7%, 52.7% and 54.29% , while 66.62% ,74.65% and 86.14% for the higher concentration 25gm. with three powder plants, Black pepper, Santonica and Cloves, respectively

The mortality after 4, 6 and 8 weeks showed nearly the same trend as indicated with after two weeks. However, all powder plants caused a significant in general mean of larvae as compared with control. Also, the Protecto was relatively the most efficient compound in protecting potato tubers against *P. operculella*

These results agree with the findings of Raman *et al*(1987); Lal (1987) and Doss et al. (1994) stated that *L. camara* significant reduced Sponta damage when compared with the untreated control and with those covered with rice straw.

Table (15): Efficiency of bioinsecticide protecto and some plant powder against *Phthorimaea operculella* (Zeller) on potato variety (Karo) under storage conditions.

Treatments	Conc. gm	Mean larval number								General mean	
		Application								No	%
		After 2 weeks		After 4 weeks		After 6 weeks		After 8 weeks			
		No.	%	No.	%	No.	%	No.	%		
1- *Piper nigrum*	25.0	26.9	62.74	28	67.02	34.4	62.32	37.6	61.71	31. 72*	63.39
	12.5	28	61.22	34	59.95	36	60.56	41	58.24	34.75*	59.89
	6.25	40	44.59	45	47.1	50.9	44.24	56	42.97	47.98*	44.63
2- *Matricaria chamomillia*	25.0	19.2	73.40	27.9	67.13	40	56.18	50	49.08	34.27*	60.44
	12.5	23.3	67.72	48	43.46	50.1	45.12	61	37.88	45.6*	47.37
	6.25	35	51.52	55.4	34.74	60	34.28	65	33.80	53.85*	37.85
3- *Syzguim aromaticum*	25.0	10	86.14	15.1	82.21	24.3	73.38	31.4	68.02	20.2*	76.69
	12.5	14.7	79.63	21.6	74.55	36.5	60.02	54.7	44.29	31.88*	63.21
	6.25	34.1	52.77	42.4	50.05	59.2	35.15	63.9	34.92	49.9*	42.41
4- *Protecto*	3.75	3.4	95.3	3.9	95.40	5.4	94.08	9.1	90.73	5.45*	93.7
5- Control	-	72.2	-	84.9	-	91.3	-	98.2	-	86.65	

LSD at 5%= 23.5 $F_{\%5}$= 13.23

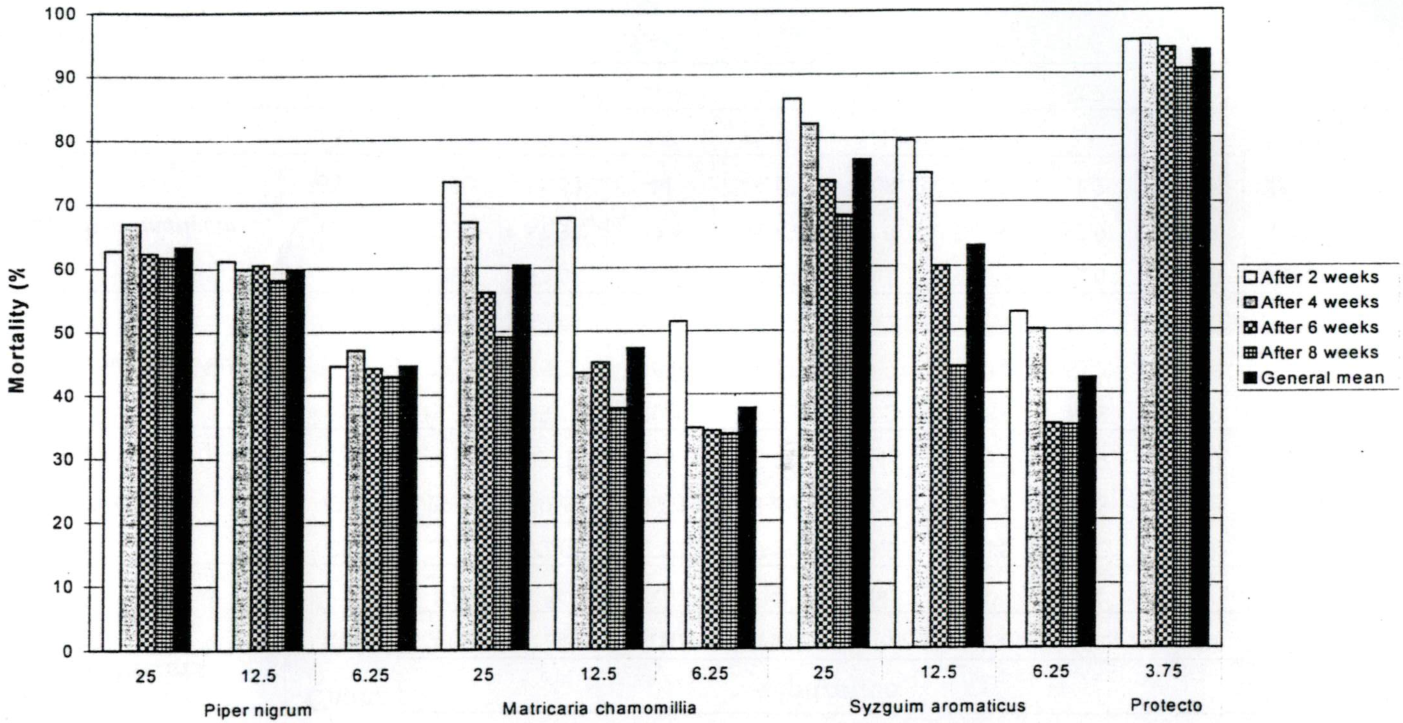


Fig.(5): Efficiency of bioinsecticide protecto and some plant powder against *Phthorimaea operculella* (Zeller) on potato variety (Karo) under storage conditions.

Table (16): Efficiency of bioinsecticide protecto and some plant powder against *Phthorimaea operculella* (Zeller) on potato variety (Diamont) under storage conditions.

Treatments	Conc. gm	Mean larval number								General mean	
		Application									
		After 2 weeks		After 4 weeks		After 6 weeks		After 8 weeks		No.	%
		No.	%	No.	%	No.	%	No.	%		
1- *Piper nigrum*	25	20.2	72.02	27.2	67.96	33.9	62.86	38.2	61.9	29.88*	65.52
	12.5	29.1	59.69	32.6	61.60	37	59.47	40.8	58.45	34.88*	59.77
	6.25	41	43.21	46	45.81	54	40.85	55.9	43.07	49.23*	43.19
2- *Matricaria chamomillia*	25	19.37	73.17	29.1	65.72	41.2	54.87	49.3	49.79	34.74*	59.90
	12.5	24.4	66.20	46.6	45.11	49.9	45.34	62.2	36.65	45.77*	47.17
	6.25	36.5	49.44	54.6	35.68	61.2	32.96	65.0	33.80	54.33*	37.31
3- *Syzguim aromaticum*	25	12.5	82.68	17.2	79.74	25.1	72.50	32.6	66.80	21.85*	74.78
	12.5	23.6	67.31	29.6	65.13	37.9	58.48	52.9	46.13	36.00*	58.45
	6.25	35	51.52	44	48.17	53.8	41.07	61.2	37.67	48.5*	40.27
4- *Protecto*	3.75	3.4	95.29	3.9	95.40	5.4	94.08	9.1	90.7	5.45*	93.7
5- Control	-	72.2	-	84.9	-	91.3	-	98.2	-	86.65	-

LSD at 5%= 21.5 $F_{\%5}$= 15.40

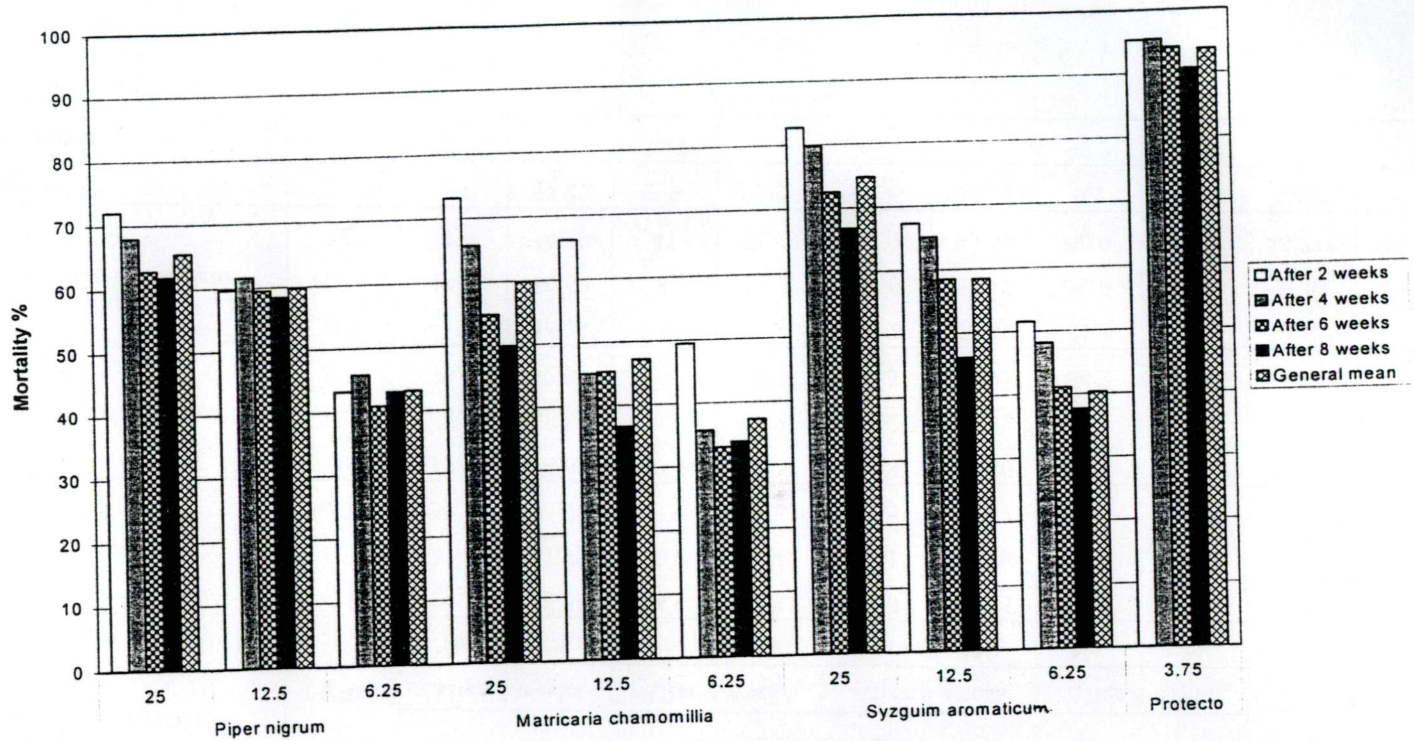


Fig.(6): Efficiency of bioinsecticide protecto and some plant powder against *Phthorimaea operculella* (Zeller) on potato variety (Diamont) under storage conditions.

Table (17): Efficiency of the bioinsecticide protecto and some plant powder against *Phthorimaea operculella* (Zeller) on potato variety (Sponta) under storage conditions.

Treatments	Conc. gm	Mean larval number								General mean	
		Application									
		After 2 weeks		After 4 weeks		After 6 weeks		After 8 weeks		NO.	%
		No.	%	No.	%	No.	%	No.	%		
1- *Piper nigrum*	25	24.1	66.62	26.9	68.31	33.0	63.85	37.1	62.21	30.28*	65.1
	12.5	27.6	61.77	30.2	64.42	36.1	60.46	40.0	59.26	33.475*	61.37
	6.25	39.2	45.70	45.3	46.64	50.6	44.57	54	45.01	47.28*	45.44
2- *Matricaria chamomillia*	25	18.3	74.65	27.9	67.13	39.8	56.40	48.2	50.91	33.55*	61.28
	12.5	22.5	68.83	46	45.81	47.2	48.30	61.1	37.78	44.2*	48.99
	6.25	34.6	52.07	53.2	37.33	60.3	33.95	64.2	34.62	53.08*	38.75
3- *Syzguim aromaticus*	25	10	86.14	16.3	80.80	24.2	73.49	31.3	68.12	20.45*	76.39
	12.5	14.0	80.60	28.2	66.78	33.6	63.19	50.6	48.47	31.6*	63.53
	6.25	33	54.29	41	51.70	52.0	43.04	60.9	37.98	46.73*	46.07
4- *Protecto*	3.75	3.4	95.29	3.9	95.29	5.4	94.08	9.1	90.73	5.45*	93.7
5- Control	-	72.2	-	84.9	-	91.3	-	98.2	-	86.65	-

LSD at 5%= 22.3 $F_{\%5}$= 14.5

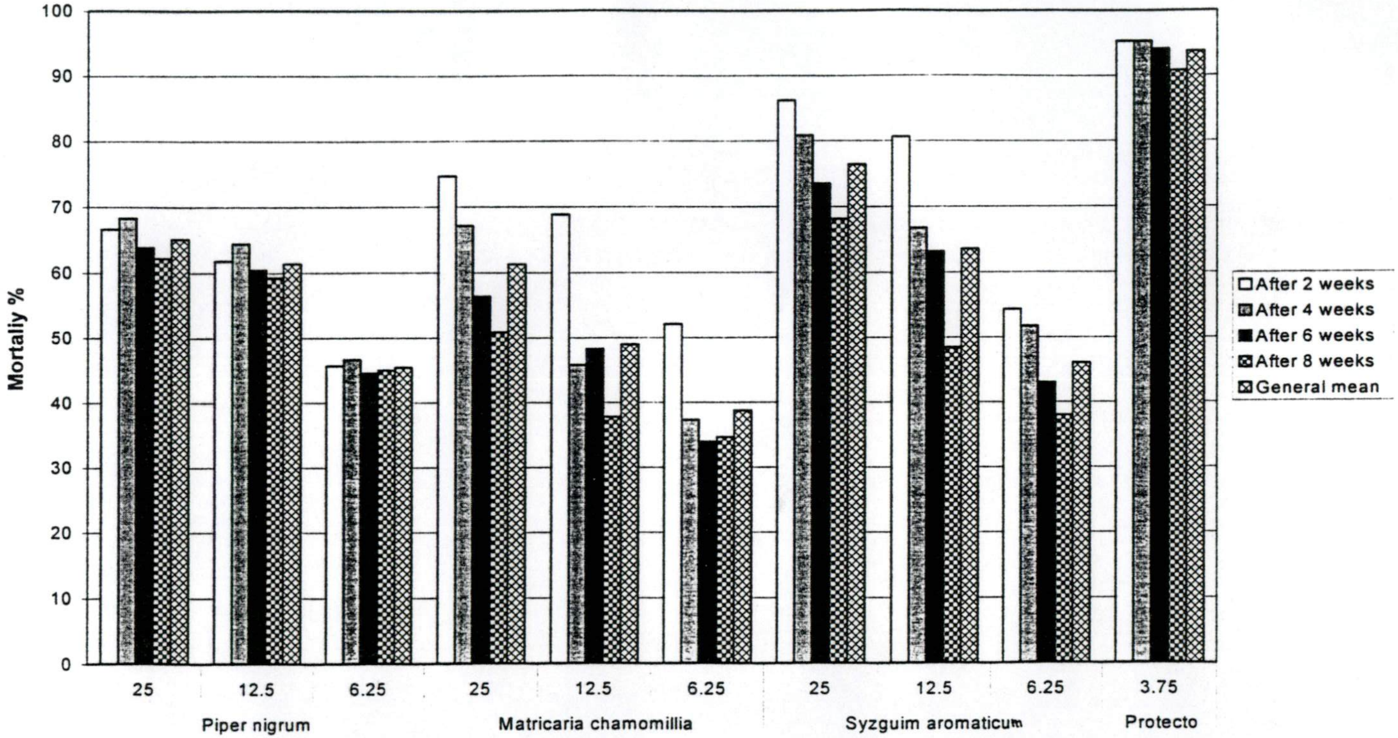


Fig. (7): Efficiency of the bioinsecticide protecto and some plant powder against *Phthorimaea operculella* (Zeller) on potato variety (Sponta) under storage conditions.

SUMMARY

SUMMARY

Ecological studies:

Field experiment was conducted at Giza Governorate during two successive seasons 2002 and 2003 to study the population fluctuation of the *Phthorimaea operculella*. Also, to study the effect of certain weather factors (daily mean temperature, daily mean R.H.) and plant age on the three potato cultivars during two seasons. The obtained data showed that:

- The potato tuber moth *P. operculella* started to occur from mid-February and the first of March and increased gradually reaching the peak in the second third of April and May or plant age (108 and 121 days from sawing) the high number of larvae were recorded (12.8; 12.3; 6.2 larvae/25 leaves and 12.9; 6.7; 6.1 larvae/25 leaves) during the first and second seasons on the potato tuber cultivars (Diamont, Karo and Sponta), respectively.
- The weather factors (mean Temp. and plant age) had significant effect on population of *P. operculella* larvae with three cultivars Sponta, Kara and Diamont) also the relative humidity had negative significant effect on population of *P. operculella* during two successive seasons 2002 and 2003 on three cultivars, respectively.

- The percentage of variance explained by three tested factors during two seasons, was 62.1, 59.2 and 76.2% and (68.4, 63.4 and 81.5%) for the three potato cultivars, (Karo, Sponta and Diamont), respectively.

Biological study

Effect of temperature and different cultivars on the biology of *P. operculella:*

Some biological data of *P. operculella* were recorded at three constant temperatures of 30, 25 and 20°C and 70±5% RH and three cultivars Diamont, Karo and Sponta.

The obtained results indicated the following:

- The shortest incubation period (3.45 and 4.2 days) was found at 30°C on Diamont and Sponta varieties, the longest (7.6 and 8.9 days) at 20°C an Diamont and Sponta cultivars.
- The highest hatching rate of eggs (81.92 and 61.32%) was obtained at 25°C on Diamont and Sponta varieties, while lower values (75.24; 56.75%) and (55.96; 49.27%) were found at 30°C and 20, on two varieties (Diamont and Sponta).
- The longest pre-oviposition period and post-oviposition periods were recorded at 20°C, while the shortest periods at 30°C on two verities.

- Adult longevity was decreased with increasing the temperature, whereas the shortest longevity (5.7;5.8 days) was detected at 30°C, and longest (13.7; 13.4 days) at 20°C on two cultivars (Diamont & Sponta).

- The mean number of eggs laid per female was (84; 77.6) (142.1; 126.7) and (121.9; 115.8) eggs at 20, 25 and 30°C, on two varieties, respectively, while indicating that the highest number of insect eggs was laid at higher temperature (25°C) on Diamont variety.

Bioactivity of some plant extract against *P. operculella:*

The petroleum ether extracts of the seeds of Dill (*Anethum graveolens* L.); Cumin (*Cumium syminum* L.); Castor bean (*Ricinus cummunis*) leaves and the water extracts of Garlic globs (*Allium sativum*) were evaluated in the laboratory 28±5°C and 70±5% R.H. against *P. operculella* infestation.

The results indicated that the bioactivity of the tested extracts were concentration-dependent, whereas, the inhibition rates of moths resulted from eggs or pupae or moths infestation increased obviously with the rise of concentration.

Meanwhile, the bioactivity of all tested extracted was relatively the most to moths infestation all tested extracted than eggs and pupae.

Based on the LC_{95} value, the results revealed that seed extracts of Dill were the most effective followed by Cumin and Castor bean leaves, while the water extract of Garlic globs were the least effective against *P. operculella.* Thus, it could be recommended to use the seeds extracts of Dill, Cumin and Castor bean against *P. operculella* infestation in the frame of an integrated pest management program.

Effect of the some plants powder and Bioinsecticide Protecto against potato tuber moth *P. operculella*:

The seeds of Black pepper (*Piper nigrum*), Clove flower (*Syzygium arematicum*) and Santonica flower (*Matricaria chamomillia*) against *P.operculella* larvae were concentrations, (6.25; 12.5; 25 gm.) on three potato cultivars (Karo, Diamont and Sponta) ,with compared protecto were evaluated under condition the laboratory .

The results explanted that the cloves flower powder the most effective against larvae of *P. operculella*, followed by santonica flower powder and black pepper seed powder, while protecto was mortality rate of larvae 95.29 %, respectively. Also the data indicated that the mortality of the potato tuber moth of larvae with three powders is increased by increasing the concentrations, respectively. While tested three potato cultivars had insignificant effect the mortality rate of larvae of this insect, respectively.

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ARABIC SUMMARY

الملخص العربي

أجريــت تجــربة حقلــية في محافظة الجيزة خلال موسمين متتاليين ٢٠٠٢، ٢٠٠٣ لدراسة التذبذب العددي لفراشة درنات البطاطس *hthorimaea operculella* وتأثــير العوامل الجوية (متوسط درجة الحرارة العظمي والصغري ومتوسط الرطوبة النســبية) وعمــر النــبات علي ثلاث أصناف من البطاطس (وهى ديامومنت، اسبونتا وكارو).

الدراسات الحقلية الإيكولوجية:

وأوضحت نتائج الدراسةالآتى:

- تــبدأ الإصابة بفراشة درنات البطاطس في منتصف شهر فبراير وأوائل شهر مــارس أي عــند عمر للنبات بعد ٤٥ يوم، ٥٨ يوم من الزراعة وقد تزداد تدريجــيا لتصل ذروتها في شهر أبريل وشهر مايو أي عند عمر النبات بعد ١٠٨، ١٢١ يوم من الزراعة وسجل أعلي تعداد (١٢,٨، ١٢,٣، ٦,٢ يرقة/ ٢٥ورقــة) ، (١٢,٩، ٦,٧، ٦,١ يــرقة/٢٥ ورقة) في السنة الأولي والثانية علي الأصناف ديامومنت، كارو واسبونتا علي التوالي.
- وجــد إرتــباط معــنوي موجــب بين عمرالنبات والمتوسط اليومي لدرجات الحرارة وتعداد فراشة درنات البطاطس خلال موسمي الدراسة وعلي الثلاث أصناف. أيضا كانت قيمة الإرتباط المعنوي عكسي (سالب) بين تعداد الحشرة والرطوبة النسبية خلال موسمي الدراسة علي الثلاث أصناف.

- وجـد أن تأثير هذه العوامل مجتمعة علي نشاط الحشرة في كلا العامين كان معنوي ٦٢,١٪، ٥٩,٢٪ ، ٧٦,٢٪ علي كارو، اسبونتا وديامومنت في العام الأول، ٦٨,٤، ٦٣,٤، ٨١,٥٪ علـي الـثلاث أصناف علي التوالي فى العام الثانى.

ثانيا الدراسات المعملية:

I-الدراسات البيولوجية لفراشة درنات البطاطس:

دراسـة تأثـير ثلاث درجات حرارة هي ٣٠، ٢٥، ٢٠°م مع رطوبة نسبية مقدارهـا ٧٠±٥٪ علي بيولوجية لفراشة درنات البطاطس *P. operculella* بالمعمل علي صنفين من البطاطس (ديامونت – أسبونتا) وأظهرت النتائج:

- وجد أن أقصر مدة لحضانة البيض هي (٣,٤٥، ٤,٢ يوم) علي درجة حرارة ٣٠°م علـي صـنف ديامونت ، أسبونتا. بينما أزدادت هذه المدة علي درجة حرارة ٢٠°م لتصبح (٧,٦، ٨,٩ يوم) علي صنف ديامونت ، أسبونتا.
- وتبيـن أن أعلـي معدل لفقس البيض هو (٨١,٩٢، ٦١,٣٢%) علي درجة حـرارة ٢٥°م علـي صـنف ديامونت وأسبونتا. وأنخفض هذا المعدل نسبيا ليصـبح (٧٥,٢٤، ٥٦,٧٥٪)، (٥٥,٩٦، ٤٩,٢٧٪) علي درجة حرارة ٣٠، ٢٠°م علي الصنف ديامونت والصنف أسبونتا علي التوالي.
- وجـد أن فترة ما قبل وضع البيض وفترة وضع البيض، وكذلك فترة ما بعد وضـع البيض قد قصرت علي درجة حرارة ٣٠°م وقصرت هذه المدة علي درجة حرارة ٣٠°م علي الصنفين.

- وجـــد أن مدة عمر الحشرة الكاملة يقل بإرتفاع درجة الحرارة حيث وجد أن أقل مدة هي ٥,٧، ٥,٨ يوم علي درجة حرارة ٣٠°م.

- وأطـــول مدة علي درجة الحرارة المنخفضة ٢٠°م وهي (١٣,٧، ١٣,٤ يوم) على الصنفين ديامومنت وأسبونتا علي التوالي.

- وجد أن متوسط عدد البيض للأنثي هو (٨٤، ٧٧,٦) ، (١٤٢,١، ١٢٦,٧) ، (١٢١,٩، ١١٥,٨) بيضة وذلك علي درجة حرارة ٢٠، ٢٥، ٣٠°م للصنفين ديامونت وأسبونتا علي التوالي وهذا يبين أن أكبر عدد من البيض قد وضعتها الأنثى علي درجة حرارة ٢٥°م.

II-الفعالية الحيوية لبعض المستخلصات النباتية ضد فراشة درنات البطاطس:

أجـــري تقيـــيم معملـــي لمستخلصات الأثير البترولي لكل من أوراق الخروع وبـــذور الكمون وبذور الشبت ومستخلص الما ئى لفصوص الثوم ضد الإصابة بفراشة درنات البطاطس وذلك علي درجة حرارة ٢٨± ٥°م ورطوبة نسبية ٧٠± ٥٪.

وقـــد أظهـــرت النـــتائج أن أستعمال المستخلصات المختلفة أدي الي إنخفاض واضـــح فـــي عـــدد الفراشات الناتجة من معاملة البيض أو معاملة العذاري أو معاملة الفراشـــات خاصـــة مـــع التركـــيزات العالية، كما أن هذا التأثير توقف علي التركيز المســـتعمل حيـــث أزدادت مقدارنســـبةالانخفاض في عدد الفراشات الناتجة للمعاملات المخـــتلفة بـــزيادة التركيز المستعمل وتبين كذلك أن النشاط الحيوي لهذه المستخلصات كان أعلي نسبيا مع معاملة الفراشات عنه مع البيض والعذاري.

كمـــا وجـــد أن مستخلص بذور الشبت كان أقوي تأثير علي الأطوار المختلفة مـــن حشـــرة فراشة درنات البطاطس من مستخلص بذور الكمون وأوراق الخروع و تبين أن المستخلص المائى للثوم هو الأقل تأثيرا علي الأطوار المختلفة للحشرة.

III-فعالـــية بعـــض المســـاحيق النباتية بالمقارنة بالمبيد الحيوي (البر وتكتو) ضد فراشة درنات البطاطس في المخزن:

أجري تقييم لثلاث مساحيق نباتية لبذور الفلفل الأسود وأزهار الشيح والبراعم الزهرية للقرنفل بالمقارنة بمبيد حيوي (البروتكتو) ضد يرقات فراشة درنات البطاطس في المخزن بتركيزات مختلفة (٦,٢٥، ١٢,٥، ٢٥ جم لكل طن) علي الثلاث أصناف من البطاطس (كارو ، ديامونت، أسبونتا) وأوضحت النتائج أن:

مســـحوق بـــراعم أزهار القرنفل كان أقوي تأثير علي يرقات فراشة درنات الـــبطاطس من مسحوق أزهار الشيح وبذور الفلفل الأسود أما بالنسبة لمبيد البروتكتو الحيوي فكانت نسبة الموت لليرقات ٩٥,٩٢٪ بينما كانت أعلي نسبة موت في اليرقات للمســـاحيق النباتية مع أعلي تركيز وقلت مع التركيز المنخفض، ووجد أن نسبة موت اليرقات علي الأصناف الثلاثة المختلفة كانت غير معنوية.

وبناء علي النتائج المتحصل عليها في هذه الدراسة أنه يمكن التوصية باستعمال مستخلصات بذور الشبت والكمون وأوراق الخروع لمكافحة فراشة درنات البطاطس فى إطار برنامج مكافحة متكاملة.

دراسات على فراشة درنات البطاطس ومكافحتها

رسالة مقدمة من

مها صبري محمد الغنام

بكالوريوس العلوم الزراعية – كلية الزراعة بمشتهر – جامعة الزقازيق ١٩٩٩م

للحصول على

درجة الماجستير

في العلوم الزراعية (حشرات اقتصادية)

<u>لجنة الإشراف العلمي:</u>

أ.د. فارس أمين محمد اللقوة ....

أستاذ الحشرات الاقتصادية ومكافحة آفات المواد المخزونة

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أ.د. حورية على عبد الوهاب ....

أستاذ الحشرات الاقتصادية– معهد بحوث وقاية النباتات

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قسم وقاية النبات

كلية الزراعة بمشتهر

جامعة الزقازيق – فرع بنها

٢٠٠٥م

دراسات على فراشة درنات البطاطس ومكافحتها

رسالة مقدمة من

مها صبري محمد الغنام

بكالوريوس العلوم الزراعية – كلية الزراعة بمشتهر – جامعة الزقازيق ١٩٩٩م

للحصول على

درجة الماجستير

في العلوم الزراعية (حشرات اقتصادية)

وقد تمت مناقشة الرسالة والموافقة عليها

لجنة الفحص والمناقشة:

أ.د. سامي عبد الحميد الدسوقي ....

أستاذ الحشرات الاقتصادية - قسم وقاية النبات
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أستاذ الحشرات الاقتصادية ورئيس قسم وقاية النبات
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أ.د. فارس أمين محمد اللقوة ....

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بسم الله الرحمن الرحيم

وَقُلِ اعْمَلُوا فَسَيَرَى اللَّهُ
عَمَلَكُمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ

صدق الله العظيم

"التوبة ١٠٥"

إهــــــــداء

إلى والدي العزيزين

براً بهما ... وحباً فيهما ...

وإكراماً لهما ... وعرفانًا بالفضل وتقديراً للجميل

وتعظــيماً لدورهما فى حياتى ... ويكون رضاهما عنى خير سبيل لرضا الله تعالى

إلى زوجى الغالي ..... إلى أبنائي الأحباء: محمود و احمد

وإلى أخواتي الأعزاء ...... والى كل من له فضل على

الباحثة

مها صبرى محمد الغنام

دراسات على فراشة درنات البطاطس

ومكافحتها

رسالة مقدمة من

مها صبري محمد الغنام

بكالوريوس العلوم الزراعية – كلية الزراعة بمشتهر – جامعة الزقازيق ١٩٩٩ م

للحصول على

درجة الماجستير

في العلوم الزراعية

(حشرات اقتصادية)

قسم وقاية النبات

كلية الزراعة بمشتهر

جامعة الزقازيق – فرع بنها

٢٠٠٥ م