INFLUENCE OF POTATO VARIETY ON SOME BIOLOGICAL ASPECTS AND LARVAL HEAD CAPSULE WIDTH OF POTATO TUBER MOTH, *PHTHORIMAEA OPERCULELLA* (ZEI)ER (LEPIDOPTERA: GELECHIIDAE)

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ABSTRACT

The effect of potato varieties on the main biological aspects and larval head capsule width of the potato tuber moth, *Phthorimaea operculella*, was studied under laboratory conditions. The averages of larval periods were 15.76, 13.69, and 16.18 days on Diamond, Kara, and Spunta varieties, respectively. The corresponding respective averages of percentages of larval mortality were 34.68, 35.87, and 49.83%. The pupal periods were 6.81, 8.62, and 8.19 days on Diamond, Kara, and Spunta varieties, respectively. No significant differences were found in the pupal mortality, female pupal weights, percentages of adult emergence and the adult sex ratios.

Present results revealed that larvae of *Ph. operculella* has four instars. The average head capsule width of the 1\textsuperscript{st} larval instar of Kara culture was significantly larger (0.195±0.013mm) than those of Diamond and Spunta cultures (0.156±0.016 and 0.166±0.005 mm) by about 25 and 17.5%, respectively. The head capsule widths of the 2\textsuperscript{nd} and 3\textsuperscript{rd} larval instars of Kara culture were significantly larger than those of Diamond culture by about 9.16 and 22.5%, respectively. Similarly, among the 4\textsuperscript{th} larval instar, significant difference was found also in head capsule width between larvae fed on Diamond and Spunta varieties.
INTRODUCTION
In Field as well as at storage, potato crop suffers several agricultural problems affecting negatively both quantity and quality features of potato. Potato insect pests play an important role in such respect, from the first appearance of seedlings, till harvesting and continuing throughout storage period. Potao tuber moth (PTM), Ph. operculella, is considered the most important insect pests. It is an oligophagous insect pest of solanaceous crops including potato, tobacco, eggplant, pepper and tomato and is widely distributed in warm temperate and subtropical climates (Fenemore, 1988; and Sporleder et al., 2004). This insect is a highly destructive pest of cultivated potato and is responsible for damage to both leaf and tuber tissues (Westedt et al., 1998) either in field or at storage (Gui and Li, 2003). The use of varieties with low susceptibility level in integrated pest management programs could represent a useful strategy to limit infestation of PTM in field and in stores (Musmeci et al., 2000).

The number of instars and other information concerning an insect’s biology help in the development of phenology models, or in the refinement of exiting models. Larval head capsule widths are often used to determine the age of various lepidopteran pests (Jobin et al., 1992; McClellan and Logan, 1994; and deGroot, 1998). Therefore, the present study was planned and achieved in order to check the effect of feeding larvae of PTM on different varieties of potatoes on the main biological aspects, number of larval instars of PTM, and to check any probable effect of rearing of PTM larvae on different potato varieties on larval head capsule width of such insect.

MATERIALS AND METHODS
a) Biological studies:
The biological studies on the PTM were carried out under controlled laboratory conditions of 27.0 °C and 73.0 % RH. Three potato varieties namely Diamond, Kara, and Spunta were collected from different potato fields at harvesting time and the infested tubers of each variety were placed in a large woody cage with dimensions of 30 x 30 x 30 cm. The newly emerged moths from each variety were collected, sexed and divided into groups of 10 couples in oviposition glass jars coated inside with white cylindrical paper as an oviposition
The jars were investigated daily to count and record the number of deposited eggs. The newly deposited eggs were collected daily and divided into four groups in plastic cups (100 eggs/replicate) for each kind of potato variety. The eggs were investigated daily until hatching. Percentage of egg hatching was calculated. Newly hatched larvae were transferred by using fine brush to four plastic jars which were furnished with paper and freshly slices of each potato variety. Newly formed pupae were collected and weighted in the same day of pupation.

The following biological parameters were recorded; larval duration, percent of larval mortality, percent of pupation, pupal duration, percent of adult emergence, adult longevity, female fecundity (total number of eggs/female) and egg fertility (hatchability percentage). These experiments were carried out in randomized complete block design (RCBD) and data were statistically analyzed according to Steel and Torrie (1984). If needed data were transformed using √x.

b) Head capsule measurement:

The stock cultures of PTM of each potato variety were reared under the aforementioned conditions. Two hundred newly hatched larvae were set in plastic jars, furnished with paper and provided with freshly slices of potato as larval food. Ten larvae from each variety culture were picked up daily from each potato variety by using a fine brush to measure the larval head capsule width. Head capsules were measured across their widest point with a stereoscopic dissecting microscope equipped with a calibrated eyepiece micrometer. The measurements of head capsules of larvae reared on the three different potato varieties were grouped according to their similarity, and data were statistically analyzed to obtain the analysis of variance (ANOVA) and least significant differences (L.S.Ds) according to the method of Steel and Torrie (1984).
RESULTS AND DISCUSSION

1. Biological studies:

Data in Table (1) show larval duration and mortality percentages, pupal duration and mortality percentages, mean weights of male and female pupae, adult emergence percentage, and sex ratio (male/total) of *Ph. operculella* reared on the above-mentioned different potato varieties. The highest larval duration value (16.18 day) was observed on larvae fed on tubers of Spunta variety. Such value was The two other larval periods were 13.6 and 15.76 days on Diamond and Kara varieties, respectively. However, no significant differences was found between larval durations of Spunta and Diamond cultures. Significant difference was observed between larval duration values of Kara and both of Diamond and Spunta cultures. Significant differences were observed in the percentage of larval mortality among the three tested potato varieties. However, the percentages of larval mortality were 35.87, 34.68, and 49.83% for the larvae reared on tuber slices of Diamond, Kara and Spunta varieties, respectively. Significant differences were found in pupal duration between Kara culture and bath of Diamond and Spunta cultures. The pupal periods were 8.62, 6.81, and 8.19 days on Diamond, Kara, and Spunta varieties, respectively. No significant difference was found in the pupal mortality among all tested potato varieties. However, the pupal mortality was 41.83% on tubers of Spunta variety followed by 31.75% and 30.7% on Diamond and Kara varieties, respectively.

No significant differences in the male pupal weights were observed between the three tested potato varieties as shown in Table (1). It is observed that male pupal weighs obtained from larvae reared on Diamond, Kara, and Spunta tubers were 8.80, 8.63, and 9.98 mg, respectively. It is observed also that female pupal weighs obtained from larvae reared on Diamond, Kara, and Spunta tubers were 8.80, 8.63, and 9.98 mg, respectively. pupae obtained from larvae reared on Spunta tubers were 10.09, 10.18, and 11.09 mg, respectively. However, despite no significant differences were found in the male and female pupal weights between the three tested potato varieties, male and female pupae on Spunta variety were heavier by about 10.2 and 11.34 % than those on Diamond and by about 11.56 and 10.89 % than those on Kara variety, respectively. However, among all of the
three tested potato varieties, it was observed that female pupae were generally heavier than male pupae. Generally, potato variety did not affect the percentage of adult emergence.

It is concluded that there were significant differences in the larval durations among the three tested varieties of potato tubers. However, several authors determined the larval duration of PTM as follow: 14.69 days (Salas and Quiroga, 1985), 9-10 days (Gamboa and Notz, 1990), 19-20 days (Singh et al., 1990), 14-18 days (Badegana and Ngament, 2000) and 12.44 days (Debnath et al., 2000).

Among the durations of pupal stage of PTM reared on different potato varieties, it was observed that pupal duration was significantly shorter for insect reared as larvae on Kara variety (6.81 days) than those of Spunta (8.19 days) or Diamond (8.62 days) varieties by about 20 and 27 %, respectively. However, Foot (1979) found that pupal duration of PTM was 8-23 days. Such pupal duration was found to be; 6-7 days (Gamboa and Notz, 1990); 7.96 days (Mariy et al., 1999); and 6.52 days (Debnath et al., 2000).

Data in Table (1) show also that there were no significant differences in the pupal mortality, male and female pupal weights, percentages of adult emergence and the sex ratios of adults of *Ph. operculella*. However, survivorship from egg to adult of tomato psyllids, *Bactrocera cockerelli* varied significantly between cotton cultivars (Liu and Trumble, 2005).

2- **Effect of potato varieties on head capsule width:**

The objective of this part of the present study was to determine the number of instars of *Ph. operculella* larvae based on the head capsule widths from laboratory observations. This study aimed also to evaluate the effect of potato varieties on head capsule width of each larval instar.

Data in Table (2) showed that there were highly significant differences among means of head capsule widths of the first larval instar when reared on different potato varieties. The head capsule width of the 1st larval instar of Kara culture was larger (0.195 mm) than those on Diamond and Spunta (0.156 and 0.166 mm) by about 25 and 17.5%, respectively. Among the 2nd larval instar highly significant difference (L.S.D 0.01 = 0.012) in the width of larval head capsule among the three tested potato varieties was observed. Head
capsules widths of the 3rd larval instar reared on the different potatoes varieties were also highly significant different. That the head capsule widths of 3rd larval instar on Kara or Spunta cultures were larger than those on Diamond culture by about 22.5%. Among the 4th larval instar, highly significant difference was found also in the head capsule width of larvae fed on the three tested potatoes varieties, since larval head capsules reared on Spunta potato were larger than those on Diamond and Kara varieties.

Figure (1) shows the frequency distribution of head capsule widths of each larval instar for the three tested potatoes varieties. There were four larval instars for the lepidopteran insect PTM larvae and there was nonoverlapping between such instars.

However, visual inspection of the frequency distribution of head capsule widths, a commonly used method for discrete data, becomes ambiguous when measurements overlap between instars (Godin et al., 2002). Figure (1) shows some differences in the normality of the observed frequency distribution of some instars especially the third and fourth instars. However, there are several possible explanations for the absence of normality of the observed frequency distribution of such instars. In certain larvae, there can be sexual differentiation beginning at the third and fourth instar (Drooz, 1965; Zenner-Polania and Helgesen, 1973; and Hoxie and Wellso, 1974). Some authors suggested that the absolute size of larvae was not the actual number of molts causes the larvae enter the pupal stage (Guppy, 1969 and Nijhout, 1975). Several factors such as food availability, temperature (Guppy, 1969; and Zenner-Polania and Helgesen, 1973), parasitism (Nealis, 1987; Jobin et al., 1992), locality, and rearing regimes may affect growth rates and morphometrics either between population or between individuals of the same population (Daly, 1985).

Dyar’s hypothesis (1890) states that mean head capsule widths follow a geometrical succession in lepidopteran larval development. Although dyar’s rule is strongly debated in lepidopteran head capsule analysis, the theory also supports the fact that PTM has four larval instars according to Dyar’s ratios (Table 2 and Figure 1). Despite greater variation in instar number among insecta, no lepidopteran has been observed to have less than for larval instars (Holland, 2003). The author found that sentia moth, Upiga virescens Hulst (Lepidoptera: Pyralidae) has only three larval instars and that larval growth
consistently conformed to Dyar's rule. Present results indicated that the mean head capsule widths of all four instars were significantly smaller for larvae fed on potato tubers variety Diamond than those fed on Kara or Spunta tubers. This difference was probably a consequence of laboratory rearing of larvae on tuber slices of different potatoes varieties. These results strongly confirm the results of Pszczolkowski et al. (2002) who found that head capsules of codling moth, *Cydia pomonella* (L.), in the second, third, and fourth instars reared on apple leaves were significantly smaller than those in larvae fed on artificial diet. However, controlled conditions do not always accurately reflect nature, but laboratory studies help to define certain variables of larval development (Godin et al., 2002).

REFERENCES


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Table (2): Means of head capsule width, ranges and Dyar’s ratios for the four larval instars of the PTM, *Ph. operculella*, reared on three potatoes varieties.

<table>
<thead>
<tr>
<th>Instar (i)</th>
<th>Potato variety</th>
<th>Sample Size (n)</th>
<th>Head capsule width (mm)</th>
<th>Lower</th>
<th>Mean</th>
<th>Upper</th>
<th>Dyar’s ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Mean</td>
<td>Upper</td>
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<tr>
<td>First</td>
<td>Diamond Kara</td>
<td>30</td>
<td>0.110</td>
<td>0.156 ± 0.016&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.170</td>
<td></td>
<td>-</td>
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<tr>
<td></td>
<td>Spunta</td>
<td>30</td>
<td>0.170</td>
<td>0.195 ± 0.013&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.210</td>
<td></td>
<td>-</td>
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<tr>
<td></td>
<td>Spunta</td>
<td>20</td>
<td>0.160</td>
<td>0.166 ± 0.005&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.170</td>
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<td></td>
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<td></td>
<td>L.S.D. &lt;sub&gt;0.01&lt;/sub&gt; = 0.009</td>
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<td>Second</td>
<td>Diamond Kara</td>
<td>30</td>
<td>0.250</td>
<td>0.284 ± 0.020&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.320</td>
<td></td>
<td>1.821</td>
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<tr>
<td></td>
<td>Spunta</td>
<td>20</td>
<td>0.290</td>
<td>0.310 ± 0.011&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.320</td>
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<td>1.590</td>
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<tr>
<td></td>
<td>Spunta</td>
<td>20</td>
<td>0.290</td>
<td>0.303 ± 0.010&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.310</td>
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<td>1.825</td>
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<tr>
<td>Third</td>
<td>Diamond Kara</td>
<td>36</td>
<td>0.390</td>
<td>0.466 ± 0.035&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.510</td>
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<td>1.641</td>
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<tr>
<td></td>
<td>Spunta</td>
<td>30</td>
<td>0.500</td>
<td>0.571 ± 0.047&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.660</td>
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<tr>
<td></td>
<td>Spunta</td>
<td>20</td>
<td>0.540</td>
<td>0.572 ± 0.032&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.640</td>
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<td>L.S.D. &lt;sub&gt;0.01&lt;/sub&gt; = 0.023</td>
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<tr>
<td>Fourth</td>
<td>Diamond Kara</td>
<td>54</td>
<td>0.820</td>
<td>0.882 ± 0.045&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.940</td>
<td></td>
<td>1.893</td>
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<td></td>
<td>Spunta</td>
<td>90</td>
<td>0.740</td>
<td>0.906 ± 0.072&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.980</td>
<td></td>
<td>1.587</td>
</tr>
<tr>
<td></td>
<td>Spunta</td>
<td>90</td>
<td>0.780</td>
<td>0.931 ± 0.077&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.070</td>
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<td>1.597</td>
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<td></td>
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<td>L.S.D. &lt;sub&gt;0.01&lt;/sub&gt; = 0.027</td>
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</table>

Dyar’s ratio: means head capsule width of instar (i) / means head capsule width of instar (i -1). Means followed by the same letter (s) are not significantly different according to L. S. D. 0.01
Figure (1): Frequencies of head capsule widths for the four larval instars of the PTM, *Ph. operculella*, reared on three potato varieties.
الملخص العربي

تأثير صنف البطاطس على بعض الخصائص البيولوجية، وعلى عرض محفظة الرأس في يرقات فراشة درنات البطاطس

Phthorimaea (Zeller) (Lepidoptera: Gelechiidae) operculella

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تم دراسة تأثير تربية حشرة فراشة درنات البطاطس على بعض الخصائص البيولوجية، وعلى عرض محفظة الرأس في يرقات الحشرة وذلك تحت الظروف المعملية. كان متوسط مدة الورك 15.76 و13.69 يوم لليرقات التي تغتت على أصناف البطاطس دايموند، كارا، وأسبونتا، على الترتيب.

المؤملة المئوية للموت في اليرقات تراجعت معنويًا من 49.83% في اليرقات التي تغتت على أصناف البطاطس دايموند، كارا، وأسبونتا، إلى 34.68% في اليرقات التي تغتت على أصناف البطاطس دايموند، كارا، وأسبونتا، على الترتيب. 비اء لم تختلف معنويًا بالنسبة للعوارق، أوزان العوارق، النسبة المئوية للعوارق المتموجة، ونسبة الجنسية للعوارق المتموجة.

النسبة المئوية للعوارق المتموجة في عوارق الحشرة هددت الفراشات، وتختلف نسبا في عوارق البطاطس.

وحول 25 و 17.5 %، على الترتيب. بحالة 25.2 و 9.16 %، على الترتيب. أما بالنسبة للعوارق المرتية فقد وجدت اختلافات معنوية في عرض محفظة الرأس بين اليرقات التي تغتت على الصنف دايموند بحالة 25 و 9.16 %، على الترتيب. أما بالنسبة للعوارق المرتية فقد وجدت اختلافات معنوية في عرض محفظة الرأس بين اليرقات التي تغتت على الصنف دايموند بحالة 25 و 9.16 %، على الترتيب.