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INFLUENCE OF CONSTANT TEMPERATURES ON THE BIOLOGICAL ASPECTS OF *Phthorimaea operculella* (Zeller) AND THERMAL UNITS (DEGREE DAYS)

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ABESTRACT

This investigation was carried out in laboratory at Vegetable Research Pests Dep. Plant Protection Research Institute Dokki,Giza.. To evaluate the effect of three temperatures (20, 25 and 30°C) on the biological aspects of *Phthorimaea operculella*(Zell.) Threshold of development (t) and accumulated heats (k) for total preimaginal development of *P. operculella* were calculated to be 4.9 °C and 741.7 degree-days (DD`s). Development of egg stage required 68.66 dd`s above 8.6 °C while larval stage demanded 451.2 dd`s above 5.8 °C and this value 138.2 dd`s above 10.03 °C for adult stage. Accumulation of 782.1 dd`s were sufficient for the completion of one generation. The accumulated thermal heat units (T.U.) or effective degree-days estimated through insect activity time The aim of this part of investigation is to establish the velocity constants (i.e the relationship between temperature and speed of development).

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).

Integrated pest management programs, demonstrates a total system approach to the suppression of pest population which depend on the importance of the predicting the seasonal abundance of insects which has led to the formulation of many mathematical models that described the developmental rates as a function of temperature .

Therefore, the aim of the current study was to estimate the influence of constant temperature on the biological aspects of *P.operculella* and thermal units (degree-days).

MATERIALS AND METHODS

The stock culture of *P. operculella* was reared on potato tubers (Diamont variety) 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 on the inner surface of other

boxes to be left for pupation. When pupation was completed, the cocoons were carefully collected, to be used for starting the experimental cultures. 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 ten 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, and. 100 larvae were used. One/kg of the potato tuber was taken from the Diamont cultivar for the test. The larval, pupal periods, adult longevity and the life cycle were assessed during this study.

Statistical analysis:

Thermal units required to complete development of each stage was determined according to the equation of thermal summation (Blunk,1923).

$$K = y(T-t0)$$

Where: y = Developmental duration of a given developmental stage.

T =Temperature in degree centigrade.

t_0 = Temperature threshold of development, in degree centigrade.

K = Thermal units (degree –days).

The developmental threshold value that has been estimated after constant temperature experiment carried out before. Where the zero development (t0) was 5.2 °C for *P. operculella* generation .Hereinafter, the following formula was used for computing the heat units (DD) according to Richmond *et al* .,(1983):

H = HJ

H = Number of accumulated heat units to emergence.

HJ = (Max.+Min.)/3-C,if max.>C&min.>C.

= (max.-C)2/2(max.-min.).if max >C&min.<C

= 0 if max. <C&min.<C

C = Threshold temperature.

RESULTS AND DISCUSSION

Data obtained in Tables (1and 2) showed that the incubation period of *Phthorimaea operculella* at 30°C was 3.45±0. 7 days; being insignificantly shorter than those at 20 and 25 °C (7.6±0.65and 4.2±0.5) respectively (<*P*0.05).

The duration of larval stage was also affected with the different degree of temperature. whereas, the duration of the larval stage was 32.6±2.9, 23.5±2.7and 7.9±1.96 at 20, 25, 30°C respectively, being insignificantly different from each other (*P*<0.05) (Table 1). From the aforementioned results, it could be concluded that *P. operculella* stayed longer developmental period at 20°C than the other tested temperature (25 & 30). In three-tested temperature, however, the duration of the developmental stages of *P. operculella* was temperature dependent; i.e., the duration of each developmental stage decreased with increasing temperature.

Developmental rates and heat summations of *P. operculella* under different constant temperature degrees:

Egg stage

As mentioned before, the incubation period of *P. operculella* was markedly affected by temperature variations. The rate of embryo development was positively dependent on temperature; i.e. increased with increasing of tested temperatures. In this case, the percentage of egg hatchability was 75.24, 81.92, and 56.75% at the three tested temperatures (Table 1) The estimated threshold of egg development (t_0) was (8.6°C) (Table 3). On the other hand, the average of thermal units or thermal summation was (86.64, 68.66 and 74.9 DD's), respectively, at 20, 25 and 30°C, with an average (76.81 DD's) (Table 3).

Table(1): Effect of various temperatures on the developmental periods of different stages and hatchability of potato tuber moth *P. operculella* reared on potato cultivar (Diamont) 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)	Hatching%
30°C	Diamont	3.45 ±0.71	7.89* ±1.96	7.82 ±0.5	19.2* ±0.98	5.7 ±1.2	75.24
25°C		4.2* ±0.53	23.5* ±2.73	9.23* ±0.69	36.9* ±1.4	10.7 ±1.4	81.92
20°C		7.6 ±0.65	32.6 ±2.93	14.2** ±0.28	54.4** ±1.3	13.7 ±0.85	56.75
LSD 0.01		2.429	2.412	1.53	4.96	2	

Table (2): Effect of different temperatures on the longevity and number of eggs laid per female of, *P. operculella* reared on two potato cultivar (Diamont) 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	10.7 ±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
LSD 0.01			1.146			12.033

Table (3): Rate of development, threshold of development (t_0) and thermal units (DD's) of eggs of *P. operculella* at constant temperatures

Temperatures	Incubation period of eggs (days)	Rate of development %	Threshold of development (to)	Thermal units (DD)	Hatchability%
20°C	7.6±65	13.2	8.6	86.64	56.8
25°C	4.2±0.5	23.8		68.66	81.9
30°C	3.5±0.7	29.0		74.9	75.2
Average	-	-		76.81	-

The larval stage

Larvae of *P. operculella* passed through three larval instars. The larval duration was shortened with the increase of temperature (Table 1). Hence, the developmental rate of larvae increased as the temperature increase from 20 to 30°C.

The threshold of larval development (t_0) was estimated as (5.8°C) and the thermal units were (462.92, 451.2 and 191.2 DD's, respectively, at 20, 25 and 30°C (Table 4) with an average of 368.43 DD's.

Table (4): Larval development, pupation, threshold of development (t_0) and thermal units (DD's) of larvae of *P. operculella* at constant temperature

Temperature	Mean of larval duration± S.E. (days)	Rate of development (%)	Mean of pupation (%)	t_0 (°C)	Thermal units (DD's)
20°C	32.6±2.9	3.1	550.9	5.8	462.9
25°C	23.5±2.7	4.25	487.6		451.2
30°C	7.89±1.96	12.65	215.8		191.2
Average			418.1		368.43

The pupal stage

As other developmental stages, the duration of the pupal stage decreased with temperature increase; while the rate of development was retarded at lower temperature.

For *P. operculella*, the estimated threshold of pupal development (t_0) was 10.03°C . The thermal units were (141.6., 138.2 and 156.2 DD's) at 20, 25 and 30°C; with an average of 145.3 DD's (Table 5). Adult emergence was highest (65.5%) at 25°C and decreased to reach 48.8 % at 20°C (Table 5).

Table (5): Pupal development, adult emergence, threshold of development (t_0) and thermal units (DD's) of pupae of *P. operculella* at different constant temperatures

Temperature	Mean Pupal period± S.E. (days)	Rate of development (%)	Mean of adult emergence (%)	t_0 (°C)	Thermal units (DD's)
20°C	14.2±0.28	7.04	48.8	10.03	141.6
25°C	9.23±0.69	10.86	65.5		138.2
30°C	7.82±0.5	12.82	61.5		156.2
Average	-	-	-		145.3

Longevity:

As in case of each developmental stage of *P. operculella*, the duration of Longevity decreased with increasing temperatures from 20 to 30°C. The development rates on the other hand increased with increasing of tested temperatures (Table 5). The estimated threshold of development differed in the three localities, being 4.6°C . The thermal units for the Longevity as a whole also varied at the three tested temperatures, being 211, 218.3 and 144.8 at 20, 25 and 30°C with an average 191.4 DDs (Table 6).

Table (6): Longevity development, threshold of development (t_0) and thermal units (DD's) of *P. operculella* at different constant temperatures

Temperature	Longevity (days) (Mean±SE)	Rate of development (%)	Zero of development (°C)	DD's
20°C	13.7±0.85	7.3	4.6	211.0
25°C	10.7±1.4	9.3		218.3
30°C	5.7±1.2	17.5		144.8
Average				191.4

The duration of total development and generation decreased with increasing temperatures from 20 to 30°C. The development rates on the other hand increased with increasing of tested temperatures, the estimated threshold of development differed in the three localities, being 4.8 and 5.2 The thermal units for the total development and generation as a whole also varied at the three tested temperatures, being 821.4, 741.7&481.9 and852.6 , 782.1 &526.1at 20, 25 and 30°C with an average 681.6 and720.2 DDs (Tables 7 and 8).

In the present study, an explanation for variation in the number of annual generations was given here in for the first time on the basis of available data and calculated degree-days required for insect development.Similarly,the expected number of annual generation could be predicted by determining the date ate which 792 dd s have been accumulated at the beginning of spring. Sevacherian (1977), and Johnson *et al.*(1979) developed similar degree-day systems for predicting the need for and timing of insecticide application for different insect species.

Table (7): Total development, threshold of development (t_0) and thermal units (DD's) of *P. operculella* at different constant temperatures .

Temperature	Total development (days) (Mean±SE)	Rate of development (%)	Zero of development (°C)	DD's
20°C	54.4±1.3	1.8	4.9	821.4
25°C	36.9±1.2	2.7		741.7
30°C	19.2±0.98	5.2		481.9
Average				681.6

Table (8): Generation development, threshold of development (t_0) and thermal units (DD's) of *P. operculella* at different constant temperature.

Temperature	Generation development (days) (Mean±SE)	Rate of development (%)	Zero of development (°C)	DD's
20°C	58.0±1.2	1.7	5.3	852.6
25°C	39.7±1.4	2.5		782.1
30°C	21.3±1.1	4.7		526.1
Average				720.2

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تاثير درجات الحرارة الثابتةعلى المظاهر البيولوجية لفراشة درنات البطاطس والوحدات الحرارية

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مقدمة :

محصول البطاطس أحد المحاصيل الهامة من الناحية الغذائية حيث يشغل الترتيب الرابع بعد القمح والذرة والأرز والترتيب الأول فى إنتاج الطاقة والثاني فى إنتاج البروتينات بعد فول الصويا وتبلغ المساحة المنزرعة عالميا من هذا المحصول حوالي ٤٢ مليون فدانا فى أكثر من ١٢٥ دولة تنتج حوالي ٢٥٠ مليون طن بطاطس, أما فى جمهورية مصر العربية فالبطاطس هي أحد محاصيل الخضر الهامة التي تنتشر زراعتها تحت ظروف بيئية متباينة حيث يزرع منها سنويا ما يقرب على ٢٠٠ ألف فدانا سنويا وتحتل البطاطس المركز الأول بين محاصيل الخضر التصديرية حيث ارتفع متوسط كميات البطاطس المصدرة إلى بعض دول الإتحاد الأوربي والدول العربية إلى حوالي ٤٣٠ ألف طن ويبلغ متوسط استهلاك الفرد فى مصر حوالي ٢٠ ــ ٢٥ كجم من البطاطس سنويا.

ويتعرض محصول البطاطس للاصابة بالعديد من الحشرات مثل:الحفار والدودة القارضة والجعل ذو الظهر الجامد ومن الخوخ ودودة ورق القطن وحفار ساق الباذنجان والجاسيد (نطاطات الأوراق) والذبابة البيضاء و العنكبوت الأحمر وتعتبر دودة درنات البطاطس أهم آفة تصيب المجموع الخضري والدرنات.

مشكلة البحث:– التنبؤ بأجيال الحشرة وتحديد ميعاد مكافحة الحشرة.

الهدف من البحث:– حساب الحد الحرج للنمو (to) للاطوار المختلفه لحشرة فراشة درنات البطاطس (صفر النمو) وحساب الوحدات الحرارية و العلاقة بين درجة الحرارة وسرعة النموو تحديد الجيل.

الملخص

تمت هذه الدراسة فى معمل قسم بحوث آفات الخضر بمعهد بحوث وقاية النباتات بالدقى . تأثير ثلاث درجات حرارة وهى ٢٠، ٣٠، ٢٥ °م على المظاهر البيولوجية المختلفة لاطوار فراشة درنات البطاطس (بيض–يرقة–عذارى– حشرة كاملة) وقد استخدمت مجموع درجات الحرارة الفعالةThermal summation لتحديد العلاقة بين درجات الحرارة و معدل النمو. تعين معدل النمو لكل طور من أطوار الحشرة. حساب صفر النمو البيولوجى لكل الاطوار وايضا الجيل حيث بلغ ٨,٦، ٥,٨، ١٠,٠٣و٤,٦لكل من البيض واليرقات والعذارى و Longevity غلى التوالى. وجد أن صفر النمو البيولوجى لفراشة درنات البطاطس وهى ٥,٣° م يحتاج الى١, ٨٢ ٧ وحدة حرارية

ويهدف البحث إلي حساب الحد الحرج للنمو (t0) للاطوار المختلفه لحشرة فراشة درنات البطاطس (صفر النمو) وحساب الوحدات الحرارية و العلاقة بين درجة الحرارة وسرعة النموو تحديد الجيل.