



THRESHOLD TEMPERATURE AND THERMAL CONSTANT OF POTATO TUBER MOTH *PHTHORIMAEA OPERCUALELLA* ON SOME POTATO VARIETIES

Z.A. AL-Tamimi^{1*} and R.S. AL-Jorany²

^{1*}Department of Environment, College of Environmental Sciences, University Al-Qasim Green, Iraq.

²Department of Plant Protection, College of Agricultural Engineering Science, University of Baghdad, Iraq.

Abstract

Potato tuber moth (*Phthorimaea operculella*) is the most common destructive insect pest which belong to Gelechiidae Lepidoptera family that infects *Solanum tuberosum* L. in fields and storage in all potato growing regions of the world. It is important to know threshold temperature (Basic Temperature) and thermal constant temperature to predict the incidence of infection and the population dynamics of the pest. The effects of three potato cultivars (Burrin, Severa and Rivera) and constant temperature (10, 15, 20, 25, 30 and 35°C) were evaluated under laboratory conditions on the life history, life table and demographic parameters. It has found that the longest development periods of egg, larvae, pupa and egg-adult were 7.83, 21.90, 11.04 and 39 days respectively at 20 °C, while the shortest development periods for the same stages were 3.43, 10.28, 4.50 and 7 days respectively at 30 °C. All stages of potato tuber moth could not complete their development under 10, 15 and 35 °C. There was no effects of cultivars of potato on the life history of potato tuber moth. The threshold development of egg, larvae, pupa and, egg –adult was found 6.59, 10.02, 10.54 and 10.25 °C respectively. The thermal constant for the same stage was found 96.57, 198.41, 106.67 and 382.30 heat units respectively too.

Key words : *Phthorimaea operculella*, Life table, threshold development.

Introduction

Potato (*Solanum tuberosum* L.) is a major food crop in many countries of the world. It occupies the fourth place among the most important food crops all over the world, following wheat, rice, and maize (Shady *et al.*, 2007).

Potatoes meet the needs of food in developing countries and involved in some industries such as potato chips, types of food, fungi and bacteria, and industrial raw materials such as paper (Haverkort *et al.*, 2013) . The potato was first cultivated in Iraq in 1960 and then expanded widely (Al-Sunbll, 2012). The production of potato in is about 165.6 thousand tons for the year 2018, and the total cultivated area is estimated at 24.6 thousand acres (Iraqi Agricultural Statistics Organization 2018). Potato crop was affected by many insect pests in Iraq (Al- Jorany, 2011; Al-Jorany and Sadik, 2012 ; Yonus and Aljorany, 2013). One of the important insect pests that affected potato in the tropical and semi tropical regions

is Potato Tuber Moth (*Phthorimaea operculella*), Which affects tubers and leaves in storage and fields (Joshi, 1989). The greatest damage in the storage is due to the continuity of moth generations that damage the healthy tubers, reducing their nutritive quality and making its susceptible to fungal and bacterial pathogens (Trivedi and Rajagopa, 1992; Flanders *et al.*, 1998).

Temperature influences the development, survival, reproduction, movement, and dynamics of insect pests and their natural enemies (Huffaker *et al.*, 1999; Roy *et al.*, 2002). Species-specific traits, including low, optimal and high temperature thresholds determine at what temperatures biological activities can take place. The relationship between temperature and development rate is an essential component of population dynamics and its accurate description is important for building phenological models to predict stage specific emergence times or outbreaks, and subsequently to develop sound control strategies (Bintz *et al.*, 1991; Liu *et al.*, 1995; Zilahi-

Balogh *et al.*, 2003).

The relationship between temperature and growth rates of insects is important and necessary to understand the dynamics of populations and to adopt phenological models for predicting the appearance times of the harmful insects which cause economical damages. From this, integrated management programs can be built to control the pest properly and environmentally (Bintz *et al.*, 1991; Liu *et al.*, 1995; Zilahi-Balogh *et al.*, 2003).

The simple liner models can calculate the basic temperature and thermal constant of insects and arthropods (Campbell *et al.*, 1974). The objective of this study was to determine the threshold temperature and thermal constant of potato tuber moth on different temperature and potato cultivars.

Materials and Methods

Potato tubers samples symptoms and signs of potato tubers moth effected were collected from the potato stores at Al- Latifiyah southern Baghdad province, Iraq. Specimens were taken to the Laboratory of Insect Research / Graduate Studies / Plant Protection Department / Faculty of Agricultural Engineering Sciences for further investigation. The infected tubers were placed in three wooden breeding cages (20 * 20 * 20 cm). Each cage was covered with a malleable cloth (buckle muslin) on three sides, and on the fourth side a cone-shaped cloth was used to maintain the colony. The upper side of the cage was covered with the buckle malleable cloth and wooden plate was place in the bottom of the cage . A light layer of sandy soil was added to the base of the cage to create a suitable place for larvae pupation. Each of these cages was provided with healthy potato tubers from one of the potato cultivars Burrin, Severa, and Rivera and left for one generation. When the adults emerged, a number of its were taken to ensure the diagnosis of the insect. It was identified by the assistant professor *Dr. Awatif Abdel Fattah*, Department of Plant Protection, Faculty of Agricultural Engineering Sciences, University of Baghdad.

To obtain fresh eggs (ageing no more than 24 hours), adult males and females of recent emergence were taken from each cultivars : Burrin, Severa and Rivera separately. The adults were placed in glass tubes 2 cm in diameter and 8 cm height and a piece of cubic shape potato was placed at its bottom. The tube was covered with a muslin cloth and tied with a rubber band and placed in incubator at temperature of 25° C, and after confirmation of mating, the eggs were taken every 24 hours. Three replicates were taken in each one 30 eggs of each cultivars. For each temperature 10, 15, 20, 25,

30 and 35 °C, the eggs of each replicate were placed in a 10 cm diameter Petri dish with filter paper. The dish was covered with a piece of cloth (filter silk thread) and attached to a rubber band. The dish was placed in German-made Binder incubators. The temperature of each one was setting according to the required.

To verify the accuracy of temperature and the relative humidity was controlled using Sodium hydroxide solution NaOH and a (Thermo hygrometer) was used to confirm moisture inside the incubator. The incubator was provided with an industrial light source that did not give high heat relatively (LED) (12 hours of light: 12 hours of darkness).

These eggs were monitored daily and when they hatched the number of hatched eggs and the period in each replicate were recorded. Each larva was transferred to a glass cups, 7 cm in high and 6.5 cm in diameter which were provided with slices of potato containing the crust according to the cultivars. The top of each cup was covered with(silk cloth). The cups were tied with a rubber band and marked according to cultivars and temperature and were monitored daily until the emergence. The development and survival rates of each egg, larva, pupa and adult-egg were recorded.

Threshold development and thermal constant Determination

The results of the development periods under the influence of temperature of 10, 15, 20, 25, 30 and 35 °C and the cultivars of potatoes Burrin, Severa and Rivera were adopted to calculate the minimum threshold development by calculating the regression equation between temperatures and the average Daily development rate for each egg, larva, pupa stages and adult- egg.

So that:

$$Y = a + bX$$

where:

Y: daily Development rate.

a :Intercept

The straight with axis representing the minimum threshold development

b: regression factor (slope)

X: Temperature (Celsius)

The thermal constant (K)

$$K = 1 / b$$

The minimum threshold development was calculated by the equation:

$$t_{\min} = -a/b$$

(Arnold, 1960 ; Campbell *et al.*, 1974).

Results and Discussion

The effect of Temperature and Potato cultivars on development periods

The development periods of Potato tuber moth stages (egg, larvae, pupa and adult- egg) was not affected by potato cultivars (Table 1). The development period of egg stage was ranged from 5.40 to 5.98 days, larvae from 14.38 to 14.17 days, pupa from 7.71 to 8.10 days. The different temperatures showed a significant effect on the length of development period of the potato tuber moth.

The longest development periods of egg, larvae, pupa and adult-egg was 7.83, 21.90 10.04 and 40.05 days respectively at 20 °C, while the lowest development periods for the same stages was 3.43, 10.28, 4.50 and 18.4 days respectively at 30 °C. All stages of potato tuber moth could not complete their development under 10,15,35 °C . In this field, Andreadi *et al.*, (2017) stated that the period of growth and development decreased with the temperature increasing between 17.5 and 35 °C and at 35 °C there was no growth or development of the moth.

Al-Saud (2005) also found that the longest

development period of potato tuber moth was at 20°C. El-Ghanam (2005) also found that the optimum length for the growth and development of potato tuber moth was 20- 30°C.

Threshold development of potato tuber moth stages

Table 2 and Figs. 1, 2, 3 and 4 shows that the threshold development of potato tuber moth stages was 6.59, 10.02, 10.54 10.25 for egg, larvae, pupa and adult respectively. as in Figs.

Al-Saud (2005) found that the threshold development of egg tuber moth is 4.9, larvae 9.65, pupa 10.77, males 12.6 and females 13.53 m. Daoud (1999) also found that the estimated thermal threshold of the different developmental stages were 9.62,, 10.98, 8.5, (14.15 : 9.91°C) for egg, larvae, pupa, stages as well as sex ratio for adult stages (male : female), respectively. Golizadih and Zalucki (2012) also found The lower temperature threshold(t) for the growth and development of potato tuber moth stages was 12.6, 10.7, 12.2 and 11.5 °C for each egg, larva, pupa and adult- egg. Sporleder *et al.*, (2004) found that The theoretical developmental thresholds were 11, 13.5, and 11.8 °C for each egg, larva, and pupa.

Thermal constant of potato tubers moth stages

Table 1: The development periods of potato tuber moth stages under the influence of different temperatures and different potato cultivars.

	Stage	Cultivars	20 °C	30 °C	Average	
Egg	Burrin	7.68±0.86a	5.98±0.84ab	4.30±0.69cb	5.98±0.63	LSD0.05 ≥
	Rivera	7.83±0.30a	5.73±0.02ab	cb0.46±3.43	5.66±0.65	
	Severa	7.01±0.41a	5.58±0.008ab	cb0.11±3.61	5.40±0.50	N.S.
	Average	7.51±0.31	5.76±0.24	0.27±3.78	5.68±0.90	
	LSD 0.05 ≥	1.219				
Larva	Burrin	20.71±1.51a	11.26±0.32b	10.55±1.16cb	14.17±1.73	LSD0.05 ≥
	Rivera	21.90±0a	11.92±0.86b	10.28±0.24cb	14.71±1.70	
	Severa	19.78±0.80a	13.03±0.28b	10.34±0.33cb	14.38±1.42	N.S.
	Average	20.80±0.60	12.07±0.38	0.35±10.39	14.42±1.34	
	LSD 0.05 ≥	1.946				
Pupa	Burrin	11.04±0.40a	7.68±0.24ab	5.58±0.34cab	8.10±0.81	LSD0.05 ≥
	Rivera	10.32±1.93a	8.04±0.54ab	5.81±0.29cab	8.06±0.87	
	Severa	10.48±2.24a	8.17±1.40ab	4.50±0.25cb	7.71±1.16	N.S.
	Average	10.61±0.87	7.96±0.44	5.30±0.25	7.95±1.96	
	LSD 0.05 ≥	2.786				
Adult-egg	Burrin	39.4±0.23a	24.9±4.66ab	20.4±0.73ba	28.3±3.17	LSD0.05 ≥
	Rivera	40.05±13.00a	25.69±5.41ab	19.52±6.02ba	28.4±5.36	
	Severa	37.3±11.43a	26.8±6.55ab	18.4±6.33ba	27.5±5.02	N.S.
	Average	38.9±5.01	25.8±2.81	19.5±2.54	28.06±12.53	
	LSD 0.05 ≥	21.49				

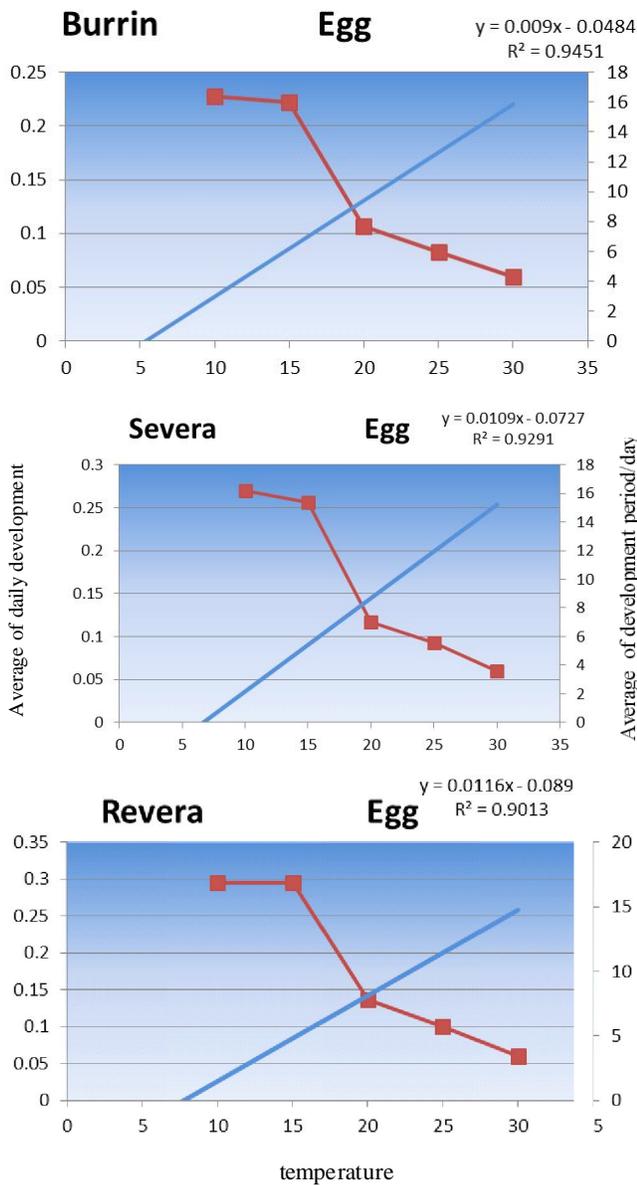


Fig. 1: Daily development average and threshold development of potato tuber moth egg and potato cultivars.

Table 2: Threshold development of potato tuber moth stages on different potato cultivars.

Cultivars	Stages			
	Egg	Larva	Pupa	egg - Adult
Burrin	5.40	9.57	10.63	9.80
Severa	6.67	10.01	13.43	10.58
Rivera	7.71	10.49	7.56	10.38
Average	6.59±0.66	10.02±0.26	10.54±1.69	10.25±0.23

(Table 3) the result showed that the thermal constant of potato tuber moth stages was 96.57, 198.41, 106.67 and 382.30 for egg, larvae, pupa and egg – adult

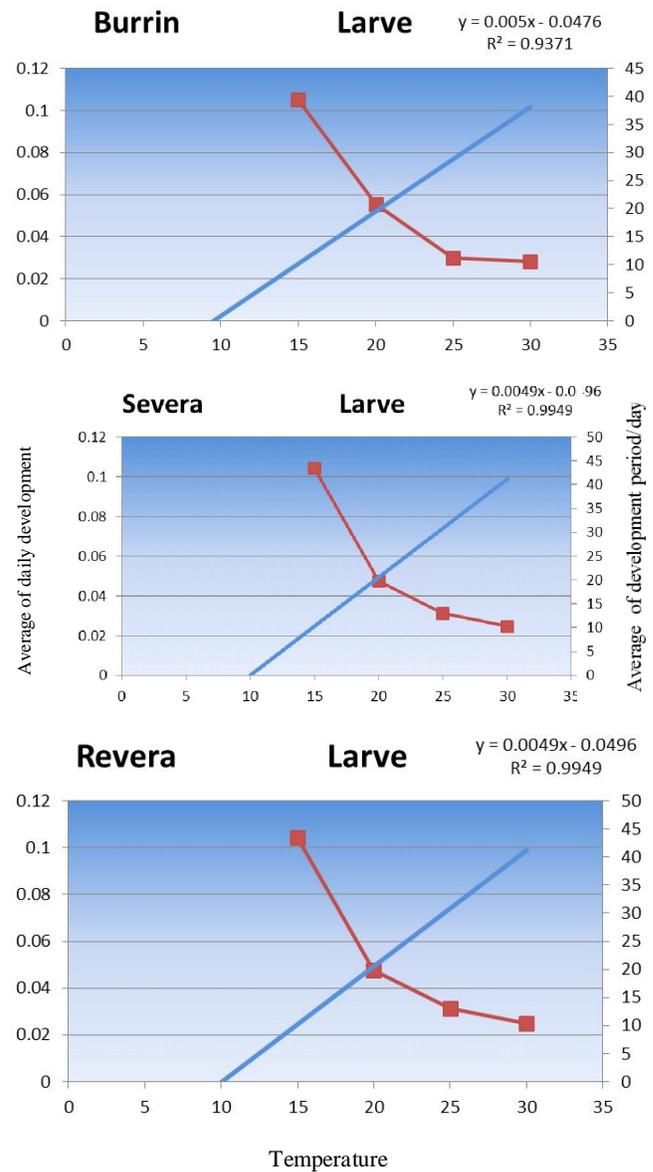


Fig. 2: Daily development average and threshold development of potato tuber moth larvae and potato cultivars.

Table 3: The thermal constant of potato tuber moth stages on different potato cultivars.

Cultivars	Stages			
	Egg	Larva	Pupa	egg - Adult
Burrin	111.66	201.01	108.22	400.76
Severa	91.82	202.13	78.86	365.35
Rivera	86.22	192.09	132.94	380.79
Average	96.57±7.71	198.41±3.17	106.67±15.63	382.30±10.25

respectively.

In this regard, Daoud *et al.*, (1999) found that the corresponding values for the thermal unit needed for

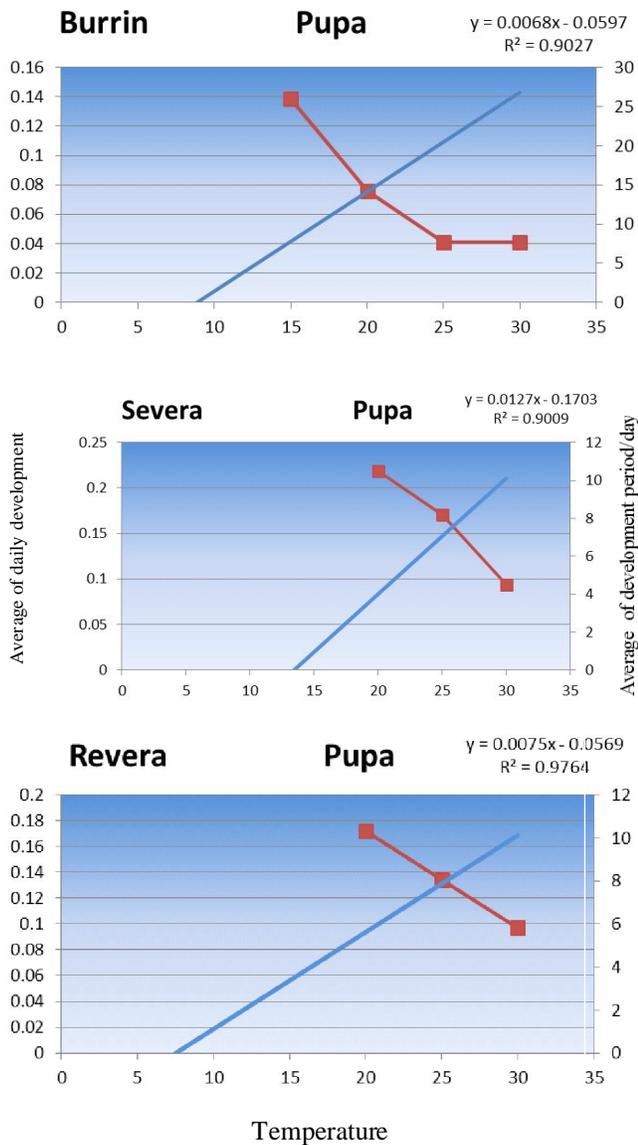


Fig. 3: Daily development average and threshold development of potato tuber moth(pupa) and potato cultivars.

development of these stages were potato tuber moth were 87.55, 201.75, 172.25 and (115.95:143.01) for egg, larvae, pupal stage as well as sex ratio for adult stages (male : female). Sporleder *et al.*, (2004) mentioned required incubation times were 65.3, 165.1, and 107.6 degree-days (DD) for the egg, larval, and pupal stages, respectively.

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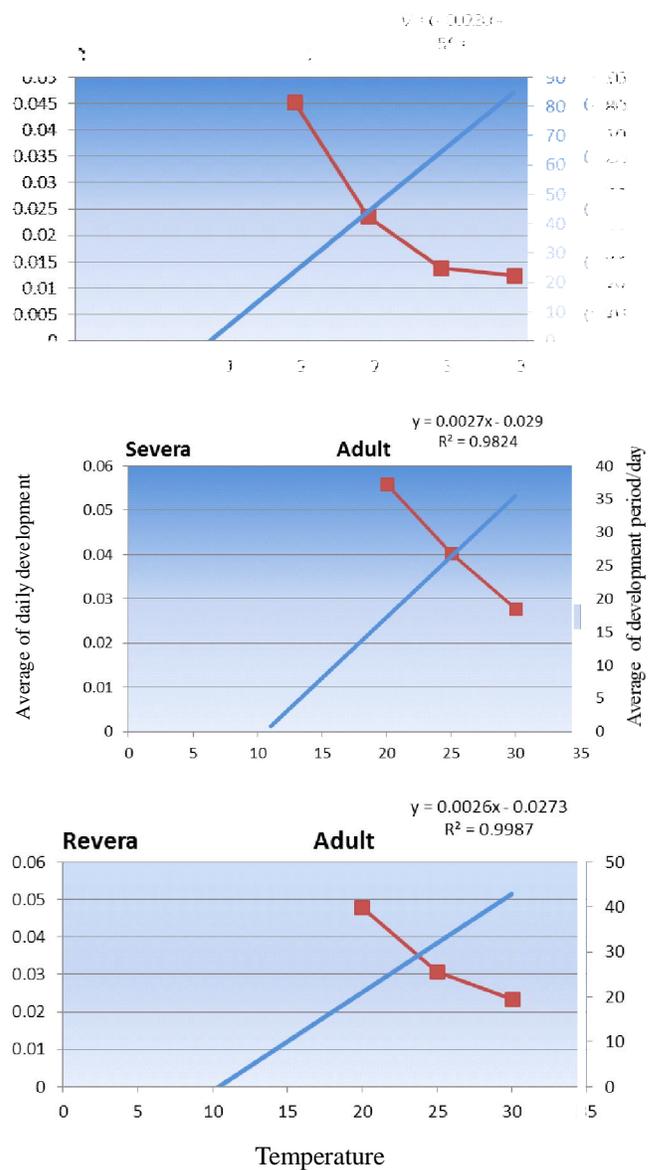


Fig. 4: The daily development average and threshold development of from an adult egg to potato tuber moth and potato cultivars.

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