Canadian Journal of Pure and Applied Sciences
Vol. 11, No. 1, pp. 4061-4066, February 2017
Online ISSN: 1920-3853; Print ISSN: 1715-9997
Available online at www.cjpas.net

DETERMINATION OF TIME OF INSECTICIDE APPLICATION AGAINST POTATO TUBER MOTH, *PHTHORIMAEA OPERCULELLA* ZELLER (LEP.: GELECHIIDAE) IN THE FIELD CONDITIONS IN TURKEY

*Pervin Erdogan[1] and Errol Hassan[2]
[1]Plant Protection Central Research Institute, 06172 Yenimahalle, Ankara, Turkey
[2]School of Agriculture and Food Sciences, University of Queensland, Gatton 4343, Queensland, Australia

ABSTRACT

The aim of this study was to determine the time of pesticides application to control potato tuber moth [*Phthorimae operculella* (Zeller) (Lep.: Gelechiidae)] in Turkish field conditions. For this purpose, the experiments were carried out in three provinces (Afyonkarahisar, Kirsehir and Bolu) of Turkey in 2013–2015. Sex pheromone traps were used to determine when adults first emerged in field and were checked at weekly intervals. During the experiments, all of the plant leaves and tubers were checked to determine any infestations. Three insecticides were used to determine against PTM. Five different pesticide schedules were tested although not in all provinces. In Bolu Province, the best schedule was achieved by a three spray technique with the first spray application being applied when adults are first identified in the field in pheromone traps, followed by a second application one month after the first application, with a third spraying 15 days before harvest. This schedule was no tested in Kirsehir and Afyonkarahisar Provinces where applications linked to pheromone trap detections and preharvest schedules were most effective.

Keywords: Potato tuber moth, application time, pheromone traps, insecticides.

INTRODUCTION

Potato (*Solanum tuberosum* L.) as a crop plant of international importance is subject to yield and quality losses by arthropod pests.Potato tuber moth (PTM) [*Phthorimae operculella* (Zeller) (Lep.: Gelechiidae)] especially causes the greatest losses. Currently PTM occurs wherever potatoes are cultivated and it is destructive especially under dry conditions in the warmer seasons. PTM also attacks tobacco (*Nicotiana tabacum* L.), tomato (*Solanum lycopersicum* L.), eggplant (*Solanum melongena* L.), Cape gooseberry (*Physalis peruviana* L.) and certain other broad-leaved weeds (Cunningham, 1969).

Fertilized female PTM lay eggs on foliage or tubers throughout the growing season, preferring foliage over tubers. When foliage has naturally or artificially senesced and tubers accessible, they deposit eggs in or near the eye buds. The larva mine leaves, stems, and petioles causing irregular galleries and excavate tunnels through tubers. Foliar damage to the potato crop usually does not result in significant yield losses. However infested tubers have reduced marketability and the losses in storage may be up to 100% especially in non-refrigerated systems (Nasser *et al*., 2012; Von *et al*., 1987; Bacon *et al*., 1971). Greatest tuber damage occurs immediately before harvest while the crop is left in the field prior to digging. Additional damage may occur in the storage if conditions are not maintained properly (Rondon *et al*., 2007; Rondon, 2010).

PTM control primarily relies on the use of insecticides to optimize production and minimize damage. Great benefits can be derived from insecticides if used judiciously, practically under emergency situations. Pesticide use must be scheduled appropriately to avoid the unnecessary applications. Well managed pesticide application also minimizes the development of resistance to pesticides, persistence of residues in food, emergence of new pests, destruction of beneficial organisms, human exposure and environmental contamination (Arnason *et al*., 1989).

To eliminate the negative effects of insecticides, researchers have conducted a number of studies to create an alternative to insecticides against PTM. For example, Steven *et al*. (2008) reported that *Bacillus thuringiensis* spp. kurstaki and granulovirus were significantly effective on PTM. Similarly, it was determined that granulovirus may be used to control Potato tuber moth under field conditions (Salah and Aalbu, 1992; Sporleder *et al*., 2005; Sporleder and Kroschel, 2008; Das, 1995; Chandel and Chandla, 2005). Additionally, researchers found that

*Corresponding author e-mail: pervinerdogan@gmail.com

Neem treatments afforded protection at acceptable levels against PTM in storage for several months (Hossein *et al*., 1994; Debnath *et al*., 1998) and Neem oil was as effective as the insecticide (Salama and Salem, 2000). Additionally, Gomaa and El-Nenaey (2006) also found that the application of Virotecto or GV infected larvae more effectively controlled PTM infestation than Bt-based insecticides. Abdel *et al*. (2014) reported that the application with Neem formulation could effectively reduce the PTM population. The main objective of this study was to determine the time of insecticide application against PTM under field conditions in Turkey.

MATERIALS AND METHODS

Experiments were carried out in three provinces in Turkey during 2013-2015. The potato fields were divided into randomized plots of 50 m^2. The experiments were made four times. The plots were equally assigned as either control or treatment. Sex pheromone traps were used to determine when adults first emerged in the field. Five pesticide application schedules were selected for evaluation. Three insecticides were used (Table 1).

Treatments were applied to in the fields in the morning. No other insecticides were used. Only water was sprayed into the control plot. The fields were irrigated weekly with a channel system. Each plot contained approximately 65 plants, producing 300 tubers. The five application schedules were as follows.

Schedule 1: One pheromone trap was placed onthe experiment field. It was checked weekly. When 15 to 20 adult PTMs were found on the pheromone trap, insecticides were sprayed. Depending on the plant's vegetation period, spray applications were carried out on all the plant and the soil surface (following Anonymous, 2010).

Schedule 2: Spray applications were made twice, one week and two weeks before the harvest. At this stage, all of the plant and the soil surface were subjected to spraying (following Salah and Aalbu, 1992).

Schedule 3: Spray applications were made 34 and 96 days after the emergence of the plants (following Steven *et al*., 2008).

Schedule 4: Spray applications were made when tubers were 4-5 cm in diameter (Rondon, 2010).

Schedule 5: Spray applications were made when the first adult was found in the trap, the first spray was applied and it was followed by a second spray one month later and a third spray 15 days prior to the harvest (Sannino *et al*., 2012).

During the course of the experiment, all of the plants and tubers were observedfrom each plot every week by the following parameters: (a) number of leaves and or stem with PTM damage, (b) number of tubers with visible PTM infestation, (c) number of tubers exposed, by soil cracking, to the sun and showing green chlorophyll areas. Potato tuber samples were gathered from the border areas of plots. At the harvest, PTM damage was assessed on 100 tubers per plot, harvest samples were taken only within the central 14 m^2 of the plots. Hundred tubers were selected as randomized from each application. These tubers were put in reinforced paper bags. Then they were placed in the laboratory and held at ambient temperature. The tubers which was found in the in reinforced paper bags were examined to determine damage of PTM. Observations were made at 10, 20 and 30 days intervals after storage. The number of tubers infested and no damage were recorded. The percentages tubers damaged by PTM after each treatment were compared to control. Effect was calculated according to Abbott (1925). The rate infestation of tubers were determined. Statistical analyses were conducted according to the SPSS program.

RESULTS AND DISCUSSION

Studies in Afyonkarahisar province

The pheromone trap was placed after plant emergence in the experiment field on 02.05.2013. The number of adult PTM determined on pheromone traps is presented in Table 2. First PTM adults emerged on 16.05.2013 and the highest number of adults appeared on 06.08.2013.

The results of experiments of insecticide applications are presented in Table 3. The highest the rate of infestation was 15.25% in the control. In spinoteram, the highest rate of infestation was 8.5% for schedule four. The lowest of rate infestation was obtained in schedule one. In deltamethrin treatment, infestation rates remained during the entire trail. Therefore a statistical analysis was performed only with the data obtained from the spinotoram applications. The highest rate of infestation was at schedule one.

Table 1. The name of the insecticides used

Commercial name	Active substance name and rate	Recommended dose
Radiant 120 SC	Spinetoram 120 gr/l	25 ml/1000 m^2
Coragen 20 SC	Chlorantraniliprole 200 g/l	20 ml/1000 m^2
Decis 2.5 EC	Deltamethrin 2.5 g/l	30 ml/1000 m^2

Table 2. The number of adults *Phthorima eoperculella* determined on pheromone trap and the dates of records in Afyonkarahisar province (2013).

Dates	The number of adults
16.05.2013	2
23.05.2013	4
27.05.2013	8
05.06.2013	5
14.06.2013	6
22.06.2013	6
30.06.2013	8
02.07.2013	25 (1. Spraying)
16.07.2013	18 (2. Spraying)
24.07.2013	5
01.08.2013	11
06.08.2013	29 (3. spraying)
13.08.2013	13
20.08.2013	12
29.08.2013	28 (4.spraying)
05.09.2013	23 (harvest)

Studies in Kirsehir province

The number of adult PTM detected in the pheromone trap are given in Table 4. The first PTM adult emerged on 05.06.2014. The highest number of adults was observed on 31.07.2014. The number of adults was below 15-20. Therefore spraying was not conducted during schedule one.

Table 4. The number of adults *Phthorima eoperculella* determined on pheromone trap and the dates of records in Kirsehir province (2014).

Dates	Thenumber of adults
25.04.2014	0
02.05.2014	0
11.05.2014	0
26.05.2014	0
05.06.2014	2
16.06.2014	8
23.06.2014	3
30.06.2014	4
08.07.2014	5
15.07.2014	7
22.07.2014	10
31.07.2014	11
10.08.2014	9
17.08.2014	7

The results of applications conducted are given in Table 5. The highest infection rates were in the control (11.77%). The spinotoram treatment had the lowest and the highest infection rates and effect were in schedule four. The chlorantraniliprole treatment also had the lowest and the highest infection rates and effects took place during schedule four. There was no significant difference in schedules between spinetoran and chlorantraniliprole treatments. Application times were important. While there was no difference between schedule two and schedule

Table 3. The rate of infestation (%) and effect (%) obtained from the experiments of *Phthorima eoperculella* in Afyonkarahisar province (2013).

The time of applications	Treatment			
	Spinetoram 120 gr/L		Deltamethrin 2,5 g/l	
	The rate of infestation (%)	Effect (%)	The rate of infestation (%)	Effect (%)
Schedule one (15-20 number of adults /per trap)	4.25	71.74±5.05a	8.75	42.56
Schedule two (Before two weeks harvest and one week)	5.75	61.57±3.09ab	8.50	44.66
Schedule three (After 34-96 days after plant emergence)	7.5	50,85±3.73 bc	9.00	43.69
Schedule four when tubers were 4-5 diameter cm	8.5	43.87±6.90 d	8.75	40.90
Control	15.25		15.25	

F=6.243; p=0.008

Table 5. The rate of infestation (%) and effect (%) obtained from the experiments of *Phthorimae operculella* in Kirsehir Province (2014).

The time of applications	Treatment			
	Spinetoram 120 gr/l		Chlorantraniliprole 200 g/l	
	The rate of infestation (%)	Effect (%)	The rate of infestation (%)	Effect (%)
Schedule two (One and two weeks before harvest)	7.00	39.97b	5.25	54.61 b
Schedule three (34-96 days after plant emergence)	6.25	46.95 b	7.50	35.26b
Schedule five (first adult trap, one month later, 15 days prior to harvest)	3.00	76.61a	2.50	81.09a
Control	15.25		15.25	

F=80,182; p=0,00

three, there was a large effect in schedule four for both spinetoran and chlorantranilip role.

Studies in Bolu province

Data on the number of adults PTM determined on pheromone trap are given in Table 6. The results clearly indicate that first adults of PTM emergency the date of 28.06.2015. The highest number of adults was on the date of 20.07.2015. It was noticed that the number of adults was less than 15-20. Therefore spraying was not conducted in application one. Statically analysis was performed by t-test at a rate of tuber infection.

Table 6. The number of adults *Phthorima eoperculella* determined on pheromone trap and the date of recorded Bolu province (2015).

Dates	Thenumber of adults
28.06.2015	3
05.07.2015	4
13.07.2015	4
20.07.2015	5
27.07.2015	1
03.08.2015	3
10.08.2015	4
17.08.2015	3
24.08.2015	4

The results given Table 7 indicated that the highest infection rate was in control. The smallest infestation rate was in schedule five.

According to observation of weekly intervals, it was determined that there were no infestation on leaves, stem and tubers visible with PTM damage. Moreover, it was found that there were few number of tubers exposed, by soil cracking, and to the sun and showing green chlorophyll areas.

When 15-20 adults/week/trap was detected, four different applications were conducted against PTM during the period of potato in the Province of Afyonkarahisar. It determined that the highest effect was in schedule one (15-20 adult/week/trap) to control PTM.

According to the results obtained from the applications in Afyon karahisar and Kirsehir, because schedule two and schedule three resulted in the lowest effects, these applications were not conducted in Bolu.

Experiments carried out in Kirsehir and Bolu found that the first spraying should occur when adults were first identified in the field in the pheromone traps followed by the second application, one month after the first application, with a third spraying 15 days before the harvest. These results are consistent with the findings reported by Anonymous (2010), who observed that the highest effect was during schedule one (15-20 adult/week/trap) to control PTM. However, this schedule was not as successful in Kirsehir and Bolu as in the experiments conducted in Afyonkarahisar, because the number of adult pheromone traps were below 15-20 adult/week/trap. Therefore, it was determined that schedule one (15-20 adult/week/trap) may not be appropriate in field conditions to control PTM in Turkey. Similarly, schedule two and schedule three were determined to be unsuccessful in field conditions to control PTM. However, Rondon (2010) revealed that these applications were successful in field conditions to

control PTM. Salah and Aalbu (1992) observed that schedule five was successful in field conditions to control PTM. However, this method appeared not successful in the experiments in Kirsehir and Bolu Provinces.

The studies were conducted in three provinces in Turkey, Afyon karahisar, Kirsehir and Bolu. According to the Bolu and Kirsehir results, we recommend that the first spraying should occur when adults were first identified in the field in the pheromone traps followed by the second application, one month after the first application, with a third spraying 15 days before the harvest. This is consistent with the results obtained by Sannino *et al*. (2012), who reported that applications of this method may be successful in field conditions to control PTM. However this schedule was not tested in Afyonkarahisar province.

CONCLUSION

This is the first study that was carried out regarding the effective spraying schedule to control PTM in Turkish field conditions. Given the different results in different provinces, one specific schedule may not be ideal for all of Turkey due to the different conditions in different provinces. More research is required to develop this initial study further.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. Numan E. Babaroglu for statistical analysis. Plant Protection Central Research Institute Ankara-Turkey. Special thanks to Bernie Dominiak for reviewed and improved an earlier version of this manuscript (Australia). Thanks to the company of Dupont and Dow Agro for supplying insecticides (Turkey).

REFERENCES

Abbott, WS. 1925. A method of computing the effectiveness of an insecticide. Journal of Economic Entomology. 18(2):265-267.

Abdel, RAS., Salem, AE. and Ghany, NMA. 2014. Sustainable potato tuber moth, *Phthorimaea operculella* (Zeller), control using biopesticides of natural andm icrobialorigin. African Journal Scienceand Technology 2 (6):125-130.

Anonymous. 2010. Cropwatch.uni.edu/potato/tubermoth.

Arnason, JT., Philogene, BJR. and Moran, P. 1989. Insecticides of plants origin. ACS Symposium Series, American Chemical Society, Washington, DC, USA. 387: 1-213.

Bacon, OG., Calley, NF., Riley, WD. and James, RH. 1971. Evaluation of insecticides for control of the green aphid and tuberworm on Irish potatoes. American Potato Journal 48: 298.

Chandel, RS. and Chandla, VK. 2005. Integrated control of potato tuber moth (*Phthorimaea operculella*) in Himachal Pradesh. Indian Journal of Agricultural Science 75:837-39.

Cuningham, LC. 1969. Alternative host plants of tobacco leaf miners, *Phthorimae operculella* (Zell.) (Lepidoptera: Gelechiidae). Queenshed. Journal of Agriculture and Animal Science. 26:107-111.

Das, GP. 1995. Plants used in controlling the potato tuber moth, *Phthorimae operculella* (Zell.) (Lepidoptera:Gelechiidae) Crop Protection. 14:631-636.

Debnath, MC.,Khound, JN., Dutta, SK. and Sarmah, PC. 1998. Management of potato tuber moth, *Phthorimaea operculella* (Zeller) in potato storage. Journal of the Agricultural Science Society of North-East India. 11 (1): 55-60.

Gomaa, AE. and El-Nenaey, HM. 2006. Evaluation of certain controlling measures for *Phthorimaea operculella* (Zeller) (Lepidoptera, Gelechiidae) on potato in stores. The Egyptian Journal of Agricultural Research. 84 (1): 31-41.

Hossein, SMZ., Das, GP. and Alam, MZ. 1994. Use of various indigenous materals and insecticides in controlling potato tuber moth in storage. Bulletin of Institute of Tropical Agriculture Kyushu University 17: 79-84.

Nasser, SM., Ahmed, SA. and Atwa DH. 2012. The Integration between *Trichogramma evanescens* West (Hymenoptera:Trichogrammatidae) and selected bioinsecticides for controlling the potato tuber moth, *Phthorimae operculella* (Zell.) (Lepidoptera:Gelechiidae) of stored potatoes. Journal of Plant Protection Research. 52 (1):41-46.

Rondon, SI., Bano, SJ., Clough, GH., Hamm, PH., Jensen, A., Schreiber, A., Alvarez, JM., Thornton, M., Barbaur, J. and Dogramaci, M. 2007. Biology and management of the potato tuberworm in the Pacific Northwest. PNW. 594.

Rondon, SI. 2010. The Potato tuberworm: A literature Review of Its Biology, Ecology and Control. Journal Potato Research. 87:149-166.

Salah, H. and Aalbu, R. 1992. Field use of Granulosis virus to reduce initial storage infestation of the potato tuber moth, *Phthorima eoperculella* (Zeller), in North Africa. Agriculture, Ecosystems and Environment. 38:119-126.

Salama, HS. and Salem, SA. 2000. Bacillus thurungiensis and neem seed oil (*Azadirachta indica*) effects on the potato tuber moth *Phthorimae operculella* Zeller in the

field and stores. Archives of Phytopathology Plant and Protection. 33:73-80.

Sporleder, M., Kroschel, J., Hube, RJ. and Lagnaoui, A. 2005. An improved method to determine the biological activity (LC_{50}) of the granulo virus PoGV in its host *Phthorimaea operculella*. Entomologia Experimentaliset Applicata. 116:191-97.

Sporleder, M. and Kroschel, J. 2008. The Potato Tuber Moth Granulovirus (PoGV): Use, Limitations and Possibilities for Field Applications. In, Integrated Pest Management for the Potato Tuber Moth, Bio-pesticides for potato tuber moth control Potato J 40 (2): July - December, 2013 141 *Phthorimaea operculella* Zeller- a Potato Pest of Global Importance. Eds. Kroschel, J. and Lacey, L. Weikersheim, Germany, Margraf Publishers: 49-71.

Sannino, L., Piro, F., CrivellI, L. and Pasquini, S. 2012. Lottaalla Tignoladellapatata con Rynaxypyr e indoxacarb. Atti Giornate Fitopatologiche. 1:281-287.

Steven, PA., Lawrence, AL., Pruneda, HN. and Rondon, S. 2008. Semi-field evaluation of a granulovirus and *Bacillus thuringiensis* spp. kurstaki for seasen-long control of the potato tuber moth, *Phthorimae operculella.* Entomologia Experimentaliset Applicata. 129 (3):276-85.

Von, AR., Goueder, J. and Temime, AB. 1987. Integrated control of potato tubermoth, *Phthorimae operculella* (Zeller) in Tunusia. Insect Science and Application. 8:989-994.

Received: Dec 26, 2016; Accepted: Jan 20, 2017