

Chemical Control of Potato Tuber Moth (PTM), *Phthorimaea operculella* (Zeller) on Two Potato Varieties under Field Conditions.

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ABSTRACT

The present work aimed to evaluate the efficiency of three insecticides [indoxacarb (Avaunt 15% EC), lufenuron (Match 5% EC) and methoxyfenozide (Runner 24% SC)] at their recommended rates at two different spray times of 10 or 15 days after the first spray against potato tuber moth (PTM), *Phthorimaea operculella* (Zeller) larvae on two potato varieties (Spunta and Mondial) during two successive summer seasons 2014 and 2015 at Appig village, Kafer El-zyaat center, Gharbia Governorate, Egypt. A randomized complete block design was applied for treatments including untreated check. The results showed that for 10 days experiments at season 2014, all treatments achieved reduction of PTM population in the foliage infestation when the highest values were recorded with Avaunt (46.29% & 41.97%) followed by Runner (34.84 % & 28.10 %) and Match (33.04% & 26.53%), for Spunta and Mondial varieties, respectively. The same trend was also recorded during the season of 2015. However, for 15 days experiments during season 2014, all treatments showed reduction of PTM population in the foliage infestation when the highest values were recorded with Avaunt (54.46% & 61.41%) followed by Runner (47.01 % & 47.47 %) and Match (41.18% & 44.51%), for Spunta and Mondial varieties, respectively. The same trend was also recorded at season 2015. Generally, all treatments achieved reduction of PTM population in the foliage infestation and resulted in increasing the potato yield of two varieties compared with untreated check. Fifteen days experiments were more appropriate than ten days where, Spunta variety was more susceptible to foliage infestation than Mondial variety.

Keywords: potato tuber moth, potato varieties, indoxacarb, methoxyfenozide, lufenuron, insecticides.

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).

In Egypt, potato is considered as a major energy – rich crop and it is consumed for its high food contents and it is also required for exportation, representing one of the most important sources of national income (Shoeb, Mona and mostafa, 2004). The whole cultivated area was 381379 fed which produced 4265178 tons, by average of 11.18 ton/ fed. in 2013 of all seasons (Sharshar *et al.*, 2015). Egypt ranks among the world's top potato exporters (Mohamed *et al.*, 2013).

Potato is used to make medicine for therapy of stomach disorders, control appetite for weight loss, infections, boils, burns, cramps, insomnia, cough and diabetes. Also potatoes contain provitamin A, vitamin K, sulfur and vitamin C. (Umadevi *et al.*, 2013).

Potatoes are liable to infestation by many insect pests, which reduce yield quantity and quality. Potato tuber moth, *Phthorimaea operculella* is considered to be one of the most serious insect pests infesting family Solanaceae (Sarhan, 2004 and Mandour *et al.*, 2012).

In Egypt, potato tuber moth has caused up to 100% losses to potato plants in fields as well as in storage (Ahmed *et al.*, 2013).

The most common control method for *P. operculella* is the used of various insecticides (Dillard *et al.*, 1993). These insecticides such as insect growth regulators (IGRs) and oxadiazine are widely used to control this pest. Insect growth regulators can be divided according to their mode of action into two major groups; chitin synthesis inhibitors (i.e. lufenuron) and substances that interfere with the action of insect hormones (methoxyfenozide) (Tunaz and Uygun, 2004). Indoxacarb is especially active on foliar-feeding

lepidopteran larvae (Sansone and Minzenmayer, 2000); it blocks the sodium channel and is reported to be a slow-acting insecticide with relatively long residual activity (Andaloro, *et al.* 2000).

This work aimed to evaluate the effect of three insecticides (i.e. indoxacarb, lufenuron and methoxyfenozide) at two different spraying times, (two different experiments and two applications at 10 or 15 days) against *P. operculella* larvae on two potato varieties (Spunta and Mondial) during two successive summer seasons of 2014 and 2015.

MATERIALS AND METHODS

Field experiments were carried out in Appig village, Kafer El-zyaat center, Gharbia Governorate during two successive summer seasons, 2014 and 2015. An area of 1680 m² was divided into 8 plots; each plot was subdivided into 5 replicates (each replicate 42 m²) for each treatment. The plot of control subjected to natural infestation. A randomized complete block design was applied for each plot including the control. Spunta and Mondial varieties were selected and planted in 1st and 3rd Jan. at 2014 and 2015, respectively. These varieties were obtained from the International Potato Center, Kafer Al-Zayate, Gharbia Governorate, Egypt. The usual seeding practices were applied by sowing in 25 cm apart in rows (80 cm wide) with the soil ridged up to bury the tuber seeds at a depth 20 cm below soil surface. Irrigation intervals and fertilization were conducted as usual. Two chemical applications were applied for all treatments; the first spray was applied 75 days after sowing whereas the second spray was applied 10 days (first experiment) or 15 days (second experiment) after the first spray during 2014 and 2015 seasons.

Insecticides used:

1-Indoxacarb insecticide:

Trade name : Avaunt 15% EC

Rate of application : 50 ml /200 liter/fed.

2-Methoxyfenozide insecticide:

Trade name : Runner 24% SC

Rate of application :150 ml/200 liter/fed.

3-Lufenuron insecticide:

Trade name : Match 5% EC

Rate of application : 160 ml/200 liter/fed.

Foliage samples:

Foliage samples of 50 leaves were taken randomly from each plot as follows:

- 1-Before the first spray immediately samples were collected 75 days after sowing.
- 2-After the first spray samples were collected 10 days (for the first experiment) and 15 days (for the second experiment).
- 3-After the second spray samples were collected 10 days (for the first experiment) and 15 days (for the second experiment).

The formula of Henderson & Tilton (1955) was used to calculate the percentage of reduction in the pest population.

$$\text{Reduction \%} = (1 - A/B \times C/D) \times 100$$

A = Number of live larvae in the treatment after application.

B = Number of live larvae in the treatment before application.

C = Number of live larvae in the control before application.

D = Number of live larvae in the control after application.

Yield increase % was calculated using the following formula:

$$\% \text{ increase in yield} = \frac{T - C}{T} \times 100$$

T = weight of yield in the treatment plot.

C = weight of yield in the untreated plot.

Statistical methods:

Data were subjected to ANOVA by using Costat program (1988) and significant differences among the treatments was portioned by LSD test at $P=0.05$ level.

RESULTS AND DISCUSSION

Effect of insecticides used on the potato tuber moth (PTM) larval mortality in potato leaves:

Field evaluations of three insecticides [i.e. indoxacarb (Avaunt 15% EC), lufenuron (Match 5% EC) and methoxyfenozide (Runner 24% SC)] against potato tuber moth, *Phthorimaea operculella* (Zeller) larvae in two potato varieties for two sprays were studied. The first spray was applied 75 days after sowing whereas the second spray was applied 10 days (first experiment) or 15 days (second experiment) after the first spray during 2014 and 2015 seasons.

Experiments of 10 days:

Results of table (1) revealed that, at season 2014, all treatments achieved reduction of PTM population in foliage infestation, while the highest values were recorded with Avaunt (46.29% & 41.97%) followed by Runner (34.84 % & 28.10 %) and Match (33.04% & 26.53%), for Spunta and Mondial varieties, respectively. The same trend was also recorded at season 2015, which ranged from 49.54% and 54.31% for Avaunt 40.95% and 40.25% in case of Match for Spunta and Mondial varieties, respectively.

Table 1. Effect of the second spray after 10 days of insecticide applications on the population reduction of potato tuber moth larvae in the leaves of two potato varieties (Spunta & Mondial) under field conditions during 2014 and 2015 seasons.

Treatments	Rate of Application / fed.	Mean of population before application immediately				Population reduction % after 10 days from the 1 st application				Population reduction % after 10 days from the 2 nd application				Mean of Reduction %			
		Spunta		Mondial		Spunta		Mondial		Spunta		Mondial		Spunta		Mondial	
		2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Indoxacarb Avaunt® 15% EC	50 ml	3.40	6.40	2.20	6.80	29.41	36.11	36.36	47.05	63.17	62.97	47.59	61.57	46.29	49.54	41.97	54.31
Methoxyfenozide Runner® 24% SC	150 ml	3.00	5.60	3.20	5.40	25.33	33.06	17.96	33.33	44.34	65.15	38.23	48.38	34.84	49.11	28.10	40.86
Lufenuron Match® 5% EC	160 ml	2.80	6.40	2.20	6.40	25.71	25.46	20.45	24.06	40.37	56.43	32.62	56.45	33.04	40.95	26.53	40.25
Control		3.20	4.60	2.80	5.40												

The statistical analysis of table (2) showed that, in season 2014, all treatments had a significant effect in reducing larval infestation compared with untreated check, except Runner with Mondial variety, while there was no significance between the tested compounds except between Avaunt and Runner with Mondial variety and there was less significant infestation found between two potato varieties. On the other side, there was significant variation between the efficacy of 1st and 2nd sprays in two cases; first was Avaunt treatment on

Spunta variety whereas the second was Runner treatment on Mondial variety.

The statistical analysis of the results during season 2015 showed that, all treatments had a significant reduction in larval infestation compared with untreated check, whereas no significant reductions were observed between the tested compounds except Runner and Match on Spunta variety. For sprays, the results indicated that, there was significant reduction between all treatments. However, there were no significant reductions between the varieties.

Table 2. Effect of the second spray after 10 days of insecticide applications on potato tuber moth larval infestation in the leaves of two potato varieties (Spunta & Mondial) under field conditions during 2014 and 2015 seasons.

Treatment	Application (sprays)	Number of larval infestation of 10 days				Mean of 10 days	
		Spunta		Mondial		2014	2015
		2014	2015	2014	2015		
Indoxacarb Avaunt® 15% EC	1 st	* 3.00	4.80	1.60	4.00	2.30	4.40
	2 nd	1.80	3.40	1.44	3.00	1.60	3.20
Methoxyfenozide Runner® 24% SC	Mean	2.40	4.10	1.50	3.50	1.95	3.80
	1 st	2.80	4.40	3.00	4.00	2.90	4.20
	2 nd	2.40	2.80	2.40	3.20	2.40	3.00
Lufenuron Match® 5% EC	Mean	2.60	3.60	2.70	3.60	2.65	3.60
	1 st	2.60	5.60	2.00	5.40	2.30	5.50
	2 nd	2.40	4.00	1.80	3.20	2.10	3.60
Control	Mean	2.50	4.80	1.90	4.30	2.20	4.55
	1 st	4.00	5.40	3.20	6.00	3.60	5.70
	2 nd	4.60	6.60	3.40	6.20	4.00	6.40
Mean	Mean	4.30	6.00	3.30	6.10	3.80	6.05
Mean		2.95	4.63	2.35	4.37	2.65	4.50

*Mean number of live larvae of five replicates (50 leaves each)

L.S.D. values at 5%	2014	2015
Treatment (T.)	0.82	0.96
Variety (V.)	0.58	0.68
Application (A.)	0.58	0.68
T * V	1.16	1.36
A * T	1.16	1.36
A * V	0.82	0.96
A * T * V	1.65	1.92

Experiments of 15 days:

Results of table (3) revealed that, during season 2014, all treatments produced reduction of PTM population in foliage infestation when the highest values were recorded with Avaunt (54.46% & 61.41%) followed by Runner (47.01 % & 47.47 %) and Match (41.18% & 44.51%), for Spunta and Mondial varieties, respectively. The same trend was also recorded at season 2015.

The data in table (4) showed that, during season 2014, all treatments had a significant effect in reduction of larval infestation compared with untreated check, but

there were no significant differences between the tested compounds, except in the effect of Avaunt and Match treatments on Mondial variety. There were significant differences between the sprays for all treatments.

However, the results indicated that during season 2015, the treatments had a significant reduction in larval infestation compared with untreated check, but there was no significant reduction between the tested compounds. However, there was significant reduction between the sprays for all treatments. But there was no significant difference in the infestations of two potato varieties.

Table 3. Effect of the second spray after 15 days of insecticide applications on the population reduction of potato tuber moth larvae in the leaves of two potato varieties (Spunta & Mondial) under field conditions during 2014 and 2015 seasons.

Treatments	Rate of Application / fed.	Mean of Population before application immediately				Population reduction% after 15 days from the 1 st application				Population reduction % after 15 days from the 2 nd application				Mean of total Reduction %			
		Spunta		Mondial		Spunta		Mondial		Spunta		Mondial		Spunta		Mondial	
		2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Indoxacarb																	
Avaunt®15% EC	50 ml	3.40	6.40	2.20	6.80	35.82	36.41	50.50	48.76	73.10	74.63	72.33	72.77	54.46	56.58	61.41	60.76
methoxyfenozide Runner® 24% SC	150 ml	3.00	5.60	3.20	5.40	32.12	36.81	36.80	32.25	61.90	66.17	58.15	71.42	47.01	53.91	47.47	51.84
Lufenuron Match® 5% EC	160 ml	2.80	6.40	2.20	6.40	27.27	41.94	22.22	40.12	55.10	64.06	66.79	61.42	41.18	53	44.51	50.77
Control		3.20	4.60	2.80	5.40												

Table 4. Effect of the second spray after 15 days of insecticide applications on potato tuber moth larval infestation in the leaves of two potato varieties (Spunta & Mondial) under field conditions during 2014 and 2015 seasons.

Treatment	Application (sprays)	Number of larval infestation of 15 days				Mean of 15 days	
		Spunta		Mondial		2014	2015
		2014	2015	2014	2015	2014	2015
Indoxacarb Avaunt® 15% EC	1 st	* 3.00	4.60	4.10	4.00	3.55	4.30
	2 nd	1.60	2.20	1.00	2.40	1.30	2.30
	Mean	2.30	3.40	2.55	3.20	2.43	3.30
Methoxyfenozide Runner® 24% SC	1 st	2.80	4.00	2.60	4.20	2.70	4.10
	2 nd	2.00	2.40	2.00	2.80	2.00	2.60
	Mean	2.40	3.20	2.30	3.50	2.35	3.35
Lufenuron Match® 5% EC	1 st	2.80	4.20	2.20	4.40	2.50	4.30
	2 nd	2.20	3.40	1.20	3.20	1.70	3.30
	Mean	2.50	3.80	1.70	3.80	2.10	3.80
Control	1 st	4.40	5.20	3.60	6.20	4.00	5.70
	2 nd	5.60	6.80	4.60	7.00	5.10	6.90
	Mean	5.00	6.00	4.10	6.60	4.55	6.30
Mean		3.05	4.10	2.66	4.28	2.86	4.19

*Mean number of live larvae of five replicates (50 leaves each)

L.S.D. values at 5%	2014	2015
Treatment (T.)	0.83	1.06
Variety (V.)	0.59	0.74
Application (A.)	0.59	0.74
T * V	1.18	1.49
A * T	1.18	1.49
A * V	0.83	1.06
A * T * V	1.67	2.12

The relation between chemical control and potato yield:**Experiments of 10 days:**

Data of table (5) indicated that, all tested compounds resulted in increasing the potato yield of the two varieties compared with untreated check. There was significantly different for all treatments at season 2015

but there were no significant difference between the varieties in both seasons.

Consequently, the overall findings showed that potato yield was the highest when treated by Avaunt while the lowest gained when potato fields were applied by Match. Implementing Runner resulted in an intermediate potato yield (table 5).

Table 5. The relation between chemical control and potato yield of the second spray after 10 days of two potato varieties (Spunta and Mondial) during 2014 and 2015 seasons.

Treatments	Rate of Application /fed.	Mean* Kg/plot of 10 days treatments				Yield increase % of 10 days treatments			
		Spunta		Mondial		Spunta		Mondial	
		2014	2015	2014	2015	2014	2015	2014	2015
Indoxacarb	50 ml	209	149	211.2	153	8.08	15.97	3.88	16.41
Avaunt® 15% EC									
Methoxyfenozide	150 ml	198.1	140.9	206.1	142.2	3.02	11.14	1.50	10.06
Runner® 24% SC									
Lufenuron	160 ml	193.7	138	203.9	139	0.82	9.28	0.44	7.99
Match® 5% EC									
Control	0.0	192.1	125.2	203	127.9				
Mean		198.23	138.28	206.1	140.53				

*Mean weight (Kg) of potato yield of five replicates.

L.S.D. values at 5%	2014	2015
Treatment (T.)	23.25	10.26
Variety (V.)	16.44	7.26
T * V	32.88	14.51

Experiments of 15 days:

Data of table (6) demonstrated that, all tested compounds resulted in increasing the potato yield of the two varieties compared with untreated check. For season 2014, there were significantly of treatments compared with untreated check in Avaunt with the two

varieties and Runner with Mondial variety. For season 2015, there were significantly of all treatments compared with untreated check except only in the case of Match with Spunta variety.

Generally, the present investigation demonstrated that, all treatments had a significant reduction of larval infestation resulted in increasing the potato yield compared with untreated check, thence indoxacarb was the highest effect followed by methoxyfenozide and lufenuron. These results are in agreement with Vaneva-Gancheva and Dimitrov (2013) cited that, the best control over potato tuber moth can be exercised by chlorantraniliprole and indoxacarb and the effectiveness under field conditions has been manifested by ensuring

a longer period of protection. Dobie (2010) showed the most continuous effect of indoxacarb against young caterpillars of the potato tuber moth compared with other tested compounds. The weak initial effect of indoxacarb is because the latter had to be swallowed by the caterpillars and metabolized to a bioactive metabolite. It is possible that indoxacarb was less efficacious because this compound has a slower mode of action as it has to be ingested and metabolized to DCMP, the bioactive metabolite.

Table 6. The relation between chemical control and potato yield of the second spray after 15 days of two potato varieties (Spunta and Mondial) during 2014 and 2015 seasons.

Treatments	Rate of Application /fed.	Mean* Kg/plot of 15 days treatments				Yield increase % of 15 days treatments			
		Spunta		Mondial		Spunta		Mondial	
		2014	2015	2014	2015	2014	2015	2014	2015
Indoxacarb Avaunt® 15% EC	50 ml	212.85	154	213.75	156	13.08	17.60	14.85	17.95
Methoxyfenozide Runner® 24% SC	150 ml	204.72	148.1	208.68	149.2	9.63	14.31	12.78	14.20
Lufenuron Match® 5% EC	160 ml	195.95	140	203.94	143	5.59	9.36	10.75	10.48
Control	0.0	185	126.90	182	128				
Mean		199.63	142.25	202.09	144.1				

*Mean weight (Kg) of potato yield of five replicates.

L.S.D. values at 5%	2014	2015
Treatment (T.)	23.85	13.47
Variety (V.)	16.87	9.52
T * V	33.73	19.04

Mohamed (2002) reported that flufenoxuron insecticide gave significant effect on PTM infestation significant increase in potato yield compared to untreated check.

Shoeb, Mona and Mostafa (2004) studied the insecticidal effects of three IGRs [Match (lufenuron), Consult (hexaflumuron) and Cascade (flufenoxuron)] on potato tuber moth. They found that, using insect growth regulators may be recommended with planning I.P.M. programs against *P. operculella*.

In conclusion, the 15 days experiment was better than 10 days experiment where, Spunta variety was more susceptible of foliage infestation than Mondial variety. These findings are in agreement with Vaneva-Gancheva and Dimitrov (2013) which reported that, the effectiveness under field conditions has been manifested by ensuring a longer period of protection. The best control over the potato tuber moth can be exercised by chlorantraniliprole and indoxacarb. Fourteen days after the first treatment the extent of damages of all tested compounds significantly decreased compared with the control.

Temerak (1979) reported that potato variety did not seem to play a significant role in increasing or decreasing the larval potency inside potato leaves after PTM attack it.

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المكافحة الكيميائية لفراشة درنات البطاطس علي صنفين من البطاطس تحت الظروف الحقلية عبدالسلام حافظ جمال الدين¹، عبدالله الحسين عبدالمنعم²، سعيد عبدالعليم حماد³ و محمد فوزي الطويل⁴ قسم وقاية النبات – أشعة مبيدات الآفات – الحشرات الاقتصادية – كلية الزراعة بالقاهرة – جامعة الأزهر

هدف هذا البحث تقييم كفاءة ثلاثة مبيدات حشرية [اندوكساكارب (أفانت ١٥% مركز قابل للإستحلاب) , ليفونيرون (ماتش ٥% مركز قابل للإستحلاب) , ميثوكسي فينوزايد (رنر ٢٤% معلق مركز)] بالمعدلات الموصي بها في وقتين مختلفين للرش ١٠ او ١٥ يوم بعد الرش الأولي ضد يرقات فراشة درنات البطاطس علي صنفين من البطاطس (اسبونتا , مونديال) خلال موسمين صيفيين متعاقبين ٢٠١٤ و ٢٠١٥ في قرية ابيج – مركز كفر الزيات – محافظة الغربية. تم تطبيق تصميم القطاعات الكاملة العشوائية لكل المعاملات متضمنه الكنترول. أظهرت النتائج بالنسبة إلي تجربة ١٠ أيام موسم ٢٠١٤ أن كل المعاملات حققت خفض في تعداد الإصابة الورقية بيرقات فراشة درنات البطاطس حيث سجلت أعلى القيم من قبل أفانت (٤٦.٢٩% , ٤١.٩٧%) يتبعه رنر (٣٤.٨٤% , ٢٨.١٠%) وماتش (٣٣.٥٤% , ٢٦.٥١%) بالنسبة لصنفي اسبونتا ومونديال علي الترتيب. أيضاً سجلت النتائج في نفس الإتجاه في موسم ٢٠١٥. بالنسبة لتجربة ١٥ يوم موسم ٢٠١٤ حققت كل المعاملات خفض في تعداد الإصابة الورقية بيرقات فراشة درنات البطاطس حيث سجلت أعلى القيم من قبل أفانت (٥٤.٤٦% , ٦١.٤١%) يتبعه رنر (٤٧.٠١% , ٤٧.٤٧%) وأخيراً ماتش (٤١.١٨% , ٤٤.٥١%) بالنسبة لصنفي اسبونتا ومونديال علي الترتيب. أيضاً سجلت النتائج في نفس الإتجاه في موسم ٢٠١٥. بالنسبة لتجربة ١٥ يوم موسم ٢٠١٥. عموماً حققت كل المعاملات خفض في تعداد فراشة درنات البطاطس في الاصابات الورقية مما أسفر عن زيادة محصول البطاطس للصنفين مقارنة بالكنترول. كانت تجربة ١٥ يوم افضل من ١٠ أيام حيث كان صنف اسبونتا أكثر حساسية للإصابة الورقية من صنف مونديال.