Efficacy of profenofos and certain bio-product agents on the potato tuber moth (PTM), in reference to their effects on certain internal properties of potato tubers

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ABSTRACT

Field trials were conducted to evaluate the effect of profenofos and certain bio-product agents against the potatoes tuber moth (*Phthorimaea operculella*), with reference to some chemical components of potato tuber, *Solanum tuberosum L. (Solanaceae)* cv. Vallor, at El-Nobaria district, El-Behaira governorate during two successive seasons of 2009 and 2010. The obtained results proved that profenofos was the most effective treatment that recorded 45.53% as general mean infestation reduction during the first season 2009, followed by emamectin benzoate and azadirachtin showing 44.49 and 35.83%, respectively. But, during the second season emamectin benzoate and azadirachtin were the most effective treatments, which attained higher 50.75 and 50.07% as general mean reduction, respectively. On the contrary, the bacterium *B. thuringenesis* showed the least effective treatment during both seasons. On the other hand, the effect of the used treatments on some tuber internal properties; namely, dry matter, specific gravity, total sugar and reducing sugar contents were evaluated during both seasons. It is obvious that dry matter and specific gravity during both seasons weren't be affected by the treatments. Meanwhile, profenofos resulted in the highest values of total sugar during both seasons. The data also declared that emamectin benzoate was the best effective treatment in reducing sugar, which has been considered as an indicator for the quality of processed potato for frying followed by *B. thuringenesis* and azadirachtin, consequently.

INTRODUCTION

Potato (*Solanum tuberosum*) is an important food crop, which placed the fifth rank from the view point of economics worldwide. Meanwhile, Potato is an important temperate crop, has been adopted well for cultivation under sub-tropical conditions. Egypt produces 2.6 million metric tons of potatoes and exports 411.000 metric tons to Europe and the Arab countries (Abd El-Gawad *et al.*, 2010). It is used as vegetable, stock feed and in industries for manufacturing starch, alcoholic beverages and other processed products. Furthermore, potato is a highly nutritious food. It provides carbohydrates, proteins, minerals, Vitamin C, number of B group vitamins and high quality dietary fibers. Potatoes give about 97 kilo calories per 100 g fresh weight, which is much less than cereals. The net protein utilization or biological value of potato protein (≈71% that of whole egg), is better than that of wheat (53%), maize (54%), peas (48%), beans (46%) and is comparable to cow's milk (75%) (http://sikkimagrisnet.org/General/en/Potato.aspx).

The potato tuber moth (PTM), is one of the serious pests of potato which found in tropical and subtropical regions of the world. The potato

tuber moth *Phthorimaea operculella* (Zeller) (Lepidoptera - Gelechiidae), is a major pest of potatoes attacking the foliage and infests the tubers in both field and store causing serious economic damage. In storage the larvae of PTM make irregular tunnels which led to a considerable weight loss especially during its outbreak (Joshi, 1989 and El-Sinary, 2002).

Hence, this investigation aimed to study: (a) the biological performance of certain bio-products agents towards the potato tuber moth to reduce its incidence as well as the use of conventional chemical insecticides, and (b) the effect of the assigned chemicals on some chemical components of tubers.

MATERIALS AND METHODS

The used bio-product agents:

A- Terpenoid.

Nimbecidine® **0.03% EC (azadirachtin),** dimethyl (3*S*, 3a*R*, 4*S*, 5*S*, 5a*R*, 5a^{1}*R*,7a*S*,8*R*,10*S*,10a*S*)-8-acetoxy-3,3a, 4,5, 5a, 5a^{1}, 7a, 8,9, 10-decahydro-3,5-dihydroxy-4-{(1*S*,3*S*,7*S*,8*R*,9*S*,11*R*)-7-hydroxy-9-methyl-2,4,10 trioxatetracyclo[6.3.1.$0^{3,7}$.$0^{9,11}$]dodec-5-en-11-yl}-4-methyl-10[(*E*)-2-methylbut-2-enoyloxy]-1*H*,7*H*-naphtho[1,8a,8-*bc*:4,4a-*c*']difuran-3,7a-dicarboxylate.

B- Bacterial insecticide.

Dipel 2X® WP (*Bacillus thuringiensis*,subsp. *Kurstaki.* var. Serotype: 3a, 3b (Novartis)),is an aerobic spore-forming Gram-positive, rod-shaped bacterium,belonging to the family Bacillaceae. At sporulation, in addition to spores, crystals of protein, the delta-endotoxin, are also formed.

C- Avermectin.

Proclaim® 5% S.G (emamectin benzoate), a mixture containing 90% of (10*E*,14*E*,16*E*,22*Z*)-(1*R*,4*S*, 5' *S* ,6*S* ,6'*R*,8*R*,12*S*,13*S*,20*R*,21*R*,24*S*)-6'-[(*S*)-*sec*-butyl]-21,24-dihydroxy-5',11,13,22-tetramethyl-2-oxo-3,7,19-trioxatetracyclo [15.6.1. $1^{4,8}$.$0^{20,24}$] pentacosa-10,14,16,22-tetraene-6-spiro -2'- (5',6' -dihydro - 2'*H*-pyran) -12-yl 2,6-dideoxy-3-*O*-methyl-4-*O*-(2,4,6-trideoxy-3-*O*-methyl-4-methylamino-α-L-*lyxo*-hexopyranosyl)-α-L-*arabino*-hexopyranoside and 10% of (10*E*, 14*E*, 16*E*, 22*Z*) - (1*R*, 4*S*, 5'*S* ,6*S* ,6' *R*, 8*R*, 12*S*, 13*S*, 20 *R*, 21*R*, 24*S*) -21, 24 - dihydroxy - 6'-isopropyl -5',11,13, 22 – tetramethyl - 2-oxo-3,7,19-trioxatetracyclo[15.6.1.$1^{4,8}$.$0^{20,24}$] pentacosa-10,14, 16,22-tetraene – 6 – spiro - 2'-(5',6'-dihydro-2'*H*-pyran) -12-yl 2,6 - dideoxy -3-*O*-methyl – 4 – *O* - (2,4,6-trideoxy-3 –*O* -methyl- 4- methyl amino - α - L -*lyxo* – hexopyranosyl)-α-L- *arabino* - hexopyranoside .

The used chemical insecticide:

Organophosphorus group.

Selecron® 72% EC (Profenofos), O -4-bromo-2-chlorophenyl O-ethyl *S*-propyl phosphorothioate.

Field experiment:

Field experiments were conducted at the Research Farm in Agrofood Company, El-Nobaria district, El-Behaira governorate, Egypt, for two successive seasons of 2009 and 2010. The experiments were accomplished on potato (*Solanum tuberosum L.*) var. Vallor, which cultivated during the second week of February in both seasons. Moreover, the recommended agricultural practices were executed according to the recommendations of the Egyptian Ministry of Agriculture.

The applied treatments during both seasons were profenofos (Selecron®) which used at the rate of one litre /fed, emamectin benzoate (Proclaim®) at 120 g/fed, azadirachtin (Nimbecidine®) at one liter / fed., and *Bacillus thuringiensis* (Diplel® 2x) at 500g/ fed. Meanwhile, each treatment was replicated three times and each replicate area was 25 m^2. In both seasons, the samples were taken by (x) method. Twenty leaves were chosen randomly every 5 days till 30 days after treatments of each replicate, to count the larvae of the potato tuber moth. Replicates were separated from each other by buffer paths of 0.5m^2 to minimize the insecticide drifts. Treatments were allotted randomly following the RCBD design.

Determination of some internal properties of potato tubers:

At harvest in both seasons, certain chemical components namely; dry matter, specific gravity, total sugar and reducing sugar were evaluated. The total sugar content (%) and reducing sugars content (%) were determined based on fresh weight according to Dubbois *et al.* (1956). On the other hand, dry matter (%) by drying the tuber sample slices at 70^0 C for 48 hrs. until a constant weight by dividing the dry weight / the fresh x100 (Haase, 2003), while specific gravity was determined using the method described by Dinesh *et al.* (2005) as follows:

$$\text{Specific gravity} = \frac{\text{Weight of tuber in air}}{\text{Weight of tuber in air - Weight of tuber under water}}$$

The reduction percentage of infestation was calculated after 1, 2 and 3 months post-treatment according to the formula of Henderson and Tilton (1955) as follows:

$$\text{Reduction \%} = \{1 - (\frac{a}{b} \times \frac{c}{d})\} \times 100$$

Where,

a = Population in treatment after treatment
b = Population in treatment before treatment
c = Population in check before treatment
d = Population in check after treatment

Statistical analysis:

Data of the present investigation were subjected to the analysis of variance test (ANOVA) as randomized complete blocks design (RCBD) and the comparisons among the means of different treatments were carried out using the revised L.S.D test as described by Duncan (1955).

RESULTS AND DISCUSSION

Efficacy of the treatments on the infestation of the potato tuber moth (PTM)

The obtained results in Table (1) revealed the efficacy of the bio-product agents as compared to profenofos against the potato tuber moth *Ph. operculella* during the first season in 2009 on potatoes. The infestation in treatments was inspected after 5, 10, 15, 20, 25 and 30 days. Significance of treatments was fluctuated during the interval periods. The general means' reductions of infestation indicated that profenofos proved to be the most effective treatment that recorded 45.53% reduction, followed by emamectin benzoate, azadirachtin and *B. thuringenesis* with values of 44.49, 35.83 and 30.76% reduction, respectively.

Results were in agreement with those of (Adhanom and Tessema, 1981) who indicated that profenofos gave a mean percent infestation of 2.33 ,that was significantly better control than the other insecticide percentages .On tomato plants, abamectin, profenofos, pirimiphos-methyl, xentari and Agerin® gave full initial kill of 100% against the first instar larvae of the insect pest (Belal *et al.*, 2005). Abamectin was the most effective against *P. operculella* followed by (profenofos, *Bacillus thuringiensi*) and granulosis virus, respectively (Abdel-Megeed *et al.* 1998).

Similarly it was obvious that all the tested bio-products were effective and reduced the potato tuber moth *P. operculella* during the second season of 2010 on potatoes (Table 2). The some evaluated treatments ascertained different levels of reductions. Emamectin benzoate and azadirachtin recorded the highest reductions 50.75 and 50.07%, consecuently.

Meanwhile, the least effective treatments were corresponded to both profenofos and *B. thuringenesis* that gave 43.65 and 28.92% reduction, subseqeuntly. Abd- El salam and Teixeira da Silva (2010) showed that Nembecidine® (azadirachtin) reduced the *P. operculella* population. (Belal *et al.*, 2005) opined also that the least effective treatment was Agerin (Bt) compared with abamectin, profenofos, pirimiphos-methyl and xentari.

Table (1). Biological performance of certain agrochemicals and natural biological agents against the potato tuber moth, *Phthorimaea operculella* (Zeller) in 2009 season.

Pesticides	Pre-spray	% infestation reduction at certain intervals (in days) after 5 days		after 10 days		after 15 days		after 20 days		after 25 days		after 30 days		Mean %
		A	B	A	B	A	B	A	B	A	B	A	B	
Profenofos	0.71	0.71	45.39^{a}	1.27	67.24^{a}	1.57	47.19^{a}	0.88	51.79^{b}	0.71	49.58^{a}	1.17	11.97^{c}	45.53
Azadirachtin	0.71	0.71	45.39^{a}	1.52	60.66^{b}	1.86	37.42^{b}	1.46	32.51^{d}	1.27	24.10^{c}	1.34	14.92^{b}	35.83
Emamectin benzoate	0.71	0.71	45.39^{a}	1.88	51.34^{c}	2.26	23.93^{c}	0.88	66.53^{a}	1.1	45.94^{b}	1.27	33.83^{a}	44.49
Bacillus thuringiensis	0.71	0.71	45.39^{a}	1.85	52.20^{c}	2.11	28.76^{d}	1.44	41.79^{c}	1.74	8.58^{d}	2.03	-7.84^{d}	30.76
Untreated check	0.71	1.56	-	3.86	-	3	-	3.46	-	2.67	-	2.52	-	-

A: Mean number of insects **B:** % Reduction

In each column, means followed by a different letter (s) are significantly different at $P \leq 0.05$ level.

Table (2). Biological performance of certain agrochemicals and natural biological agent against the potato tuber moth, *Phthorimaea operculella* (Zeller)in 2010 season.

Pesticides	Pre-spray	% infestation reduction at certain intervals (in days) after 5 days		after 10 days		after 15 days		after 20 days		after 25 days		after 30 days		Mean %
		A	B	A	B	A	B	A	B	A	B	A	B	
Profenofos	1.65	1.85	33.3^{c}	0.88	69.8^{b}	0.71	43.3^{c}	1.01	53.4^{c}	0.71	47.5^{b}	0.71	14.6^{b}	43.65
Azadirachtin	2.03	2.11	37.9^{b}	1.01	71.8^{a}	0.88	74.1^{a}	1.11	58.7^{b}	0.88	51.9^{a}	1.01	6^{c}	50.07
Emamectin benzoate	1.65	2.31	61^{a}	1.65	43.3^{c}	1.28	53.7^{b}	1.01	95.3^{a}	1.01	25.6^{c}	0.88	25.6^{a}	50.75
Bacillus thuringiensis	1.77	2	32.5^{c}	1.9	39.2^{d}	2	32.5^{d}	1.3	44.4^{d}	1.3	10.3^{d}	1.3	14.6^{b}	28.92
Check untreated	2.21	3.7	-	3.9	-	3.7	-	2.9	-	1.81	-	2.12	-	-

A: Mean number of insects **B:** % Reduction

In each column, means followed by a different letter (s) are significantly different at $P \leq 0.05$ level.

Biological performance of treatments on some potato internal components

In case of dry matter and specific gravity, there weren't any significant differences among all the treatments and untreated check (Table, 3). Emamectin benzoate was slightly higher in the dry matter percentage (15.63%) compared with 15.53% in the other treatments and untreated check. The specific gravity wasn't significantly affected and recorded 1.058 for each treatment.

On the other hand, profenofos significantly increased the total sugar percentage (0.195) followed by *B. thuringenesis* and emamectin benzoate with values of 0.189 and 0.183, respectively. Moreover, the least total sugar (0.173%) was observed with the azadirachtin treatment.

Profenofos recorded the significant highest value of reducing sugar by 1.451 than the other treatments except the untreated check. Meanwhile, emamectin benzoate induced the least significant value (1.263). The other treatments: azadirachtin and *B. thuringenesis* showed slightly lower values 1.345 and 1.308 of reducing sugar than the untreated check, respectively.

Table (3). Effect of profenofos, *Bacillus thuringiensis*, emamectin benzoate and azadirachtin on some internal components of potato tuber during the summer season (2009).

Treatments	Nutrient composition			
	Dry matter%	Specific gravity	Total sugar%	Reducing sugar%
Profenofos	15.53^{a}	1.058^{a}	0.195^{a}	1.451^{a}
Bacillus thuringiensis	15.5^{a}	1.058^{a}	0.189^{ab}	1.308^{bc}
Emamectin benzoate	15.63^{a}	1.058^{a}	0.183^{bc}	1.263^{c}
Azadirachtin	15.53^{a}	1.058^{a}	0.173^{c}	1.345^{bc}
Untreated check	15.53^{a}	1.058^{a}	0.182^{bc}	1.371^{ab}

In each column, means followed by different letter are significant differently at 5% probability level.

The listed data in Table (4) indicated the efficacy of the evaluated insecticides profenofos, azadirachtin, emamectin benzoate and *B. thuringenesis*, on some properties of potatoes, *S tuberosum L. (Solanaceae)* cv. Vallor, during the second season of 2010. The evaluated treatments didn't record any significant differences on the dry matter and/or the specific gravity than the untreated check.

Moreover, profenofos significantly increased the total sugar54

percentage (0.191) followed by *B. thuringenesis* (0.185) and emamectin benzoate (0.181), respectively. Whilst the least total sugar (0.170%) was noticed in the azadirachtin treatment

All the evaluated treatments constricted the reducing sugar in comparison with the untreated check, whereas, emamectin benzoate, *B. thuringenesis* and azadirachtin recorded the least reducing sugar with 1.90, 1.88 and 1.43%, respectively.

Table (4). Effect of profenofos, *Bacillus thuringiensis*, emamectin benzoate and azadirachtin on some internal components of potato tuber during the summer season (2010)

Treatments	Nutrient materials			
	Dry matter%	Specific gravity	Total sugar%	Reducing sugar%
Profenofos	15.63[a]	1.058[a]	0.191[a]	1.933[ab]
Bacillus thuringiensis	15.60[a]	1.057[a]	0.185[b]	1.88[b]
Emamectin benzoate	15.66[a]	1.058[a]	0.181[b]	1.90[b]
Azadirachtin	15.46[a]	1.057[a]	0.170[c]	1.433[c]
Untreated check	15.60[a]	1.058[a]	0.183[b]	1.966[a]

In each column, means followed by different letter are significant differently at 5% level

Tuber sugar content has an important indicator for the quality of processed potato products; because of its large influence on fried product color. When potato slices are exposed to the high levels of heat, which is typical of the deep process, sugars combine with amino acids and other compounds to form the dark color and flavor, associated with "burned" food. This process is known as the "Maillard reaction".

The reducing sugars, glucose and fructose create the most serious problems during frying, because they are chemically reactive. Sucrose contributes little to dark color development, but is still important because it is the substrate for creating more reducing sugars under the right environmental and physiological conditions (Stark, 1985).

Based on this scientific fact, the data implied that emamectin benzoate and azadirachtin in 2009 and 2010, respectively, were the best effective treatments in reducing sugar as an indicator of the quality of processed potato for deep frying followed by *B. thuringenesis* and azadirachtin, consequently.

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الملخص العربي

فعالية بروفينوفوس و بعض المنتجات الحيوية على فراشة درنات البطاطس في إشارة إلى تأثيرها على بعض المكونات الكيميائية لدرنات البطاطس

مجدي عبدالظاهرمسعود، عبدالفتاح سعدعبدالكريم وعمادالعدوي

تم إجراء عدة تجارب حقلية لتقييم فعالية المبيد الحشرى بروفينوفوس مع عدة مبيدات حيوية ضد فراشة درنات البطاطس و كذلك على بعض المكونات الكيماوية لدرنات البطاطس في منطقة النوبارية، محافظة البحيرة خلال موسمي ٢٠٠٩ و ٢٠١٠.

أوضحت النتائج أن مبيد بروفينوفوس كان الأكثر فعالية في خفض المتوسط العام للإصابة بنسبة ٤٥.٥٣%.خلال موسم ٢٠٠٩ و تبعه إيمامكتين بنزوات (٤٤.٤٩) و أزاديراختين (٣٥.٨٣) على الترتيب. بينما في موسم ٢٠١٠ كان إيمامكتين و أزاديرختين هما الأكثر فعالية معطيان نسبة خفض عام للإصابة ٥٠.٧٥ و ٥٠.٠٧% على التوالي، بينما كان المبيد البكتيري باسيلس ثرينجينسيس هو الأقل فعالية في كلا الموسمين.

كذلك أوضحت النتائج المكونات الداخلية للدرنات أنها تنوعت في مدى تأثرها بالمعاملات. حيث أن المادة الجافة و الكثافة النوعية لم تتأثرا بالمعامل ات في كلا الموسمين مقارنة بالكونترول. بينما أدى مبيد بروفينوفوس الى حدوث زيادة معنوية لنسبة السكريات الكلية في حين أن أزاديراختين أدى الى نقصها معنويا.

و كان من أهم النتائج أن ايمامكتين وبنزوات هو الأفضل من حيث خفض السكريات المختزلة و التي تعتبر مؤشر ا على جودة البطاطس في صناعة البطاطس المحمرة و تلاه في ذلك باسيلس ثرينجينسيس و أزاديراختين على التوالى.