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EVALUATION OF DIFFERENT *Trichogramma evanescens* WEST. RELEASES AND ITS COMBINED WITH BACTERIAL INSECTICIDE AS CONTROL MANAGEMENT TOOLS OF *Phthorimaea operculella* (Zeller) IN POTATO FIELDS IN THE NEWLY RECLAIMED LAND

Amany M. Rizk

Environmental Studies and Research Institute, El Sadat city ,Minufiya University, Egypt

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ABSTRACT: ***Experiments were carried out at the farm of the Environmental Studies and Research Institute , Minufiya University, at El Sadat area during season 2007and 2008 to investigate the effect of different Trichogramma evanescens West releases alone and its integrated with Bacillus thuringiensis (B.T.) application as biocontrol agents against Phthorimaea operculella (Zeller)in potato fields. Results. indicated that, the 4th early releases of wasps only was the best treatment and most effective comparing with the other tested treatments, whereas gave the lowest mean of (infested tubers ,galleries, produced pupae and emerged moths),(7.25 & 9.75 tubers/200 tubers) , (7.5&10.75galleies), (6.25&8.25pupae), (5.75 & 6.0 moths)as well as the highest mean values of yield (8.96 & 9.15ton/fed.)with lowest yield losses due to infestation (42.75 & 42.67kg/ton), followed by the 3rd early releases of the egg parasitoid Trichogramma plus (B.T.) while the 3rd late releases of the tested parasitoids only seemed to be the weakest one for the same criteria , recorded a relatively high mean of the previous trials , respectively, (24.25 & 26.0 infested tubers/ 200 tubers), (33.0 34.25galleries), (28.25&29.0pupae), (24.25&25.25emerged moths), as well as a relatively low mean values of tuber yield(6.95 & 7.47ton/fed.)with relatively high mean values of yield losses due to infestation (112.75 & 113.0kg/ton) in both 2007 and 2008 , respectively.***

Key words : ***Biological control. Bacillus thuringiensis, Phthorimaea operculella (Zeller), Potato tuber worm,Releases, Trichogramma evanescens West.***

INTRODUCTION

Potato is one of the most important food crop all over the world, it occupied the forth rank after wheat , maize and rice .It is grown in more than 140 countries , every year producing about 309 million tons. Egypt, South Africa , Algeria and Morocco produce more than 80% of all potatoes produced in Africa. In Egypt potato is considered one of the most important exporting vegetable crops , ranks the third among other field crops next to

cotton and rice (Gomaa and Ibrahim 2003). Potato is attacked by numerous insect pest , which reduce yield quantity and quality, the potato tuber worm , *Phthorimaea operculella* (Zeller)(Gelechiidae:Lepidoptera) , is the most destructive insect pest for potato crop which damage both foliage and tubers causing serious in the field and during storage in many countries (Raman and Booth,1983; Von Arx, etAl1987Fenemore 1988: Raman,1988 and Kirkham,1995) . Tunnels conducted in the tubers facilitate the growth of many bacterial and fungal diseases and reduce exportation value .This pest attacks solanaceous crops throughout the year including potato , tomato , pepper and egg-plant in Egypt.

The insecticides application has disrupted the effectiveness of parasitoids, greatly reduced population of predators. To decrease pesticide use in plant protection as well as protect the biodiversity , IPM policies were recently recommended by the Ministry of agriculture specialist in the newly reclaimed land . Biological control is a corner stone in such IPM program . In the field , different control measurements have been used to combat this pest ; planting date , hilling and sowing depth, distance of cultivation , intercropping systems, managing hosts / season, transgenic varieties, varietal resistance, sex pheromone , management and manipulation of levels of irrigation and chemical conventional insecticides (cited from Temerak, 2003), biological control agents as *Bacillus thuringensis* or granulas virus or release of parasitoid were also used (Ali 1991 ; Kurjade and Pokharkar 1997, respectively) .

***Trichogramma evanescens* (West.) were widely used to control different Lepidopteran pests world wide which preserves the endemic natural enemy complex, reduces the need for additional treatments to control secondary pests and reduce the risks to human and environmental pollution that are associated with insecticides(Pimentel et al 1993and Smith 1996).PTM. was controlled by *T. brasilensus* on tomato in Chile (Loo and Aguilera,1983) , by *T. chilonios* on potato field and store in India (Pokkhart and Jogi ,2000)and by T. evanecenesin potatofield in Egypt (Agamy, 2003).**

The present study aims to improve technique for biological control program against PTM using the egg parasitoid *T. evanescens* by choosing the best number of efficient releases separately and integrated with the B.T application to reduce the PTM damage and to increase the yield as well as protection the environmental balance and preservation the biodiversity .

MATERIALS AND METHODS

Field studies:

Experiments were conducted at the farm of the Environmental Studies and Research Institute , Minufiya University, at El Sadat City Minufiya Governorate. An area about one Faddan (4200^{m2}) was selected and divided into six equal parts (about400^{m2} each). Each part contained four plots.

Randomized complete block design with four replicates was followed. Spunt potato variety was planted during season 2007and 2008 as summer plantation. All plots received the recommended agricultural practices .Six treatments were applied for controlling the potato tuber moth on potato crop. Each treatment was separately by 350 meters from the other treatment to prevent migration of the beneficial wasps from the first part to another site .

***T. evanescens* was reared on the grain moth egg, *Sitotroga cerealla* according to the method described by Hassan(1993 and 1995). Produced releasing cards included about 3000 parasitized egg / card. Each card contained 3- age groups, allowing adult emergence of Trichogramma along a period of one week post card installation in the potato field . The first date for wasp releasing occurred after the first PTM trapped by PTM pheromone.**

The cards were distributed at the rate of 40 cards / fed. ,ie. 120,000 parasitoids/ fed./ release. The cards were transported to the field in a cooling box to avoid the harmful effect of heating during transportation .The releasing cards were placed at the plant heart and by 10 meters distances between releases points at 10 days intervals, in the (first, second , third , fourth , and fifth part) of the experiment. The BT bioinsecticide was applied two times before releasing the Trichogramma .

Materials Used:

1-Four releases of the egg parasitoid Trichogramma alone during the first appearance of the potato tuber moth in the field(4^{th} & 2^{nd}March)in 2007 and 2008 respectively , each with (120,000 parasitoids / fed.) as (T1).

2-Three releases of the egg parasitoid Trichogramma alone during the first appearance of the potato tuber moth in the field, each with (120,000 parasitoids / fed.) as (T2).

3- Three releases of the egg parasitoid Trichogramma only, beginning after 10 days from the first PTM appearance in the field., each with (120,000 parasitoids / fed.) as (T3).

4-Protecto:is Protecto (WP) 10%, a commercial product formulation contains $32x10^6$ IU/mg of *Bacillus thuringiensis* Subsp *Kurstak with rate (300 gm/fed)* integrated with three early releases of the egg parasitoid Trichogramma each with (120,000 parasitoids / fed. as (T4).

5- Three releases of the egg parasitoid Trichogramma only, beginning after 10 days from the first PTM appearance in the field , each with (120,000 parasitoids / fed.) combined with B.T. application(protecto) as (T5) .

Plantation date were (4^{th} &2^{nd} January) in both 2007 and 2008 seasons , respectively . Soil type is sandy soil. Volume of spray was 200L /Fed. plot size was about $100^{m2.}$

Assessment:

During harvest 200 tubers were inspected randomized from each treatments (4 replicates / treatments) to count surface hole infestations, as number of infested tubers as well as number of galleries and to assess the relative effect of the treatments on the infestation and produced yield . Tubers were placed on sand inside cages (50 x 50 x 50 cm) to count both the produced pupae and the emerged moths. The obtained results were subjected to the analysis of variance test(ANOVA) and LSD at 5% level probability to compare the differences among means according to Senedcor and Cochran (1973) .The correlation coefficients between the studied treatments and the all tested trials were statistically calculated during two seasons of study. Results were tabulated and illustrated in histogram.

RESULTS AND DISCUSSION

Obtained results in Table (1,2) and Fig. (1,2,3,4,5 and 6) shows the effect of different treatments on the PTM damage at harvest during seasons 2007and 2008.

Degree and intensity of infestation are represented by the mean number of(infested tubers ,galleries , produced pupae and emerged moths)as well as losses of yield due to infestation Kg/ton and the potato tuber yield ton / fed. For the each tested treatments.

Data indicated highly significant differences between the control and the other five studied treatments in both 2007 and 2008 seasons.

According to L.S.D. value for two years, the tested treatments could be arranged according to their efficacy in a descending order as follows, the4th early releases of Trichogramma alone, the 3rd early releases of Trichogramma combined with *Bacillus thuringiensis, both the* early 3rd releases of Trichogramma only and the 3rd late releases of Trichogramma integrated with the BT product and the 3rd late Trichogramma releases alone.

First season:

The 4th releases of Trichogramma alone, each with about 120,000 parasitoids/fed. during the first presence of the PTM in the field were significantly the best treatment and most effective to reduce the PTM damage as well as increase the potato tuber yield ,whereas recorded the lowest mean number of (infested tubers & galleries), (7.25 &7.5),respectively .On the other hand this treatment recorded the highest mean values of the produced potato tuber yield (8.96ton / fed.)with lowest mean values of losses due to infestation (42.75 kg/ton) .The highest yield recorded by this treatment may be due to early foliage protection, increasing the natural role of the egg parasitoids Trichogramma by extensive number of releases, which gave its effect early and continuous up to the end of season.

Table 1

Table 2

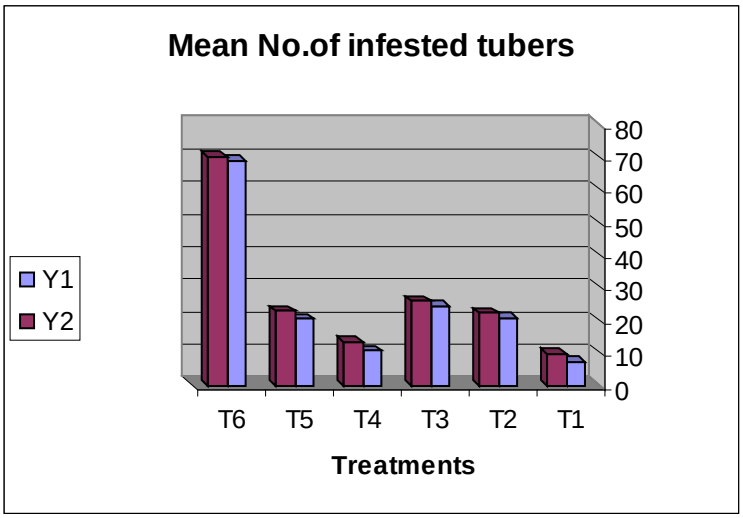

Fig (1) : Mean number of infested tubers based on different *Trichogramma evanescens* West. releases and its integrated with *Bacillus thuringiensis during 2007 - 2008* .

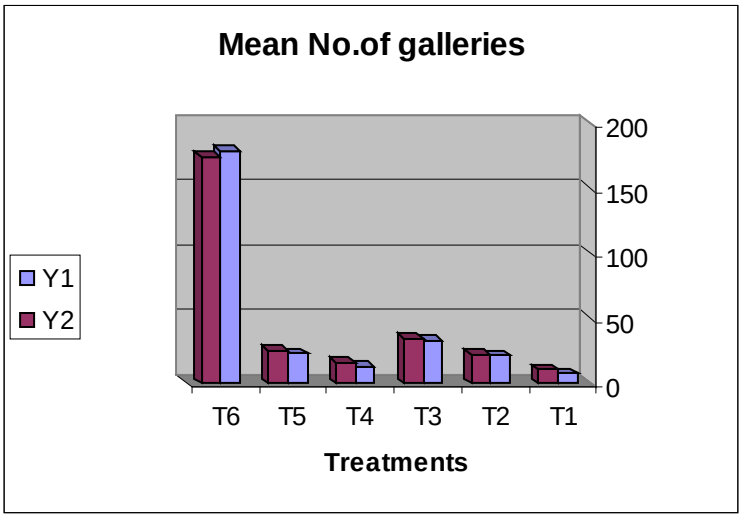

Fig (2) : Mean number of galleries based on different *Trichogramma evanescens* West. releases and its integrated with *Bacillus thuringiensis during 2007 - 2008* .

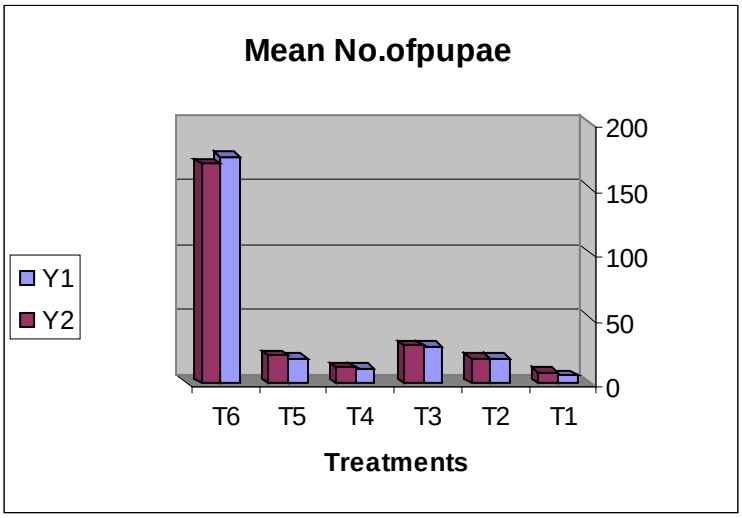

Fig (3) : Mean number of pupae based on different *Trichogramma evanescens* West. releases and its integrated with *Bacillus thuringiensis during 2007 - 2008* .

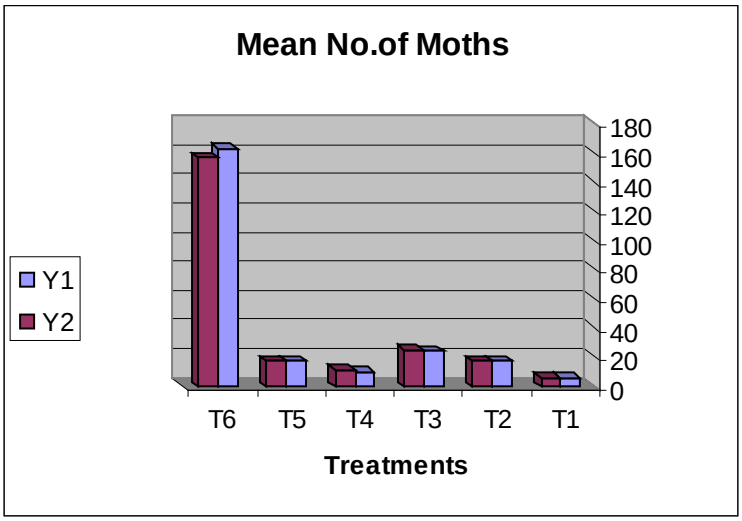

Fig (4) : Mean number of moths based on different *Trichogramma evanescens* West. releases and its integrated with *Bacillus thuringiensis during 2007 - 2008* .

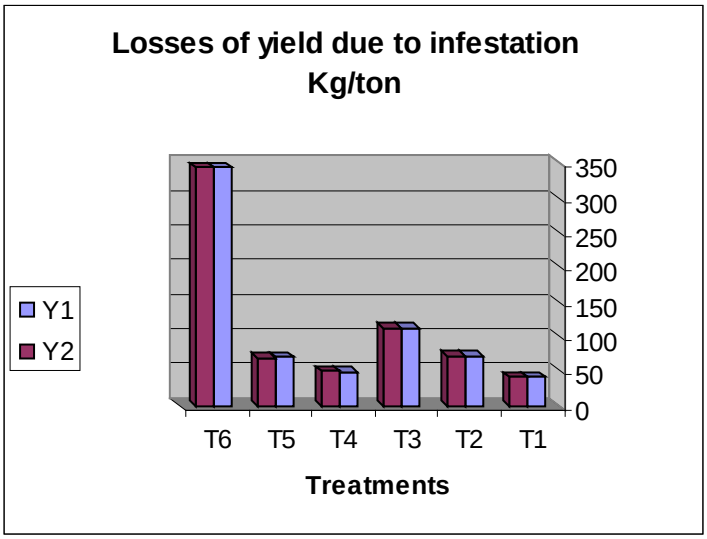

Fig (5) : Mean values of yield losses based on different *Trichogramma evanescens* West. releases and its integrated with *Bacillus thuringiensis during 2007 - 2008* .

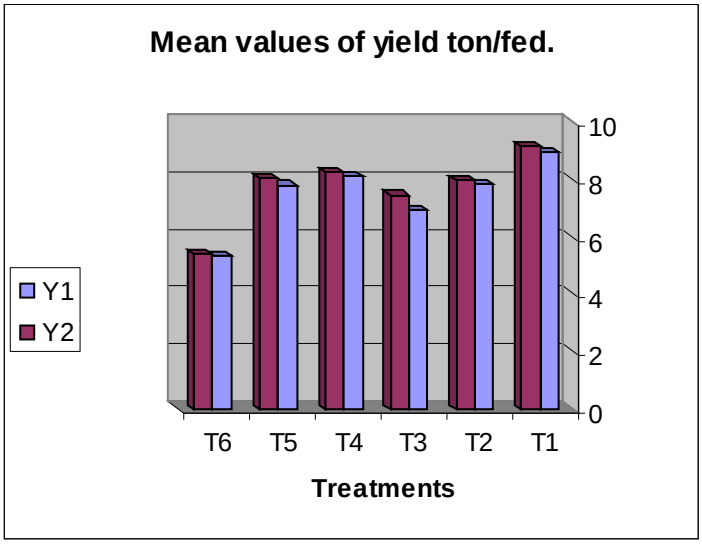

Fig (6) : Mean values of yield based on different *Trichogramma evanescens* West. releases and its integrated with *Bacillus thuringiensis during 2007 - 2008* .

The 3rd early releases of Trichogramma integrated with *B. thuringiensis* recoded the second degree of efficiency after the 4th early releases of the wasp parasitoid only for decreasing the mean number of (infested tubers , galleries)as well as increasing (mean values of the produced potato tuber yield with low mean of yield losses due to infestation).

Additional B.T. with low number (3rd.releases of Trichogramma) seemed to be more successful in reduction PTM infestation by improving the efficiency of the egg parasitoid Trichogramma in this criteria, comparing to the same number of the previous parasitoid releases alone .

The previous results agree with Awad A. Sarhan (2004) who stated that, using the true egg parasitoid Trichogramma combined with the bacterialcide Agerin scored the highest protection against PTM in the store. Also the previous obtained results is in line with Kares, *et al.* (2002), whereas studied the efficiency of *B. thuringiensis* integrated *with* releases of Trichogramma against *Ostrinia nublalis* , and found that the releases of wasp parasitoid combined with *B. thuringiensis was superior to* releases of Trichogramma only for reducing the *O. nublalis* larvae in the field as another lepidopterous insect .

Insignificant differences were detected between the two treatments that received the 3rd early releases of Trichogramma only and that received the 3rd late releases of the previous parasitoids combined with the tested B.T. for the all studied trials, while the3rd late release of Trichogramma alone recorded lowest effect on the pest reduction as gave relatively high mean of (infested tubers & galleries) (24.25 & 33.0), respectively .On the other hand this treatment recorded relatively low mean of the produced tuber yield (6.95ton/fed.) with relatively high losses of infested tuber yield (112.75kg/ton). The previous results agree with Agamy (2003) ,who reported that the three releases of *T . evanescen*s in potato field with moderate level of PTM infestation was more successful in suppressing infestation of produce tuber yield (4.8%) than in heavily infested field (8.84%).

Tuber infestation was expressed as mean number of infested tubers (may it has one or more surface holes), also as number of galleries and furthermore as emerged moths from the harvested tubers, which gave new infestation in the next generation of the pest in the field or storage .

Regarding the produced pupae from the infested tuber ,it is clear from Table (1) and Fig.(3) that all treatments caused considerable reduction in the mean of produced pupae compared to the control. Statistical analysis indicated that the 4th early releases of wasp parasitoids only was the most effective to reduce the mean number of pupae comparing with the other tested treatments whereas gave the lowest mean (6.25) pupae, while the3rd late release of the previous parasitoids alone gave lowest effect, recorded relatively high mean of the produced pupae (28.25).

As for emerged moths as presented in Table (1) and Fig. (4) , it is obvious that the lowest mean of the moths was recorded with the 4th early releases of the wasps alone, whereas gave (5.75) moths followed by the 3rd early releases plus B.T. product, while the 3rd late releases wasp only showed relatively high mean of the moths (24.25)individuals.

Tubers infestation as surface infestation without real galleries or with real galleries, indicated the accumulated effect of the whole season based on the different studied treatments. Also , the emerged moths from that tubers in the best treatment may reflect that this treatment was suitable to make high protection to both foliage and tuber against PTM infestation , so it reduce the new infestation in the next generation of potato tuber moth.

Second season:

Nearly the same results were obtained in season 2008. Results revealed highly significant differences between control and the other studied treatments. Statistical analysis indicated that the 4 th early releases of wasps only was the best treatment and most effective comparing with the other tested treatments, whereas gave the lowest mean of (infested tubers , galleries, pupae and emerged moths), (9.75tubers/200tubers), (10.75galleies), (8.25pupae), (6.0 moths) as well as the highest values of yield (9.15ton/fed.)with lowest losses of infested tuber yield (42.67kg/ton),. however the 3 rd late releases of the tested parasitoids only seemed to be the weakest one for the same criteria , whereas recorded a relatively high mean of the previous trials , respectively,(26.0 infested tubers/200tubers),(34.25 galleries), (29.0 pupae), (25.25 emerged moths), as well as a relatively low mean of yield (7.47ton/fed.)with relatively high values of losses due to infestation (113.0kg/ton).The 3rd early releases of the studied parasitoid combined with the *B.thuringiensis* scored the second degree of efficiency after the early 4 th releases of Trichogramma only in protecting PTM damage for all the previous trials . Insignificant differences were detected between the two plots that received the 3 rd early releases o f Trichogramma only and that received the 3 rd late releases of the previous parasitoids combined with the tested BT for the all studied trials. The previous results is in line with E.A. Agamy (2003), who reported that 3 rd, releases of Trichogramma with 120,000 parasitoids/fed./release in a moderately infested fields decreased potato tuber infestation to 4.8% compared to 8.84% in case of releasing in highly infested fields.

Statistical analysis showed significant positive correlation coefficient between mean number of infested tubers and mean number of (galleries , produced pupae and emerged moths) in both seasons , respectively , whereas recorded (0.98), (0.98), (0.98) for the previous trials , respectively. as well as the mean value of yield losses due to infestation(0.99).On the other hand obtained results found negative correlation coefficient between mean number of infested tuber and the mean values of produced potato tuber yield with (-0.92 & - 0.96) in both 2007 and 2008, respectively.

From the foregoing data and obtained results, it may be conclude that the 4 th early releases of Trichogramma each with 120,000 wasps/fed. only *is the best treatments against P. operculella in the field whereas gave the highest potato tuber protection, recorded the highest mean of the produced tuber yield and reduce the source of potato tuber moth infestation as next generation from the infested tubers as well as* preservation the biodiversity . *and increasing the environmental balance.*

To minimize the negative effects of *P.operculella* in the potato field and produce the highest values of potato tuber yield free from any pesticides residues , the biological control program should start early from the first presence of the PTM with 4th Trichogramma releases. In moderately infested field, the 3 rd releases of the wasp parasitoid each with 120,000 wasps/fed. integrated with *B.thuringiensis may be applied ,* However that treatment achieved relatively significant PTM protection based on the reduction of (infested tubers , galleries , produced pupae ,emerged moths) as well as increasing the produced tuber yield .

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تقييم اطلاقات مختلفة من طفيل التريكوجراما *Trichogramma evanescens* و المركب البكتيري كأداة لإدارة التحكم لمكافحة فراشة درنات البطاطس في حقول البطاطس بالأراضي المستصلحة حديثا

أماني محمد رزق

معهد الدراسات والبحوث البيئية – جامعة المنوفية – مدينة السادات

الملخص العربي

أجريت الدراسة بحقول ومعامل معهد الدراسات والبحوث البيئية بمدينة السادات – جامعة المنوفية بجمهورية مصر العربية و ذلك خلال موسمين زراعيين ٢٠٠٧ ،٢٠٠٨ لدراسة التأثيرات المختلفة لعدة اطلاقات من طفيل التريكو جراما منفردة ومع المركب البكتيري بروتكتو كعوامل مكافحة حيوية لفراشة درنات البطاطس فى حقول البطاطس بالأراضي المستصلحة حديثا وأظهرت النتائج ما يلى :

١ – أفضل المعاملات هي أربع اطلاقات مبكرة و منفردة من طفيل التريكو جراما حيث سجلت أقل متوسط إصابة في الصفات تحت الدراسة وهى عدد الدرنات المصابة ، عدد الأنفاق ، عدد العذارى ، عدد الفراشات المنبثقة (٧.٢٥ ، ٩.٧) درنة مصابة / ٢٠٠ درنة – (٧.٥ ، ١٠.٧٥) نفق (٦.٢٥ ، ٨.٢٥) عذراء- (٥.٧٥ ، ٦.٠) فراشة فى كلا موسمي الدراسة على التوالي . كما أنها أظهرت أفضل متوسط لمحصول الدرنات الناتج (٨.٩٦ ،٩.١٥) طن للفدان بأقل نسبة من الفقد الراجع للإصابة، (٤٢.٧٥ ، ٤٢.٦٧) كجم للطن فى كلا موسمي الدراسة على التوالي .

٢ – أوضحت النتائج أن ثلاث اطلاقات مبكرة من طفيل الترايكوجراما بالإضافة للمركب الحيوي بروتكتو جاءت في المرتبة الثانية بعد أربع اطلاقات مبكرة و منفردة من الترايكوجراما كوسيلة فعالة لتقليل الإصابة بالآفة تحت الدراسة و إعطاء محصول مرتفع معنويا مقارنة بباقي المعاملات المختبرة .

٣- أضعف المعاملات المختبرة تأثيرا هي ثلاث اطلاقات متأخرة ومنفردة من الطفيل حيث أعطت متوسطات عالية نسبيا للصفات السابقة في كلا الموسمين علي التوالي (٢٤.٢٥ ، ٢٦.٠)

درنـة مصـابة /٢٠٠ درنـة- (٣٣.٠٨، ٣٤.٢٥) نفـق- (٢٨.٢٥ ، ٢٩.٠) عـذراء – (٢٤.٢٥ ، ٢٥.٢٥) فراشــة كمــا أظهــرت قــيم منخفضــة نســبيا مــن المحصــول (٦.٩٥ ،٧.٤٧) طن/ فدان بمتوسط مرتفـع نسـبيا من الفقد الراجـع للإصـابة (١١٢.٧٥ ،١١٣.٠٠) كجم/طن

لذا توصي الدراسة بضرورة تطبيق برامج المكافحة الحيوية مبكرا (مع بداية ظهور أول فراشة في الحقل) باستخدام أربعة اطلاقات من طفيل البيض التراكوجراما بمعدل (١٢٠٠٠٠ طفيل/ فدان) و ذلك لتقليل التأثير السلبي لفراشة درنات البطاطس في الحقل و الحصول علي أعلي نسبة من المحصول الخالي من أي متبقيات للمبيدات .

كذلك توصي الدراسة باستخدام ثلاث اطلاقات من طفيل البيض التراكوجراما بمعدل (١٢٠٠٠٠ طفيل/ فدان) مع رشتين من المركب الحيوي بروتكتو في حالة الإصابة المتوسطة للآفة في الحقل للحصول علي قيم مرتفعة نسبيا من المحصول.