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Efficacy of Certain Chemical, Safe Alternative Compounds, and Egg Parasitoid *Trichogramma evanescens* Treatments for Controlling *Pieris rapae* on Cabbage Cultivation at Assiut Governorate, Egypt

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ABSTRACT

Cabbage plantations suffer greatly from infestations of the small white butterfly (*Pieris rapae*), resulting in substantial financial harm to growers. Therefore, a comparative field study in Assiut, Upper Egypt, assessed various control strategies for *Pieris rapae* infestation on cabbage, focusing on the potential of the biological control agent *Trichogramma evanescens* "Westwood" against chemical and safe alternative compounds. Results assessed the reduction in infested cabbage plants at 5, 10, and 15 days after applying one chemical and three safe alternatives. Malathion 57% demonstrated the highest efficacy, reducing infested plants by 62.96% after 15 days. Naterlo oil, KZ oil, and Ashock showed reductions of 27.37%, 26.96%, and 18.31%, respectively. In parallel, *T. evanescens* releases proved effective, lowering infestation by 41.69% (2 releases), 44.58% (3 releases), and 50.84% (4 releases). Critically, four releases of *T. evanescens* proved more effective than any biologically safe alternative compounds. These findings strongly advocate using four releases of *T. evanescens* as a new, effective, and environmentally friendly biological control tactic for *P. rapae* management in cabbage cultivation, providing a required alternative to traditional chemical insecticides.

INTRODUCTION

Cabbage (*Brassica oleracea var. capitata* L.) (Brassicales: Brassicaceae) is a globally significant vegetable, prized for its nutritional and medicinal value, including vitamins, minerals, antioxidants, and potential anti-cancer compounds like sulforaphane (Sain *et al*., 2017; Rathod *et al*., 2020; Ray *et al*., 2018; Ashfaq *et al*., 2020; Patra *et al*., 2024). In 2020, it was the fourth largest vegetable crop globally, contributing approximately 6% of total production (FAO, 2022). However, its high nutritional content makes it susceptible to various phytophagous insects, leading to substantial economic losses. Among these, the small white cabbage butterfly, *Pieris rapae* (Linnaeus, 1758) (Lepidoptera: Pieridae), is a major cruciferous pest. Its high reproductive rate, wide temperature tolerance, covert larval feeding, and resistance to chemical pesticides make its control challenging (Aioub *et al*., 2021).

Sustainable and effective alternative control methods are crucial. *Trichogramma* wasps (Hymenoptera: Trichogrammatidae) offer an ecologically sound biological control strategy. Their effectiveness has been demonstrated against *Helicoverpa* sp. on various crops in India (Krishnamoorthy, 2012) and against *Erinnyis ello* (L.) on cassava in Brazil (Soares *et al*., 2014). Recent field trials in Giza, Egypt, showed that combining *Bacillus thuringiensis* or botanical extracts with *Trichogramma evanescens* releases significantly reduced *P. rapae* populations on cauliflower, outperforming standalone treatments and synthetic insecticides (Siam and El-Kholy, 2023). Similarly, in Assiut Governorate, Egypt, Mohamed *et al*. (2016) evaluated the effectiveness of releasing the egg parasitoid, *Trichogrammatoidea bactrae*, against pink (PBW) *Pectinophora gossypiella* (Saunders, 1844) (Lepidoptera: Gelechiidae) and spiny bollworms (SBW) *Earias insulana* (Boisduval, 1833) (Lepidoptera: Nolidae) in cotton. They tested different release timings (flowering and boll formation) and rates (one to four releases). For fresh market cabbage, stringent quality demands often lead to pest management relying on low thresholds or weekly chemical sprays (Su *et al*., 2017). However, there's a shift towards a threshold-based approach, where treatments are applied only when pest numbers or crop damage reach economically damaging levels, optimizing pesticide use through strategic monitoring and timing (Wright *et al*., 2013). However, information on *Trichogramma* use by cabbage producers is scarce. Previous research by Abdel-Galil *et al*. (2019) compared the potency of certain chemical and safe alternative compounds in reducing *P. rapae* larval populations. Building upon this, the current study aimed to compare the effectiveness of chemical compounds, safe alternative compounds, and the biological control agent *Trichogramma evanescens* against *P. rapae* infestations on cabbage plantations in Assiut, Upper Egypt.

MATERIALS AND METHODS

1-Experimental Site:

Experiments were conducted on a private farm in the El-Fath district during the 2024 cabbage growing season using the Sabeny cabbage cultivar. The experimental area spanned approximately 1100m², with individual plots measuring 10.5m². Cabbage seeds were grown in a greenhouse on May 1st. One month later, on July 1st, the seedlings were transplanted to the sustainable farm with a 50 cm spacing between plants. The sustainable farm was divided into two distinct areas for different experimental objectives:

Area 1, was dedicated to evaluating the effectiveness of various compounds in suppressing *Pieris rapae* larval infestation in cabbage.

Area 2, was used to assess the efficacy of releasing the egg parasitoid, *Trichogramma evanescens*, to control *P. rapae* larval infestation. This area was located 100 meters away from both the insect release zone and the untreated control area.

2-Potency of the Tested Chemical and Safe Alternative Compounds to Reduce *Pieris rapae* Infestation:

Insecticide applications began on cabbage heads when the infestation surpassed a threshold of 0.3 larvae per plant, as established by Cartwright *et al*. (1987), two months post-transplantation. To assess the reduction in infested heads, four cabbage plants were visually inspected per replicate (four replicates plus controls). Replicates were arranged in a completely randomized block design. The average number of infested heads was tallied before spraying with the chosen compounds (Table 1), and then again 5, 10, and 15days after application. The percentage reduction of infested cabbage heads was determined using the Henderson and Tilton (1955) equation.

3-Potency of *Trichogramma evanescens* to Reduce *Pieris rapae* Infestation:

3.1-Rearing of *Trichogramma evanescens*:

The egg parasitoid *T. evanescens* was acquired from the Center of Bio-organic Agricultural Services (CBAS) in Assiut. It was mass-reared in a laboratory by using eggs of the Angoumois grain moth, *Sitotroga cerealella*. For the preparation of egg parasitoid cards, *S. cerealella* eggs were adhered to 10 x 15cm white paper cards. These cards were then exposed to adult parasitoids for 24hr. to mitigate super-parasitism. Following this exposure, the cards were removed and kept refrigerated until their application. Before releasing the egg parasitoids, the colony was incubated under controlled conditions of 25±10 °C and 60±10% relative humidity.

3.2-Release of *Trichogramma evanescens* in the Field:

Egg parasitoids were released into the experimental plots at a rate of approximately 48,000 parasitoid individuals per 4200m². These parasitoids were housed in thick paper envelopes (5x8cm) to safeguard them against predators and adverse weather conditions. To keep labor costs down, each envelope, containing three 1x1cm strips of parasitized eggs in various developmental stages, was manually attached to cabbage leaves at a height of about 50cm from the ground, as detailed by Abd El-Rahman *et al*. (2008). Releases were strategically conducted in the late afternoon to mitigate the impact of heat.

Subsequent monitoring occurred from July to September over eight weeks. Every ten days, 40 randomly chosen green cabbage heads from each plot (treated and control) underwent visual examination. The head infestation rate was calculated by comparing it to the control plots. The percentage of *P. rapae* infestation was determined through visual observations. Notably, infestation records were based on the presence of injury symptoms, even if larvae were not observed, following the equation provided by Mohamed *et al*. (2016):

$$\text{Infestation\%} = \frac{\text{Number of infested cabbage plants/plot}}{\text{Total number of cabbage plants/plot}} \times 100$$

To assess the parasitoid's effect, it counted the mean number of infested cabbage heads before its release and then at regular intervals (10, 20, 30, 40, and 50 days) after application. The reduction percentage of infested heads was calculated based on the Henderson and Tilton (1955) equation. For statistical analysis, data were subjected to the F-test, and mean comparisons were made using Duncan's multiple-range test, as described by Steel and Torrie (1980).

Table1. Trade and common names and using rates of the tested compounds.

Common name	Trade name	Using rate
Malathion 57%	Malathion 57% (non-effective material) 43%	1 L/400 Letter water
Ashock 0.15%	Azaderaktin 0.15% (non-effective material 99.85%)	100 ml/100 Letter water
Naterlo 93% (Natural oil)	Soybean oil 93% (non-effective material 7%)	125 ml/100 letter water
KZ oil 95%	Natural oil	1 L/100 Letter water

RESULTS

1-Potency of the Tested Chemical And Safe Alternative Compounds To Reduce *Pieris rapae* Infestation:

Figure (1) and Table (2), present data on the effectiveness of various compounds in reducing white butterfly (*Pieris rapae*) infestation in cabbage plants during the 2024 growing season in the Assiut region. Potency of these compounds was evaluated in the field 5, 10, and 15days after application, with results expressed as mean and general mean percentage reductions in infested cabbage plants.

Figure (2) shows that Malathion 57% was the most effective compound, reducing infested cabbage plants by 71.90% after 15 days and ranking first among the tested compounds. It was followed by Naterlo oil, KZ oil, and Ashock, which reduced infestation by 30.13%, 28.97%, and 18.78%, respectively. Table 2 also indicates a highly significant variation (f = 136.647**) in the effectiveness among the tested compounds.

Table 2: Efficacy of Compounds on *Pieris rapae* Infestation: General Mean Percentage ±SD, with Statistical Analysis

Compound	General Mean Percentage ±SD
Malathion 57%	3.08±2.56A
Ashock	6.42±2.02C
Naterlo oil	7.67±1.53B
KZ oil	8.42±2.01B
F value between treatments	136.647**
LSD	6.53

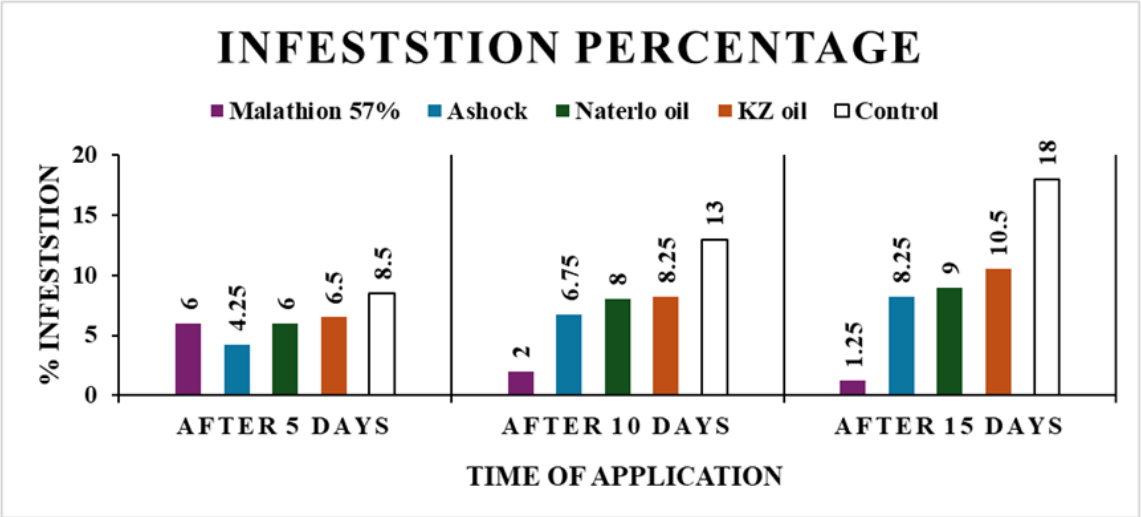

Fig. 1: Infestation Percentage of Cabbage After Application of Different Treatments Over Time (5, 10, and 15Days).

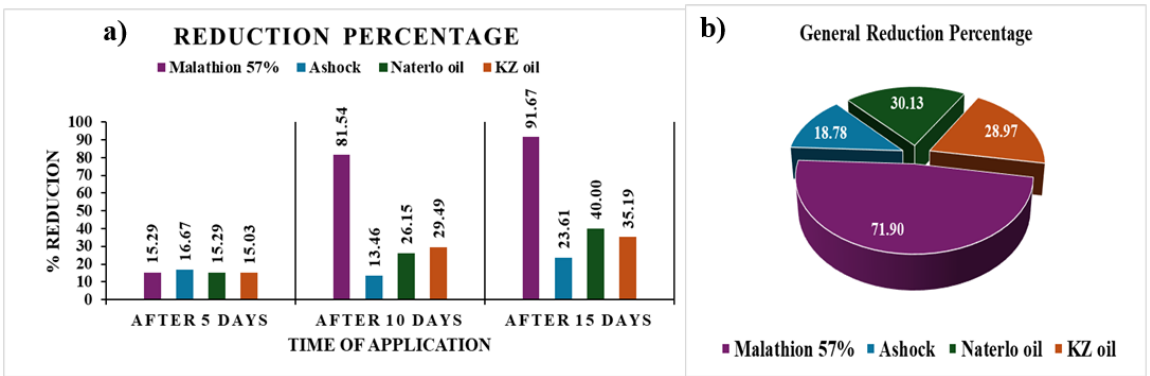

Fig. 2: Comparative Reduction of Cabbage Achieved by Chemical and Alternative Compounds Over Time (5, 10, and 15 Days). **a**) Reduction Percentages **b**) General Reduction Percentages**.**

2-Potency of *Trichogramma evanescens* to Reduce *Pieris rapae* Infestation:

In the 2024 cabbage growing season in Assiut, releasing *Trichogramma evanescens* proved to be a potent method for reducing white butterfly (*Pieris rapae*) infestations. As detailed in Figure (3) and Table (3), the percentage of infested cabbage plants significantly decreased with more releases. Two releases of *T. evanescens* reduced infestation by 41.69%, while three releases resulted in a 44.58% reduction, and four releases achieved the highest reduction at 50.84% (Fig. 4). Table (3) further highlights the significant differences (f=21.813**) in efficacy among the various release strategies.

Table 3: Efficacy of *Trichogramma evanescens* releases on infestation: General Mean Percentage ±SD, with Statistical Analysis.

No. of Releases	General Mean Percentage ±SD
2 releases	14.33±1.44C
3 releases	13.9±1.44B
4 releases	12.08±1.58A
F value	21.813**
LSD	4.76

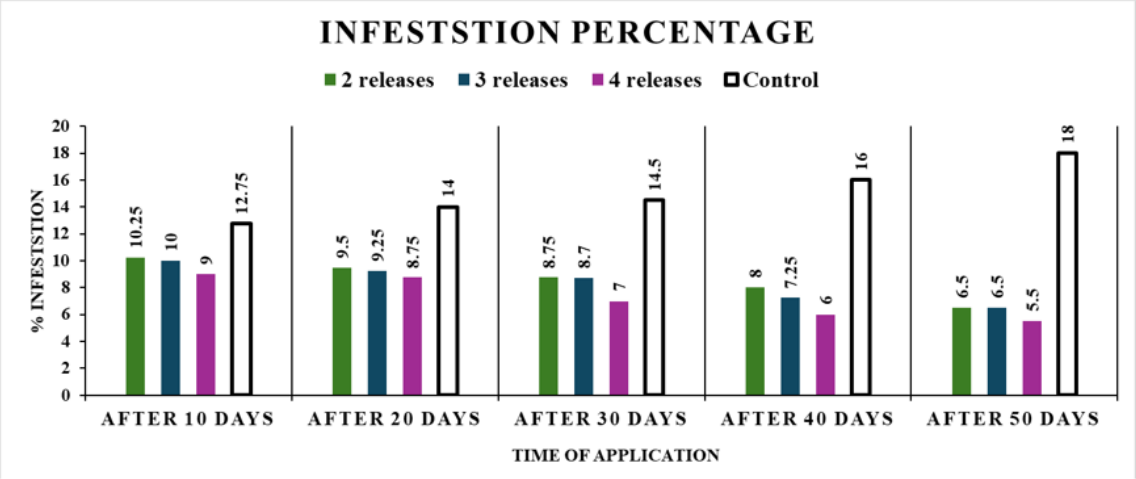

Fig. 3: Infestation Percentage After Varying Numbers of *Trichogramma evanescens* Releases (2, 3, 4) Over Time (10, 20, 30, 40, and 50Days).

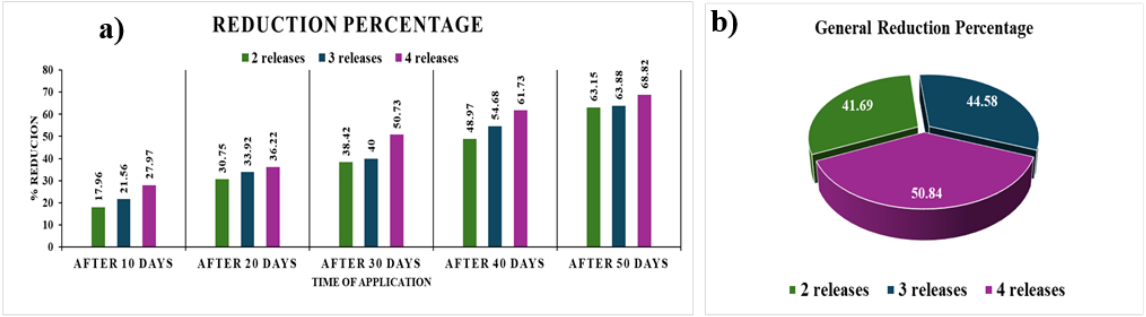

Fig. 4: Comparative Reduction of Cabbage Achieved by Varying *Trichogramma evanescens* Release Numbers (2, 3, 4) Over Time (10, 20, 30, 40, and 50 Days).
a) Reduction Percentages b) General Reduction Percentages.

DISCUSSION

The small white butterfly, *Pieris rapae* (L.), presents a significant global challenge to cabbage cultivation, including in Egypt, often requiring intensive control. However, the conventional reliance on synthetic chemical insecticides is increasingly problematic due to rising concerns over environmental pollution, undesirable pesticide residues in food, and the accelerated development of pest resistance (Aioub *et al*., 2021; Siam and El-Kholy, 2023). The growing awareness has spurred a global shift towards more sustainable and eco-friendly pest management strategies, emphasizing the integration of various control methods challenges.

In response to these challenges, the present work aimed to conduct a comprehensive comparative study to evaluate the effectiveness of different pest management tactics against *Pieris rapae* on cabbage plantations in Assiut, Northern Upper Egypt. So, concerning results of the chemical insecticide Malathion 57% demonstrated the highest efficacy among the tested compounds, achieving a substantial 71.90% reduction in *P. rapae* infestation after 15 days of application. This rapid and strong performance is consistent with the known potency of synthetic insecticides. However, the use of chemical compounds raises concerns regarding environmental impact, residue accumulation, and the potential for pest resistance, as highlighted by several authors including Li *et al*. (1999), Aioub *et al*. (2021), Siam and El-Kholy, (2023).

Conversely, the safe alternative compounds, Naterlo oil, KZ oil, and Ashock, showed moderate reduction percentages of 30.13%, 28.97%, and 18.78%, respectively. While these reductions are lower than that of Malathion, their appeal lies in their reduced environmental risk and potential for use in organic farming systems. It is important to note that the chemical compound reduced the percentage of the infested cabbage plants by 2.38, 2.48, and 3.83fold of that obtained by Naterlo oil, KZ oil, and Ashock, respectively. The present results are also in agreement with previous results by Abdel-Galil *et al*. (2019). Results emphasized that chemical compounds provided higher initial reductions. Certain safe alternatives (like Karate® Zeon and Evure®) still offered desirable control levels. The observed significant variations ($f = 136.647^{**}$) among the tested chemical and alternative compounds underscore the importance of selecting effective and environmentally friendly options for pest management. Data from the present work suggested that for sustained control and minimizing chemical reliance, multiple applications of these safe alternatives might be more desirable, though this would require further investigation into optimal application frequencies.

Trichogramma wasps are well-recognized egg parasitoids and crucial components of biological control programs globally, offering an environmentally sound and sustainable solution (Krishnamoorthy, 2012; Soares *et al*., 2014).

Concerning the results of using *T. evanescens*, as a biological control agent proved to be an increasingly effective tool against *P. rapae* with successive releases. While two releases resulted in a 41.69% reduction and three releases yielded 44.58%, four releases significantly boosted efficacy to 50.84%. This dose-dependent response indicates that a higher frequency of parasitoid release can lead to more substantial pest suppression. The observed highly significant variations ($f= 21.813^{**}$) among different release frequencies further support this finding. Specifically, the 4-release strategy yielded a 1.21fold greater reduction than two releases and a 1.14fold greater reduction than three releases. A critical finding of the present study is that four releases of *T. evanescens* (50.84% reduction) were more effective than all tested safe alternative compounds (Naterlo oil: 30.13%, KZ oil: 28.97%, Ashock: 18.78%). This highlights the potential of biological control as a superior alternative to some eco-friendly compounds for *P. rapae* management. In agreement with

the recent field trials in Giza, Egypt, by Siam and El-Kholy (2023) demonstrated that releases of *T. evanescens* significantly reduced *P. rapae* populations on cauliflower, proving more effective than standalone treatments and synthetic insecticides. The sustained effectiveness of *Trichogramma* in maintaining pest densities below economic thresholds, as observed in other Egyptian studies (Abd El-Hafez and Nada 2000; Mesbah *et al*., 2003; Khidr *et al*., 2003; Saad *et al*., 2015), further reinforces its viability. This study indicated that the four releases of *T. evanescens* as a new, effective biological control tactic for *P. rapae* in cabbage, offering a sustainable alternative to chemical compounds. This contributes to developing integrated pest management strategies that balance agricultural productivity with environmental stewardship.

Conclusion

It is of interest to point herein that, while Malathion provided immediate and high levels of reduction, this strongly advocates for the adoption of biological control with *T. evanescens* as a primary and sustainable method for managing *P. rapae* on cabbage in Assiut. Specifically, cabbage growers implement four releases of *T. evanescens*. This approach offers a new, effective, and environmentally acceptable biological control tactic, serving as a viable and desirable replacement for conventional chemical compounds, thereby contributing to more sustainable agricultural practices in the region.

Declarations

Ethical Approval: This study has been granted by the Research Ethics Committee of Faculty of Agriculture at Assiut University in accordance with Egyptian laws and university guidelines for the care of animals (approval no. 03-2025-0033).

Competing Interests: The authors declare that they have no competing interests.

Authors' Contributions: GNA, SMAA, and SEM did the conceptualization. GNA, SMAA, and SEM contributed to the formal analysis. GNA, SMAA, and SEM took part in the investigation. SMAA wrote the original draft. GNA and SEM did the writing–review and approved the final manuscript. All authors read and approved the final manuscript.

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Availability of Data and Materials: All datasets analyzed and described during the present study are available.

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ARABIC SUMMARY

فاعلية بعض المركبات الكيميائية والبدائل الأمنة والمعاملات بطفيل البيض *Trichogramma evanescens* في مكافحة *Pieris rapae* على زراعات الكرنب بمحافظة أسيوط ، مصر

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تتأثر زراعة الكرنب بشدة من تفشي أبى الدقيق الكرنب الصغير(*Pieris rapae*) ، مما يؤدي إلى أضرار مالية جسيمة للمزارعين. لذلك، أجرت دراسة حقلية مقارنة في أسيوط، صعيد مصر، لتقييم استراتيجيات مكافحة مختلفة لتفشي أبى الدقيق الكرنب على محاصيل الكرنب، مع التركيز على إمكانات استخدام عنصر المكافحة الحيوية طفيل البيض الترايكوجراما مقارنةً بالمركبات الكيميائية والبدائل الآمنة. قيّمت نتائج نسب الخفض في رؤوس الكرنب المصابة بعد 5 و10 و15 يومًا من تطبيق المركب كيميائي وثلاثة بدائل آمنة. أظهر الملاثيون 57% أعلى كفاءة، مُخفضًا النباتات المصابة بنسبة 71.90% بعد 15 يومًا. بينما أظهرت أستخدام المركبات الأمنة ناترلو و كزد أويل و أشوك انخفاضاً بنسب بلغت 30.13%، و28.97%، و18.78% على التوالي. بالموازاة، أثبتت إطلاقات *T. evanescens* فعاليتها، مُخفضةً الإصابة بنسبة 41.69% (إطلاقان)، و44.58% (3 إطلاقات)، و50.84% (4 إطلاقات). وقد ثبت أن أربعة إطلاقات من *T. evanescens* كانت أكثر فعالية من أي بدائل حيوية آمنة أخرى. تدعم هذه النتائج بقوة استخدام أربعة إطلاقات من *T. evanescens* كتكتيك جديد وفعال وصديق للبيئة للمكافحة الحيوية لأبى الدقيق الكرنب،ُوفِّرًا بديلًا ضروريًا للمبيدات الحشرية الكيميائية التقليدية.

الكلمات الدالة: تريكوجراماتيدى، بيرليدى، الكرنب، نسب الخفض.