RESEARCH ARTICLE OPEN ACCESS

NEW VALLEY JOURNAL OF AGRICULTURAL SCIENCE
Published by Faculty of Agriculture, New Valley University, Egypt

Print ISSN 2805-2420 Online ISSN 2805-2439

10.21608/NVJAS.2024.299620.1289

Toxicity and morphological changes induced by diatomaceous earth and malathion against *Tribolium castaneum*

Alzahraa Abdelaty Elmadawy[1], Doaa Mohamed El-Talpanty[1], Mostafa El-Ebiary[1], Tamer Ismail[2], Ahmed Fayez Omar[2]

[1]Department of Stored Product Pests Research, Sakha Station, Plant Protection Research Institute, Agricultural Research Centre, Giza, Egypt
[2]Pesticide Chemistry and Toxicology Department, Agriculture Faculty, Kafrelsheikh University, Kafrelsheikh, Egypt

* Corresponding author

Elmadawy, A. A.

Received: 26/06/2024

Revised: 07/07/2024

Accepted: 09/07/2024

Published: 15/07/2024

Abstract

Tribolium castaneum is a secondary destructive insect which causes significant damage to grains. In this study we evaluate the insecticidal activity of diatomaceous earth (DE) and malathion against this insect and its offspring. Also, the morphological effects of these materials on adult and larvae were studied using scanning electron microscopy (SEM). The results showed that malathion had higher toxicity than diatomaceous earth by comparing their LC50 values over exposure periods. DE and malathion significantly reduced the progeny production of the target insect by 2.4 to 95.8 % and 12.6 to 57.4 % for malathion and DE, respectively. SEM analysis revealed external morphological alterations. Firstly, adult treated with DE had particles stuck to the mouth parts and abdominal end, and the sensilla of the treated area was damaged. In addition, the abdominal end (ovipositor tip) of both treatments appears enlarged and prominent. Secondly, for larvae DE and malathion treatments make (maxillary palp, labial palp) of the mouth parts and the abdominal end in shrinking shape. Also, spiracles and thorax segments appear shrunken and losing of spiracles hairs. Overall, DE causes physical damage observable by SEM. DE is a promising alternative to pesticides due to its insecticidal activity as well as its relative safety to human and environment so, it can be used as natural pesticides in stored product pest control.

Keywords: *Tribolium castaneum*, scanning electron microscopy (SEM), Diatomaceous earth (DE), malathion

Introduction

The rapid increase in population, coupled with post-harvest losses of pulses and grain crops as the result of insect attacks may threaten food security by the year 2050 if food production does not increase by 70% according to FAO report. Insect infestation alone can result in losses ranging from 5 to 30% of the world's stored food grains production (**Prusky 2011**).

Insects can cause damage to grains and pulses two ways directly by consuming the kernels, and indirectly, through a loss of food quality by making the grain unsuitable for human consumption. (**Rajashekar et al 2012**). One of the most common reasons for damaging grain is due to stored-product insect infestations either to whole grain or their products (**Mason and McDonough 2012**). Among the stored products insects which cause damage to stored products is the red flour beetle, *Tribolium castaneum* (Herbst), a destructive secondary insect belonging to (Coleoptera: Tenebrionidae), both adult and larvae cause damage to stored products by converting grains into powder (**Mariadoss and Umamaheswari, 2020; Suleiman and Rosentrater 2022**). It is considered a dangerous insect pest that causes significant economic losses during wheat storage (**Campbell et al 2022**). The use of synthetic insecticides is a common way to control stored product pests (**Donahaye, 2000**). The use of insecticides such as organophosphates or pyrethroids is widespread worldwide and considered the major tool for controlling stored products pest in storage units, alongside the use of phosphine as a fumigant (**Ortega et al. 2021; Wakil et al., 2024**).

However, overuse of insecticides is effective but toxic resulting in low-quality food, their residues affecting humans, non-target organisms, and the environment . In addition to the development of resistance towards insecticides. So, there is an urgent need to find alternative safe ways to control stored-product insect infestations to prevent grain loss and increase consumer safety. Recently, scientists have made significant efforts to utilize natural products in pest control instead of pesticides. Some studies demonstrated the effectiveness of diatomaceous earth against a wide range of stored-product insect species (**Vayias 2009, Arthur 2004**). Inert dust based on natural substances such as diatomaceous earth originating from the fossils of unicellular algae (**Losic and Korunic 2018**) is promising alternative formulation against numerous stored-product insect species in many parts of the world (**Agrafioti et al 2023).** Adults of the red flour beetle, *T. castaneum* and *Tribolium confusum* are considered to be the least susceptible beetle species to different DE formulations as mentioned by **Athanassiou et al. (2004)** reported that three different doses of diatomaceous earth (DE) showed high mortality levels against adults of the red flour beetle, *T. castaneum* and *T. confusum* even at the lowest dose rate. On the other side, most beetle larvae are expected to be more susceptible than adults as reported by (**Athanassiou and Arthur 2018**) in larvae of the confused flour beetle, *T.confusum*. **Romei and Schilman (2024)** reported that one of the three major ways of losing insect water typically is through their body surface area or cuticle (water loss by simple diffusion through their epidermis). So (DEs) mode of action may occur through its physical properties by scratching the cuticle (wax layer) of the insect enhancing the insect's dehydration or desiccation effect. In addition, it has. low mammalian toxicity, long active, stable and easy to eliminate from the bulk density of the grain **(Losic and Korunic 2018; Romei and Schilman 2024).**

This study aims to investigate the insecticidal effectiveness of diatomaceous earth (DE) comparing to malathion as a recommended insecticide upon the red flour beetle, *T. castaneum* adult and larvae. Also, toxicological effects of treated insects have been examined by Scanning Electron Microscopy (SEM) to understand the mode of action.

Material and methods

Insects

In this study, adults of *T. castaneum* were taken from a culture that was kept on wheat flour plus 5% brewer's yeast (by weight) at 28℃, 65±5 % RH. The adults used for all bioassays were <14 days old and mixed sexes.

Tested materials

Diatomaceous earth (Celatom®, purchased from EP Minerals, a U.S. Silica company) and malathion (Malason® 1% D from KZ company).

Toxicity of diatomaceous earth and malathion on *Tribolium castaneum.*

Laboratory bioassay tests were carried out to evaluate the insecticidal efficacy of DE and malathion against 10 adults of *T. castaneum* at 28 °C and 65 ,75% RH. Ten grams of crushed wheat were treated with four dose rates: 500, 1000, 1500, and 2000 mg of DE and 50, 100, 200, and 400 mg for malathion per one kg of grains and untreated jars served as controls. The treatments were conducted in 350 ml glass jars with three replicates for each. The jars were covered with their caps and manually shaken to ensure that the contents were evenly distributed and placed in incubators (**Delgarm et al., 2020**). Mortality percentages were calculated after 1, 2 and 3 days of exposure. The LC_{50} values were calculated based on Finney's method of probit analysis (**Finney, 1971**).

Progeny reduction

After treating the grains with DE and malathion as mentioned before, all insects, both dead and live, were removed at the end of the experiment. The grains were then kept under the same experimental conditions until the emergence of F_1 progeny. The reduction percentage in adult emergence of F_1 progeny (called inhibition rate IR %) was calculated by following equation:

% IR= (C-T) /C *100. Where C is the number of newly emerged insects in the untreated jar and T is the number of insects in the treated jar (**Tapondjou et al, 2002**).

Scanning Electron Microscopy (SEM)

In this experiment, 20 g of crushed wheat were treated with LC_{50} values of each treatment, and the experiment was conducted under the same conditions as previously described. Fifteen days post treatment all introduced insects were removed and the treated grains were kept until emergence. The larvae and adults that emerged from these treatments were used for SEM to examine their extrinsic variations resulting from DE and malathion treatment.

Small pieces of fresh specimens of *T. castaneum* were removed and fixed by immersing them immediately in 4F1G (fixative, phosphate buffer solution) pH=1.4 at °C for 3 h. The specimens were then postfixed in 2% OsO_4 in the same buffer at 4°C for 2 h. Samples were washed in the buffer and dehydrated at 4°C through a graded series of ethanol (e.g., 70%, 80%, 90%, 95%, 100%). Samples of insects were dried using the critical point method, mounted using carbon paste on an AL-stub and coated with gold up to a thickness of 400 A in a sputter-coating unit (JFC-1100E). Observations of *T. castaneum* morphology in coded specimens were performed in a Jeol JSM-5300 SEM operated between 15 and 20 KeV (**Tahmasebi et al. 2015**).

Statistical Analysis:

The experiments were performed in triplicate, and the data presented are the mean ± SE. The results were analyzed by one-way analysis of variance ANOVA using Duncan (1955). P values of ≤0. 05 were considered significant. LC_{50} (the lethal concentration for 50% mortality) was determined by log-probit analysis, and the data were analyzed by determining chi-square values and degrees of freedom, using SPSS. The analysis of data was performed with SPSS program version 24.0 for Windows (SPSS Inc., IBM Corp.)

Results

Toxicity assessment

The bioassay results of both DE and malathion demonstrated the insecticidal efficiency against the target insect, *T. castaneum*, over three exposure periods (1, 2 and 3 days). Table 1 shows that malathion was superior to DE based on LC_{50} values. as a lower LC50 value indicates higher potency. In this case, malathion's LC50 values (2761.8, 200.3 and 116.7 mg/kg grain) were lower than those of DE (3430.5, 1957.5 and 1215.3 mg/kg grain) after 1, 2 and 3 days of exposure, respectively.

Table (1): Lethal concentrations of diatomaceous earth and malathion against *Tribolium castaneum* over three exposure periods.

	Time (d)	LC_{50} Value (mg/Kg grain)	Confidence Intervals 95 %		Slope value	Chi-Square (X^2)
			Lower	Upper		
DE	**1 d**	3430.5	2161.7	4218.9	2.03	1.23
	2 d	1957.5	1458.6	4117.0	2.03	5.02
	3 d	1215.3	966.7	1573.5	2.52	5.98
Malathion	**1 d**	2761.8	652.1	8854.0	0.97	0.26
	2 d	200.3	149.1	295.6	1.90	2.48
	3 d	116.7	85.4	153.8	2.14	1.51

DE, Diatomaceous earth

Progeny reduction

In the present study, both DE and malathion had significant effects on the progeny production of *T. castaneum*. The reduction percentages ranging from 2.4 to 95.8 % with malathion and 12.6 to 57.4 % with DE depend on their concentrations compared to control as illustrated in Fig. 1&2.

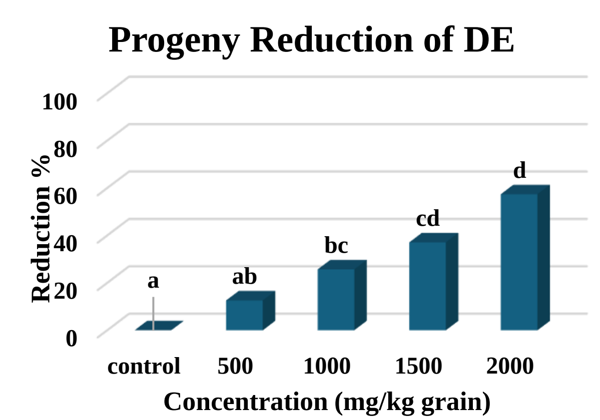

Figure (1): Progeny Reduction percentage of *Tribolium castaneum* adults exposed to different concentrations *of diatomaceous dust Values are represented as mean ± SEM of 3 independent experiments. Values followed by the same letters are not significantly different (p > 0.05) according to ANOVA and Duncan multiple-comparison tests*

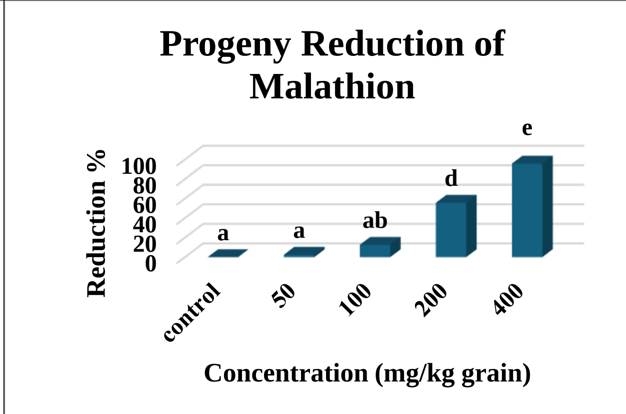

Figure (2): Progeny Reduction percentage of *Tribolium castaneum* adults exposed to different concentrations *of malathion insecticide. Values are represented as mean ± SEM of 3 independent experiments.* Values followed by the same letters are not significantly different (*p* > 0.05) according to ANOVA and Duncan multiple-comparison tests

Morphology Scanning by SEM

SEM has been utilized to investigate the visible damage in insect's wax layer that resulted from DE and malathion exposure. To elucidate the mode of action of both tested materials depending mainly on their physical or chemical properties.

The SEM examination of the cuticular surfaces of the *T. castaneum* adults showed that the sensilla are sensory organs that covers almost the whole body of the insect (mouthparts, antennae, and abdominal ends) as shown in (Figs. 3A, 3B and 3C). Insects that were treated with DE had particles adhering to the mouth parts and abdominal end. In addition, sensilla in the treated area appeared damaged, removed, or obscured compared to control insects treatment in (Figs. 3D, 3E and 3F). In contrast, malathion treatment caused no noticeable changes in mouth parts or the abdominal end (Figs. 3G, 3H, and 3I) compared to the control. Interestingly, the abdominal end (ovipositor tip) appeared enlarged and prominent in both DE and malathion treatments (Figs. 3F & 3I) compared to control insects (Figure 3C). The effect seemed more pronounced with malathion.

For larvae SEM examination, three micrographs were taken for the last larval instar included mouthparts, abdominal ends, and finally the spiracles in thorax segments in each treatment as shown in Figs. (4 and 5). The mouthparts and abdominal end of the control treatment appear normally in (Figures 4A and 4B). In contrast, both DE and malathion treatments caused abnormal shape (shrinkage) in maxillary palps, labial palps, and the mouthparts (Figs. 4C and 4E) as well as the abdominal ends (Figs. 4D and 4F) than control treatments.

In addition, spiracles and thorax segments (Figs. 5A and 5B) appear in normal shape oppositely thorax segments appear shrunken and lost spiracle hairs in both DE and malathion treatments (Figs. 5C, 5E, 5D and 5F).

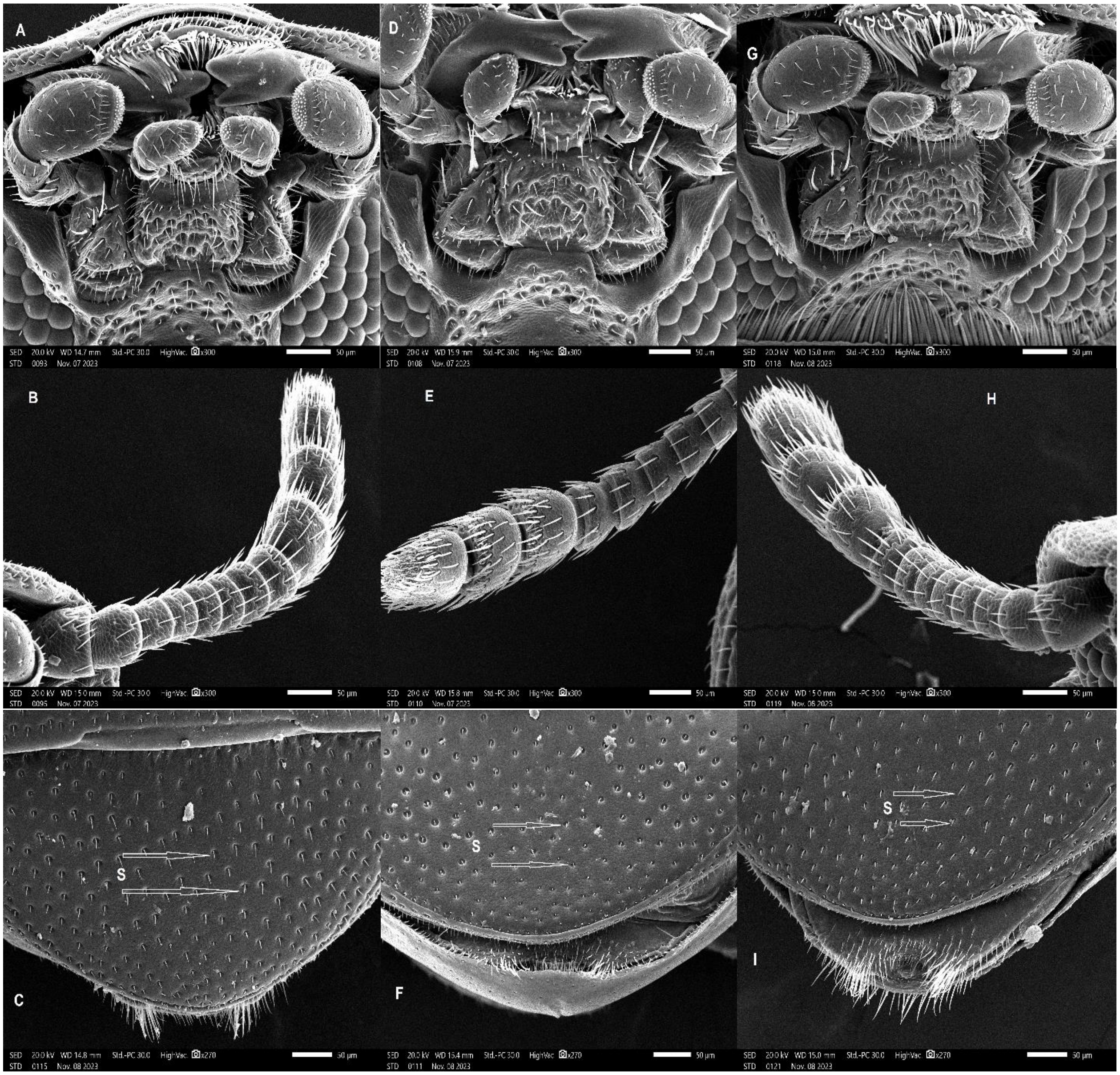

Fig. (3): images of *Tribolium castaneum* adults taken by scanning electron microscopy (SEM). A, B and C: mouth parts, antenna and abdomen of untreated insect, D, E and F: mouth parts, antenna and abdomen of insect exposed to diatomaceous earth, G, H and I: mouth parts, antenna and abdomen of insect exposed to malathion. Sensilla (S).

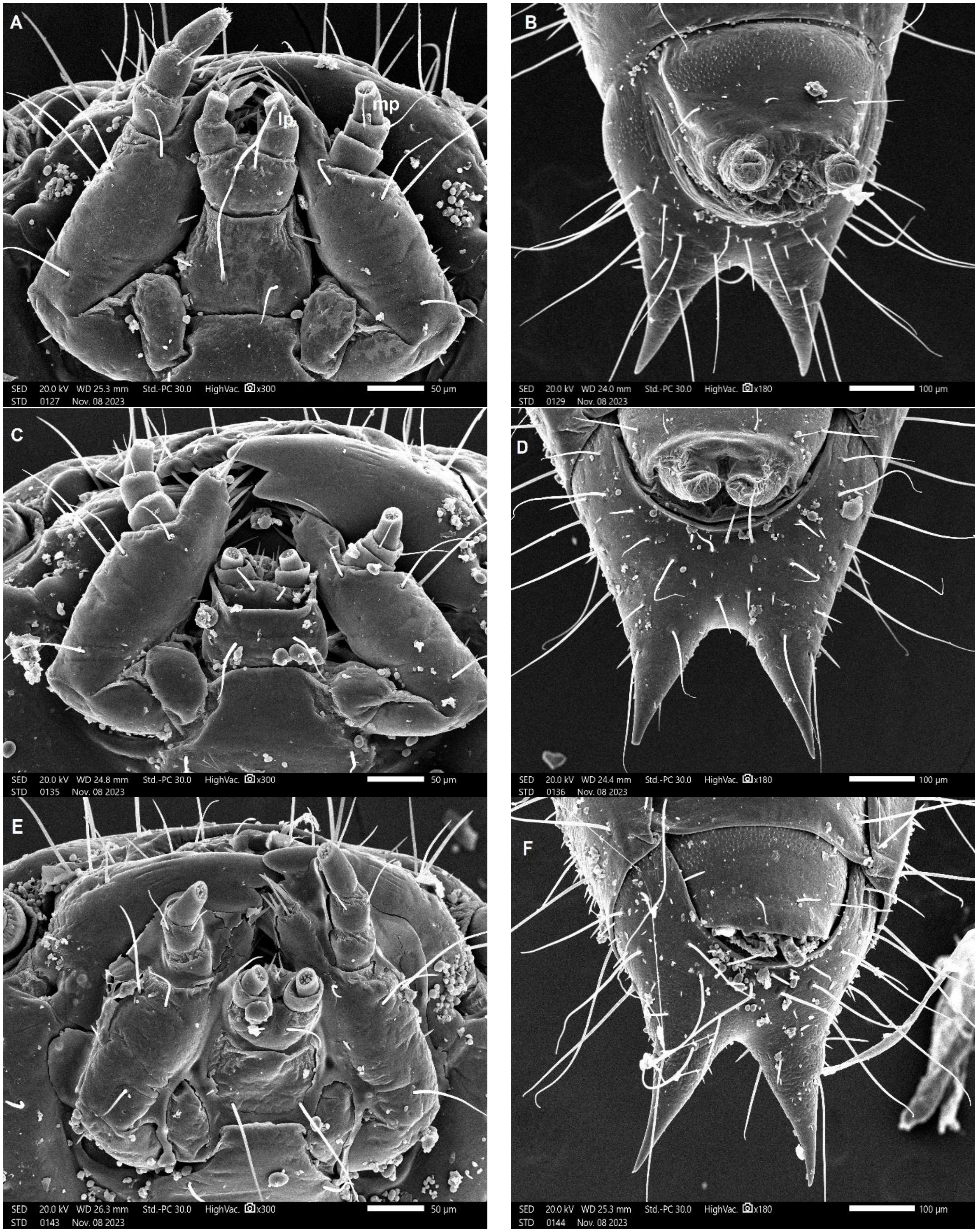

Fig. (4): images of *Tribolium castaneum* larvae taken by scanning electron microscopy (SEM). A and B: mouth parts and abdomen of untreated insect. Maxillary palp (mp), labial palp (lp); C and D: mouth parts and abdomen insect exposed to diatomaceous earth, E and F: mouth parts and abdomen insect exposed to malathion.

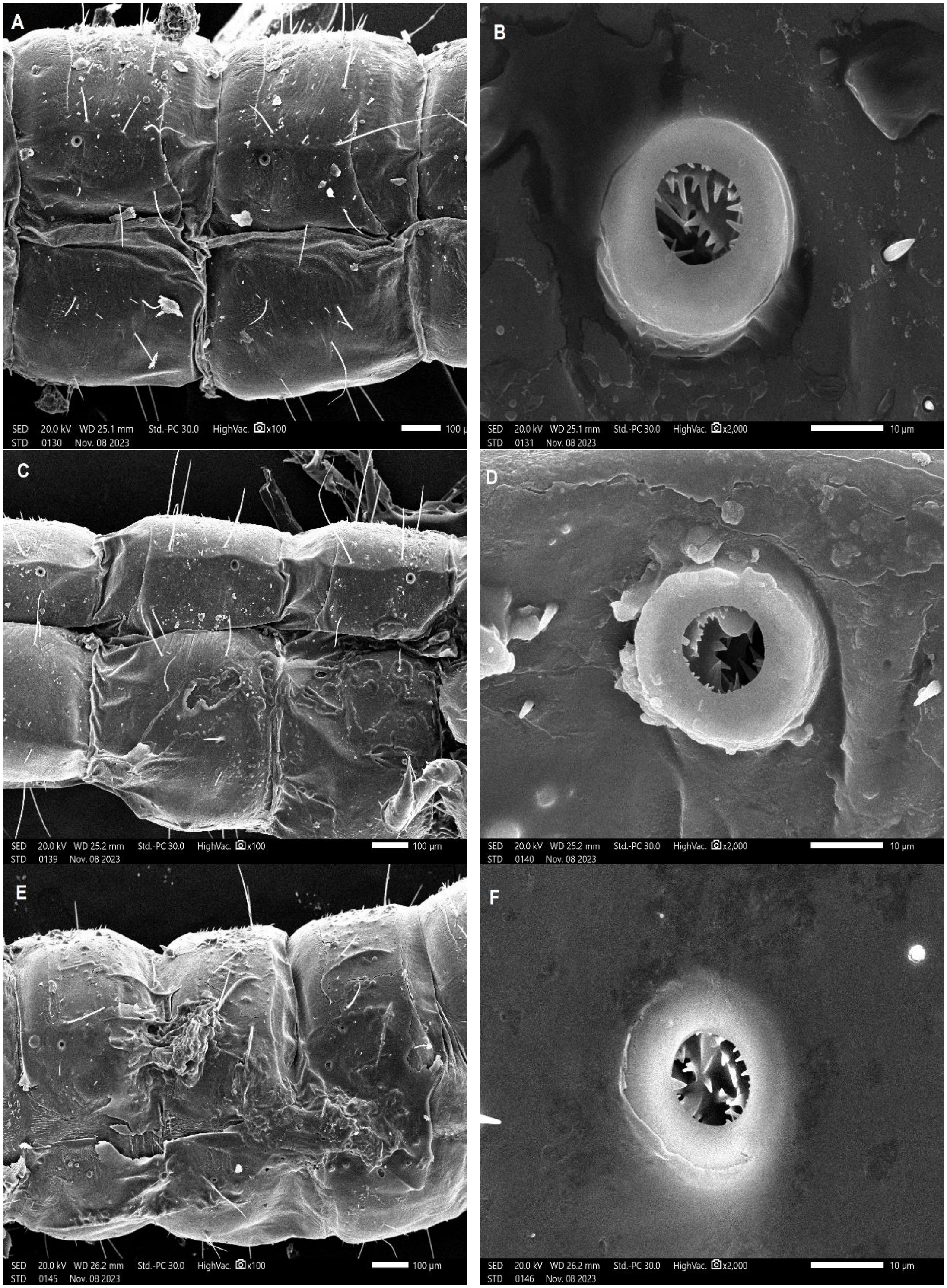

Fig. (5): images of *Tribolium castaneum* larvae taken by scanning electron microscopy (SEM). A and B: side view and spiracle of untreated insect, C and D: side view and spiracle of insect exposed to diatomaceous earth, E and F: side view and spiracle of insect exposed to malathion.

Discussion

Synthetic insecticides are considered the traditional way to protect most stored products from insect attacks for many reasons, including rapid action long-active effects, a wide range of spread and persistence. However, it has many problems such as high residue levels from excessive application, health risks, and environmental hazards and insect resistance development. Therefore, seeking alternative materials for protecting stored products and controlling stored product pests safely and economically is one of the primary goals of scientific research.

In the present study toxicity assessment of both tested materials provided that although malathion insecticide can offer protection for grain against adult on the action site of the compound through high mortality rate and progeny reduction. Diatomaceous dust, a natural material, has effective protection against the same insect with insecticidal activity and suppresses their offspring. Additionally, DE offers several advantages over malathion several advantages of being safer to mammals, lower cost, a high level of persistence and adherence on treated cereals, and a lower risk of insect resistance development (**Losic and Korunic 2018; Audu and Ibrahim 2021**). Our findings are in line with **Wakil et al. (2024)** reported that the efficacy of insecticide represented an increase in mortality rates and a decrease in the number of offspring. Other studies (**Jankov et al. 2013**; **Khalequzzaman and Nahar 2001**) mentioned that the efficacy of insecticides from different insecticide categories (organophospherous and pyrethroid) against *Sitophilus oryzae* and *T. castaneum*, showed toxicity action and persistence activity up to 180 days. In a study by **Wakil et al. (2024)** reported that the single and combined effect of the insecticide lambda-cyhalothrin, and DE were effective in wheat as protectants against *T. castaneum* adult and their progeny in laboratory and persistence bioassays. Diatomaceous dust can be considered an appreciable natural insecticidal material. This finding agrees with **Agrafioti et al. (2023); Romei and Schilman (2024)** who mentioned that DE can effectively protect wheat storages against adult *T. castaneum*. **Wakil et al. (2023)** reported that diatomaceous earth has a potential effectiveness on *T. castaneum* and their offspring in vitro after 14 days in addition to their potential against numerous stored-grain pests. **Also, Wakil et al. (2021)** indicated that the combination of *Beauveria bassiana* and diatomaceous earth was effective against *T. castaneum* adults and progeny. SEM analysis revealed morphological changes in *T. castaneum,* likely caused by the physical properties of diatomaceous earth (DE) and its interactions with the cuticle of both adult and larvae. However, changes occurred by malathion are mainly due to its chemical properties. The insecticidal activity of DE on insects has been explained by several studies. DE particles cause immediate damage to the outer protective wax layer on the cuticle, mostly by sorption and to a lesser degree by abrasion, or both as mentioned by Prasantha et al. (2015) in *Callosobruchus maculatus* and by Malia et al. (2016) in *Sitophilus zeamais*. DE's mode of action may occur through its physical properties by scratching the cuticle of the insect enhancing the insect's dehydration **(Losic and Korunic 2018; Romei and Schilman 2024).** Another possible mode of action involves abrasive effects, which can damage the digestive tract in addition to plugging the insect's spiracles, resulting in suffocation **(Freitas et al. 2020).** The most widely accepted explanation, by **Subramanyam and Roesli (2000),** suggests that DE may block insect spiracles, resulting in death from asphyxiation or increase water loss by entering between cuticular segments and scratching the cuticle, as well as absorbing water from the insect's cuticle. DE possesses a unique physicochemical structure of pores, porosity, excellent absorption capacity, chemical inactivity, and a large available surface area, and non-toxicity for human and non-target organisms (**Sun et al. 2013; Djadi et al., 2021**).

Conclusion

Diatomaceous earth (DE) and malathion demonstrate insecticidal efficiency against T. *castaneum* under laboratory conditions. DE particles act as insecticides by their physical properties, causing changes in the insect's cuticle wax layer. DE is environmentally safe, has a low cost, and can be utilized in place of pesticides during the stored product insect control.

References

Agrafioti, P., Vrontaki, M., Rigopoulou, M., Lampiri, E., Grigoriadou, K., Ioannidis, P. M., Athanassiou, C. G. (2023). Insecticidal effect of diatomaceous earth formulations for the control of a wide range of stored-product beetle species. *Insects, 14*(7): 656.

Arthur, F. H. (2004). Evaluation of methoprene alone and in combination with diatomaceous earth to control *Rhyzopertha dominica* (Coleoptera: Bostrichidae) on stored wheat. *J. Stored Prod. Res. 40*, 485–498.

Athanassiou, C. G.; Arthur, F. H. (2018). *Recent Advances in Stored Product Protection*; Springer GmbH Germany: Berlin/Heidelberg, Germany.

Athanassiou, C. G.; Vayias, B. J.; Dimizas, C. B.; Kavallieratos, N. G.; Papagregoriou, A. S.; Buchelos, C. T. (2004). Insecticidal efficacy of diatomaceous earth against *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) and *Tribolium confusum* Du Val (Coleoptera: Tenebrionidae) on stored wheat: Influence of dose rate, temperature and exposure interval. *J. Stored Prod. Res.*, *41*: 47–55.

Audu A., Ibrahim N. D. (2021). Evaluation of raw diatomaceous earth, leaf powders of eucalyptus and melia as toxicant and repellent against *Callosobruchus subinnotatus* (Pic.) (Coleoptera: Chrysomelidae). *J. Agric. Econ Environ. Soc. Sci. 7*:18–32.

Campbell, J. F., Athanassiou, C. G., Hagstrum D. W. and Zhu K. Y. (2022). *Tribolium castaneum*: a model insect for fundamental and applied research. *Annu.Rev. Entomol. 67*:347–365.

Delgarm, N., Ziaee M., McLaughlin, A. (2020). Enhanced-Efficacy Iranian Diatomaceous Earth for Controlling Two Stored- Product Insect Pests. *Journal of Economic Entomology 113*(1): 504-510. doi: 10.1093/jee/toz261

Djadi, A., Bouzid, M., Bezzazi, B. (2021). Study of the Insecticidal Potential of Diatomaceous Earth from Sig (Algeria) on the Dermestes haemorrhoidalis-A Pest of Stored Food Products. *Nature Environment and Pollution Technology, 20*(2): 533-539.

Donahaye, E. J. (2000). Current status of non-residual control methods against stored product pests. *Crop Protection*, *19*(8-10): 571-576.

Duncan, D. B. (1955). Multiple range and multiple F. test. *Biometrics*, *11*: 1- 42.

Finney, D. J. (1971). A statistical treatment of the sigmoid response curve. *Probit analysis. Cambridge University Press, London*, *633*.

Freitas, A. C. O., Gigliolli, A. A. S., Caleffe, R. R. T. C., Conte, H. (2020). Insecticidal effect of diatomaceous earth and dolomite powder against Corn weevil *Sitophilus zeamais* Motschulsky, 1855 (Coleoptera: Curculionidae). *Turkish Journal of Zoology, 44*(6), 490-497.

Jankov, D., Inđić, D., Kljajić, P., Almaši, R., Andrić, G., Vuković, S., Grahovac, Khalequzzaman, M., Nahar, J. (2001). Toxicity of nine insecticides to adult *Tribolium castaneum* (Herbst). *J. Biol Sci 1*:1043–1045.

Losic, D.; Korunic, Z. (2018). Diatomaceous Earth, a Natural Insecticide for Stored Grain Protection: Recent Progress and

Perspectives. In *Diatom Nanotechnology: Progress and Emerging Applications*; Losic, D., Ed.; Royal Society of Chemistry: Croydon, UK, pp. 219–247.

Jankov, D., Inđić, D., Kljajić, P., Almaši, R., Andrić, G., Vuković, S. & Grahovac, M. (2013). Initial and residual efficacy of insecticides on different surfaces against rice weevil Sitophilus oryzae (L.). *J. Pest Sci., 86*:211–216

Malia, H. A. E., Rosi-Denadai C. A., Guedes N. M. P., Martins, G. F., Guedes, R. N. C. (2016). Diatomaceous earth impairment of water balance in the maize weevil, Sitophilus zeamais. *Journal of Pest Science 89*: 945-954. doi: 10.1007/s10340-016-0732-0

Mariadoss, A., Umamaheswari, S. (2020). Feeding preference and development of red flour beetle, *Tribolium castaneum* (Herbst.) in different rice varieties stored for public distribution in India.

Mason, L. J., McDonough, M. (2012). Biology, behavior, and ecology of stored grain and legume insects. *Stored product protection*, *1*(7): 7-20.

Ortega, D. S., Bacca, T., Silva, A. P. N., Canal, N. A., Haddi, K. (2021). Control failure and insecticides resistance in populations of *Rhyzopertha dominica* (Coleoptera: Bostrichidae) from Colombia. *Journal of Stored Products Research*, *92*, 101802.

Prasantha, B. D. R., Reichmuth, C. H., Adler, C., Felgentreu, D. (2015). Lipid adsorption of diatomaceous earths and increased water permeability in the epicuticle layer of the cowpea weevil *Callosobruchus maculatus* (F.) and the bean weevil Acanthoscelides obtectus (Say) (Chrysomelidae). *Journal of Stored Product Research 64*: 36-41. doi: 10.1016/j. jspr.2015.08.003

Prusky, D. (2011). Reduction of the incidence of postharvest quality losses, and future prospects. *Food Security*, *3*, 463-474.

Rajashekar, Y., Bakthavatsalam, N., Shivanandappa, T. (2012). Botanicals as grain protectants. *Psyche: A Journal of Entomology*, 1-13.

Romei, F., and Schilman, P. E. (2024). Diatomaceous earth as insecticide: physiological and morphological evidence of its underlying mechanism. *Pest Management Science*.

Subramanyam, B., & Roesli, R. (2000). Inert dusts. In Bh. Subramanyam & D. W. Hagstrum (Eds.), *Alternatives to pesticides in stored-product IPM* (pp. 321–380). Kluwer Academic Publishers.

Suleiman, R. A., Rosentrater, K. A. (2022) Grain storage in developing countries. In: Rosentrater KA (ed) *Storage of cereal grains and their products*, 5th edn. Woodhead Publishing, Sawston, pp 113–133.

Sun, Z., Yang, X., Zhang, G., Zheng, S. and Frost, R. L. (2013). A novel method for purifcation of low-grade diatomite powders in centrifugal felds. *Int. J. Miner. Process., 125*: 18-26.

Tahmasebi, P., Javadpour, F. & Sahimi, M. Three-Dimensional Stochastic Characterization of Shale SEM Images. *Transp Porous Med* **110**, 521–531 (2015). https://doi.org/10.1007/s11242-015-0570-1

Tapondjou, L. A.; C. Adler; H. Bouda and D. A. Fontem (2002). "Efficacy of powder and essential oil from *Chenopodium ambrosioides* leaves as post-harvest grain protectants against six stored product beetles," *Journal of Stored Products Research, 38*(4): 395–402.

Vayias, B. J., Athanassiou, C. G., Korunic, Z., Rozman, V. (2009). Evaluation of natural diatomaceous earth deposits from south-eastern Europe for stored-grain protection: the effect of particle size. *Pest Management Science: formerly Pesticide Science, 65*(10): 1118-1123.

Wakil, W., Kavallieratos, N. G., Eleftheriadou, N., Haider, S. A., Qayyum, M. A., Tahir, M., ... & Aldawood, A. S. (2024). A winning formula: sustainable control of three stored-product insects through paired combinations of entomopathogenic fungus, diatomaceous earth, and lambda-cyhalothrin. *Environmental Science and Pollution Research*, *31*(10), 15364-15378.

Wakil, W., Kavallieratos, N. G., Eleftheriadou, N., Riasat, T., Rasool, K. G., Husain, M., Aldawood, A. S. (2023). Unleashing the power of diatomaceous earths for sustainable management of *Tribolium castaneum* infestation in wheat. *Journal of Asia-Pacific Entomology*, *26*(4): 102147.

Wakil, W., Schmitt, T., Kavallieratos, N. G. (2021). Mortality and progeny production of four stored-product insect species on three grain commodities treated with Beauveria bassiana and diatomaceous earths. *Journal of Stored Products Research, 93*: 101738.

السمية والتغيرات المورفولوجية المحدثة بالتراب الدياتومي والملاثيون ضد خنفساء الدقيق الصدائية (Tribolium castaneum)

الزهراء عبد العاطى المعداوى[1]*، دعاء محمد التلبنتى[1]، مصطفى الايبارى[1]، تامر اسماعيل [2]، احمد فايز عمر[2]

[1]قسم بحوث آفات الحبوب والمواد المخزونة – معهد بحوث وقاية النباتات – مركز البحوث الزراعية، جمهورية مصر العربية
[2]قسم كيمياء وسمية المبيدات، كلية الزراعة، جامعة كفر الشيخ، جمهورية مصر العربية

الملخص العربى

خنفساء الدقيق الصدائية هي حشرة مدمرة ثانوية تسبب ضررا كبيرا للحبوب. في هذه الدراسة تم تقييم النشاط المبيد للحشرات للتراب الدياتومي (DE) والملاثيون ضد هذه الحشرة ونسلها. كما تمت دراسة التأثيرات المورفولوجية لهذه المواد على البالغات واليرقات باستخدام المجهر الإلكتروني الماسح .(SEM) أظهرت النتائج أن الملاثيون كان له تأثير أقوى من التراب الدياتومي من خلال مقارنة قيم LC50 الخاصة به خلال فترات التعرض. خفضت التراب الدياتومي والملاثيون بشكل ملحوظ إنتاج ذرية الحشرة المستهدفة بنسبة 2.4 إلى 95.8٪ و12.6 إلى 57.4٪ بالنسبة للملاثيون وDE، على التوالي. بالإضافة إلى ملاحظة التغيرات الخارجية على البالغين واليرقات المعالجة باستخدام SEM أولاً، كان لدى البالغين الذين عولجوا بـ DE جزيئات ملتصقة بأجزاء الفم ونهاية البطن، مما أدى إلى تلف مستشعر المنطقة المعالجة. بالإضافة إلى ذلك، تظهر نهاية البطن (طرف وضع البيض) في كلا العلاجين متضخمة وبارزة. ثانياً، بالنسبة لليرقات، فإن علاجات الملاثيون والملاثيون تجعل أجزاء الفم ونهاية البطن (الملامس الفكي والملامس الشفوي) في شكل متقلص. أيضًا، تظهر أجزاء الفتحات التنفسية والصدر منكمشة وفقدان شعيرات الفتحات التنفسية. بشكل عام، يعد التراب الدياتومي بديلاً واعدًا للمبيدات الحشرية نظرًا لنشاطه المبيد للحشرات بالإضافة إلى كونه آمنًا نسبيًا على الإنسان والبيئة، لذلك يمكن استخدامه كمبيدات طبيعية في مكافحة آفات المنتجات المخزنة.

الكلمات المفتاحية: خنفساء الدقيق الصدائية، المجهر الإلكتروني الماسح(SEM) ، التراب الدياتومي(DE) ، الملاثيون.