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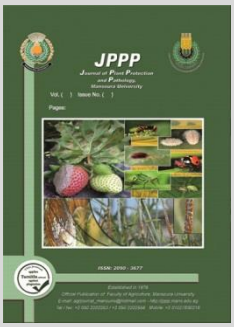
Contact Toxicity and Effect on Progeny of Two Green Pesticides Against some Stored Product Insects Compared to Malathion

Abouelatta, A. M. *; Doaa M. El-Talpanty and Walaa M. Alkot

Stored Grain and Product Pests Research Department, Plant Protection Research Institute, Agriculture Research Center, Giza 12611, Egypt.



ABSTRACT

The study investigated the efficacy of two plant-derived green pesticides (Techno oil and Berna star) in comparison with Malathion for controlling two major stored product insect pests: *Rhyzopertha dominica* and *Tribolium castaneum*. The research assessed both the contact toxicity and the impact on progeny, with the aim of finding safer alternatives to conventional chemical pesticides. Malathion exhibited the strongest toxicity against both *R. dominica* and *T. castaneum*. After 24 hours of exposure, it showed a significant impact on both insect species, with a pronounced effect on *R. dominica*. For *T. castaneum*, no mortality was observed after 24 hours of exposure to either green pesticide, indicating limited effectiveness. However, after 72 hours, the green pesticides showed a 100% mortality against *R. dominica*. For *R. dominica*, both Techno oil and Berna star were effective against *R. dominica*, achieving 100% mortality after 72 hours across all concentrations. The study also examined the impact of these treatments on progeny production, which is an important consideration in pest control. While Malathion was more immediately effective, both plant extracts showed potential in reducing progeny over time. Techno oil also exhibited a delayed effect but had a weaker performance compared to Malathion and Berna star. *T. castaneum* was found to be more tolerant to the tested pesticides, particularly the green alternatives, compared to *R. dominica*. This could indicate that *T. castaneum* might require longer exposure times or higher concentrations for effective control.

***Keywords*:** Berna star, Techno oil, *Tribolium castaneum*, *Rhyzopertha dominica*, Thin film, LC_{50}.

INTRODUCTION

Wheat is a vital crop worldwide, crucial for food security and economic stability, particularly in poor and developing countries where it serves as a significant source of protein (FAO, 2015). Effective storage during transportation from wheat-producing to consumer countries is essential to maintain quality (Abouelatta *et al.* 2020). However, pests like *Tribolium castaneum* and *Rhyzopertha dominica* pose serious threats during storage. Infestation can lead to complete weight loss of stored wheat within six months without preventive measures. This highlights the importance of effective pest management to protect the quality and safety of wheat during storage (Abouelatta *et al.* 2016). Investigate new and safe components can be used in stored product protection is very important to protect one of the most important sources of food. Also to protect the environment using chemical pesticides must be decreased and increasing the use of green pesticides and natural components.

Techno oil is a vegetable oil which is efficient as acaricide and pesticide (Esmail et al. 2020). Techno oil is a non-ionic surfactant bioactivator and water conditioner derived from botanical sources, primarily used for foliar applications in agriculture and chemical processes. It works by breaking down physical barriers of insects and fungi, such as chitin and waxes. Research has increasingly explored the use of plant essential oils as a means to control insect pests. These oils can be extracted from various parts of plants, including seeds, leaves, stems, and flowers, and they contain beneficial fatty acids and lipids (Lglutamic amino acid) (El-Khiat et al. 2016). Common fatty acids found in plant oils include palmitic, stearic, linoleic, and oleic acids, which are widely utilized in food and feed products. Additionally, many plant oils are exempt from EPA regulations, making them suitable for organic production (Abouelatta et al. 2022). Common fatty acids found in these oils include palmitic, stearic, linoleic, and oleic acids, making them valuable in food and feed products.

Both Techno oil and Berna star exhibit insecticidal activities against stored grain insects, highlighting their potential use in pest management within agricultural settings. These properties make them attractive options for controlling pest populations while adhering to organic standards. (Carlos E. Borgan et al. 2006). Techno oil and Berna star have insecticidal activities against stored grain insects (Abouelatta et al. 2022).

Mineral oils, including dormant and horticultural oils, are effective tools in integrated pest management (IPM) strategies. They control a variety of pests, reduce the spread of fungal diseases, and help manage insect-vectored viruses, making them valuable for sustainable agricultural practices. Their versatility and relatively low toxicity to non-target organisms make them an attractive option in organic and environmentally-conscious farming systems (Esmail et al. 2020).

Aim of study to evaluate the toxicity and biological effect of two new and green pesticides against stored grain products

MATERIALS AND METHODS

Test insects

Wheat grains and flour were used to rear adults of *R. dominica* and *T. castaneum*, respectively. The wheat grains and flour were heated at 50°C for 6 hours to eliminate any prior insect infestations. Rearing of insects carried out according to Abouelatta et al. (2020).

Bio products as green pesticides

* **Corresponding author.**
E-mail address: ahmedabouelatta2@gmail.com
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a.Techno oil

(Vegetable oil) Water conditioner and plants bio activator. Non-Ionic surfactant extracted from botanical source.

Produced by: Starchem Industrial for Chemical (Cairo, Egypt).

b. Berna star

Plant extract (40% Coconut fruit core + 38% Avocado fruit seed + 8% Plant extracted Sulfur components +14% Water).

Produced by: Shoura Industrial for Chemical (Cairo, Egypt).

Synthetic pesticide

Malathion (50%) Malation is a chemical pesticide and was bought from Kafr Elzayat Company (Kafr El-zayat, Gharbeya, Egypt).

Contact toxicity

a- Thin film

According to (Abo Arab *et al.* 2020) four concentrations of (500, 1000, 2000 and 4000) mg/L of tow tested green compounds and 2, 4, 6 and 8 mg/L for Malathion were prepared by dissolving in water. Mortality was recorded after 24, 48 and 72h of exposure and corrected by Abbott's formula (Abbott, 1925).

b- Mixing with medium

Various concentrations of Berna Star and Techno oil (4000, 8000, 16000, and 32000 mg/kg) and Malathion (2, 4, 6, and 8 mg/L) were prepared in water, then mixed with 20 g of wheat grains for *R. dominica* and 20 g of crushed wheat grains for *T. castaneum* in 50 ml glass jars. This method was described by (Hashem et al. 2018). Mortality percentages were recorded after 1, 2, 3, 4, and 5 days of exposure for *R. dominica*, and after 4, 5, 6, 7, and 14 days of exposure for *T. castaneum*. Mortality data were corrected using Abbott's formula (Abbott, 1925). The slope, LC50, and confidence limits were estimated using Finney's analysis method (Finney, 1971).

Effect on progeny:

A laboratory experiment was conducted to evaluate effects of the tested toxicants on the progeny of *T. castaneum* and *R. dominica*. Batches of 50 g of crushed wheat grain or wheat grains were placed in small jars and treated with the respective concentrations of the two green pesticides (4000, 8000, 16000, and 32000 mg/kg) and Malathion (2, 4, 6, and 8 mg/kg). Each jar was infested with 20 adults. After two weeks, all insects were removed. The jars were then kept in an incubator at 26 ± 1°C and 65 ± 5% relative humidity. Untreated wheat grains and crushed wheat grains were used as the control. The treatments (both treated and control) were repeated three times. The number of newly emerged adults was recorded for two weeks, and the percentage of adult reduction was calculated using the following equation:

$$\% \text{ Reduction} = [(MNEC - MNET) / MNEC] \times 100$$

Where:

- **MNEC = Mean number of adults that emerged in the control**
- **MNET = Mean number of adults that emerged in the treatment.**

Data analysis

Data were analyzed using the SPSS software program, version 23, based on one-way ANOVA, followed by a least significant difference (LSD) test for mean separation at P = 0.05. The 50% lethal concentrations (LC50), slope, and 95% confidence limits (CL) were calculated using Finney's analysis (Finney, 1971) with the LDP Line software program.

RESULTS AND DISCUSSION

Results

Contact toxicity

a.Thin film

Data in Table (1) shows that Malathion had the strongest effect on *R. dominica* compared to Berna Star and Techno Oil at all exposure periods, followed by Berna Star. The data also indicated that *T. castaneum* was more tolerant than *R. dominica*. After 24 hours of exposure, Malathion was the only compound that caused mortality, with an LC50 of 5.29 mg/L, while Berna Star and Techno Oil showed no effect on *T. castaneum*. After 72 hours of exposure, the mortality of *R. dominica* reached 100% at all concentrations for both Berna Star and Malathion. For *T. castaneum*, Malathion exhibited the strongest effect compared to the other compounds, with LC50 values of 5.29 mg/L and 3.98 mg/L after 24 and 48 hours of exposure, respectively, followed by Berna Star, with an LC50 of 1582.00 mg/L after 48 hours of exposure.

Table 1. Thin film effect of Techno oil, Berna star and Malathion against adults of Rhizopirtha dominica and Tribolium castaneum.

compound	Exposure period (h)	LC_{50} (mg/L)	95% Confidence limits	Slope value	Chi^2
		Rhizopirtha dominica			
	24	2061.00	1634.1 – 2770.2	1.28	4.27
Techno oil	48	1085.00	797.2 – 1396.1	1.16	3.97
	72	545.00	364.1 – 723.3	1.44	2.70
	24	1783.30	1200.5 – 2973.7	1.43	0.35
Berna star	48	824.14	603.1 – 1021.40	2.73	1.76
	72	--	-- --	--	--
	24	4.10	0.44 – 38.70	1.10	2.30
Malathion	48	3.40	0.25 – 26.80	3.01	0.28
	72	--	--	--	--
		Tribolium castaneum			
	24	--	-- --	--	--
Techno oil	48	5993.40	3881.3 – 14282.2	1.10	3.15
	72	813.70	630.3 – 970.5	1.72	1.28
	24	--	--	--	--
Berna star	48	1582.00	1077.2 – 2433.8	1.52	0.46
	72	688.50	377.5 – 982.4	1.74	0.05
	24	5.29	1.43 – 53.01	1.79	1.03
Malathion	48	3.98	0.41 – 40.20	2.11	2.86
	72	--	--	--	--

b. Mixing with medium

The data from Table (2) suggests that *T. castaneum* is more tolerant to the tested substances compared to *R. dominica*. Here's a summary of the observed effects. For *T. castaneum* no significant effect was observed before 7 days of exposure to Techno oil and Berna star at any of the concentrations used. For *R. dominica*, Malathion had the

strongest effect on *R. dominica*, especially after one and two days of exposure.

After one day, Techno oil was the second most effective, while after two days, Berna star showed a higher toxicity effect. After five days, Techno oil and Berna star both caused 100% mortality. Malathion caused 100% mortality after three days of exposure. This data indicates that *R. dominica* is more susceptible to the tested substances, with Malathion being the most potent, while *T. castaneum* shows greater resistance.

Table 2. Mixing with medium effect of Techno oil, Berna star and Malathion against adults of Rhizopirtha dominica and Tribolium castaneum.

Component	Exposure period (day)	LC_{50} (mg/Kg)	95% Confidence limits	Slope value	Chi^2
Rhizopirtha dominica					
Techno oil	1	72850.10	40806.6 – 543163.2	1.67	1.10
	2	36978.20	23177.6 – 114164.5	1.34	0.34
	3	15152.50	9981.9 – 24191.4	1.40	0.22
	4	8273.20	5448.8 – 11237.2	1.88	0.75
	5	--	-- --	--	--
Berna star	1	86920.80	39361.9 – 3031480.5	1.12	1.56
	2	28990.40	20011.1 – 56987.3	1.59	0.26
	3	19080.60	12882.3 – 33417.9	1.40	0.58
	4	8974.40	5762.0 – 12359.6	1.73	0.60
	5	--	-- --	--	--
Malathion	1	4.60	1.02 – 51.10	0.98	2.33
	2	3.90	0.44 – 28.11	1.98	0.53
	3	--	-- --	--	--
	4	--	-- --	--	--
	5	--	-- --	--	--
Tribolium castaneum					
Techno oil	1	--	-- --	--	--
	2	--	-- --	--	--
	3	--	-- --	--	--
	4	--	-- --	--	--
	5	--	-- --	--	--
	6	--	-- --	--	--
	7	37037.8	27482.6 – 64884.5	2.36	0.70
	14	20113.2	14677.4 – 30557.8	1.76	0.01
Berna star	1	--	-- --	--	--
	2	--	-- --	--	--
	3	--	-- --	--	--
	4	--	-- --	--	--
	5	--	-- --	--	--
	6	--	-- --	--	--
	7	27037.5	18290.6 – 55778.7	1.46	0.32
	14	8937.4	5762.0 – 12359.6	1.73	0.60
Malathion	1	5.60	0.71 – 61.11	2.22	1.88
	2	4.10	0.62 – 40.32	3.10	4.53
	3	2.31	0.23 – 22.55	0.98	0.77
	4	--	-- --	--	--
	5	--	-- --	--	--
	6	--	-- --	--	--
	7	--	-- --	--	--
	14	--	-- --	--	--

Effect on progeny

The inhibition rates in the production of the first generation (F1) of *R. dominica* and *T. castaneum* adults in seeds and crushed wheat grain treated with Techno oil, Berna star and Malathion with different concentrations (Table 3). The results show that all tested compounds achieved 100% reduction with all concentrations

Table 3. Means of F1-progeny production in *Rhizopirtha dominica* and *Tribolium castaneum* exposed to wheat grains and crushed wheat grains mixed with Techno oil, Berna star and Malathion components at different concentrations compared to control treatment.

Plant oil	Concentration (mg/kg)	Mean no. of adults emerged ± SE	% Reduction[a] in F1-progeny
Rhizopirtha dominica			
Control	-	53	
Tehno oil	4000	0.00	100.00
	8000	0.00	100.00
	16000	0.00	100.00
	32000	0.00	100.00
Berna star	4000	0.00	100.00
	8000	0.00	100.00
	16000	0.00	100.00
	32000	0.00	100.00
Malathion	2	0.00	100.00
	4	0.00	100.00
	6	0.00	100.00
	8	0.00	100.00
Tribolium castaneum			
Control	-	61.3	
Tehno oil	4000	0.00	100.00
	8000	0.00	100.00
	16000	0.00	100.00
	32000	0.00	100.00
Berna star	4000	0.00	100.00
	8000	0.00	100.00
	16000	0.00	100.00
	32000	0.00	100.00
Malathion	2	0.00	100.00
	4	0.00	100.00
	6	0.00	100.00
	8	0.00	100.00

Means followed by the same letter(s) in each column are not significantly different (P=0.05; LSD test).a% Reduction in F1-progeny production =[Cn-Tn] / [Cn] x 100, where, Cn is the number of newly emerged insects in the untreated (control) jar, and Tn the number of insects in the treated jar.

Discussion

A few studies were carried out on Techno oil and Berna star while many studies were carried out on plant extracts. In agreement with current study (Esmail *et al.* 2020) reported that, Techno oil is a vegetable oil which is efficient as acaricide and pesticide. (El-Khiat *et al*. 2016) described the composition of techno oil and reported that, it is a non-ionic surfactant and a water conditioner extracted from botanical source. Techno oil eliminates physical barriers of the insects and fungi such as chitin; waxes (paraffin). In current all tested compounds had insecticidal activities against the two tested insects. Results cleared that, Malathion had the strongest toxicity followed by Berna star. Techno oil and Berna Star can be used in stored product protection to decrease the using of synthetic pesticides. Techno oil and Berna star are plant extracts. In thin film and mixing with medium method based on LC_{50} *T. castaneum* is much tolerant than *R. dominica* for all tested compounds. All tested compounds achieved 100% reduction with all tested concentrations. In agreement with current study (Esmail *et al.* 2020) studied the efficiency of Techno oil and Berna star against *Bemisia tabaci* on potato cultivar Hatma at Qaha, Qalubiya Governorate on autumn 2017 and recorded the mortality after 14 days and found that the two compounds had toxicity effect against *B. tabaci*. They found that, the mortality for Techno oil after 14 days was 67.9% and 73.1% for Techno oil and Berna star, respectively. Also in agreement with current study Techno oil and Berna star effected on progeny and recorded 100% reduction for *B. tabaci* on potato. Plant extracts common used in plant protection (Esmail *et al.* 2020). (Carlos E. Borgan *et al.* 2006) reported that, most oil-based products have a similar mode of action. The toxic action of plant extracts is more physical than chemical (Omar *et al.* 2024). Many studies reported that plant oils especially essential oils had negative effect on acetylcholine receptors (nACh-R) (Abouelatta *et al.* 2020,

2016 and El-Talpanty *et al.* 2024). The activation of the nACh-R receptors causes hyperactivity and muscle spasms, and highly toxic to insects, but less toxic to mammals (Clive Tomlin *et al.* 2018). Also in agreement with current study (Abd-Elhaleim *et al.* 2021) studied the effect of Techno oil and Berna star on terrestrial snail *Massylaeae vermiculata* and found that, Techno oil had the highest toxicity. They also recorded that compared to synthetic pesticides, plant extracts had lower effect than synthetic pesticides. Result (Yaman and Şimşek 2021) studied the insecticidal effect of three extracted *Hypericum* species against *R. dominica*, *Sitophilus oryzae* and *T. confusum* and they found that *R. dominica* was much sensitive. (Abdelmaksoud et al. 2020) studied the effect of Berna star in the control of thrips and red spider mites on strawberry plants and found that Berna star had a significant effect on mortality and reduction of all tested insects.

CONCLUSION

The study suggests that while Malathion remains the most effective option for controlling both *R. dominica* and *T. castaneum* in the short term, both Techno oil and Berna star hold promise as greener alternatives, especially for longer-term control, with Berna star showing particular promise in controlling *R. dominica*. However, the slower action and reduced efficacy against *T. castaneum* highlight the need for further research into optimizing these plant-based solutions for broader application.

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السمية بالملاسة والتأثير على الخلفة لإثنين من المبيدات الصديقة للبيئة ضد بعض حشرات المواد المخزونة مقارنة بمبيد الملاثيون

أحمد محمد أحمد أبوالعطا ، دعاء محمد التلبنتي و ولاء مسعود القط

مركز البحوث الزراعية – معهد بحوث وقاية النباتات – قسم افات الحبوب والمواد المخزونة – الدقي – جيزة – مصر

الملخص

خنفساء الدقيق الصدئية وثاقبة الحبوب الصغرى (Tribolium castaneum و Rhyzopertha dominica) هما حشرتان رئيسيتان للمنتجات المخزنة. أجريت الدراسة الحالية لتقييم النشاط الإبادي لمستخلصين نباتيين يعتبرا من المبيدات الصديقة للبيئة والمستخدمة بشكل تجاري في السوق المحلي (تكنو أويل و بيرنا ستار) مقارنة بالمبيد الكيميائي (ملاثيون) ضد الطور البالغ لاثنتين من الحشرات الرئيسية للمواد المخزونة *R. dominica* و *T. castaneum* وذلك باستخدام السمية بالملامسة والتأثير على ذرية. وكان للملاثيون التأثير الأقوى ضد الحشرتين المختبرتين يليه بيرنا ستار. بعد 24 ساعة من التعريض لم يكن للمركبين النباتيين أي تأثير ضد *T. castaneum* بينما بعد 72 ساعة من التعرض كانت نسبة الموت 100% مع جميع التراكيز ضد *R. dominica*. وباستخدام طريقة الخلط مع البيئة لم يكن هناك أي تأثير على *T. castaneum* قبل 7 أيام لكل من المكونات المختبرة مع تكنو أويل بيرنا ستار. بالنسبة لـ *R. dominica* بعد يوم وثلاثة وأربعة أيام من التعرض، كان للملاثيون أقوى تأثير يليه تكنو أويل، بينما بالنسبة لـ *T. castaneum* كان الملاثيون هو المركب الوحيد الذي كان له تأثير سام بعد يوم ويومين وثلاثة أيام يليه بيرنا ستار والذي كان له تأثير سام. كان التأثير الأول بعد 7 أيام من التعرض. حققت جميع المنتجات المختبرة خفض في التعداد بنسبة 100% ضد الحشرتين المختبرتين. وكان *T. castaneum* أكثر تحملاً من *R. dominica*.