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The Chemically Effect of Titanium oxide (TiO_2) Nanoparticles Against *Bactrocera oleae* (Rossi) (Diptera: Tephritidae) Under Laboratory and Field conditions

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Olive plant trees attack by harmful insect pest species that decrease the yield quality and quantity. Among the most harmful olive pest species surveyed in Egypt is *Bactrocera oleae*. This pest controlled by chemical insecticide. A photo catalyst Titanium oxide (TiO_2) is recently used against some pests this is due to its non-toxic nature, also due to its lower cost in addition to photochemical stability. The present study aimed to evaluate the efficacy of TiO_2 and its nano-particles against *B. oleae* under laboratory and field conditions. The results obtained showed that the LC_{50} of TiO_2 on the third larval instars was 120 ppm. However, when nano- TiO_2 was applied on the target pest, the LC_{50} decreased to 38 ppm. Under field conditions, both and nano- TiO_2 declined the rate of infestation by *B. oleae* with the least infestation in case of treatment with nano- compared to untreated olive trees. The yield of harvested olive fruits increased due to treatment with and nano- with the highest yield in case of trees treated with nano-TiO_2.

Keywords: ***Bactrocera oleae*, TiO2, nano-, Toxicity, Infestation,**

INTRODUCTION

Olive (*Olea europaea*) plays an important role among the important economical crops in Egypt (Mahmoud, 2009). Olive trees are attacked by many insect pests that affect yield quality and quantity. *B. oleae* is the worldwide key pest damaging olive trees (Rice, 2000; Eid, 2003). This pest was a native to Mediterranean countries which represent about 98% of olive trees cultivated in the world (Montiel-Bueno and Jones, 2002).

Thus nanotechnology deals with the targeted nano particles as and when the particles exhibit different physical strength, chemical reactivity, electrical conductance and magnetic properties (Nykypanchuk et al., 2008). Nanotechnology, a promising field of research opens up in the present decade a wide array of opportunities and is expected to give major impulses to technical innovations in a variety of industrial sectors in the future. Nano encapsulation is currently the most promising technology for protection of host plants against insect pests. Thus nanotechnology will revolutionize agriculture including pest management in the near future. Over the next two decades, the green revolution would be accelerated by means of nanotechnology (Bhattacharyya et al., 2010). Therefore, the present study aimed to evaluate the efficacy of TiO_2 and nano-TiO_2 against *B. oleae* under laboratory and field conditions.

MATERIALS AND METHODS

Bactrocera oleae adults used in the present work were originally obtained from a laboratory colony maintained at 25±2°C and 60–65% RH and 12:12 h (L: D) photoperiod. Adults were offered water and a solid diet consisting of 40% sugar, 10% hydrolyzed yeast, and 5% egg yolk. They were maintained in cylindrical glass cages (15 cm in diameter × 22 cm in height), covered with muslin, and fed on 10% sucrose solution.

TiO_2 and nano-TiO_2 was obtained from Shanghai Fuang Agrochemical Co. Ltd (99.9% purity). Nano- was prepared according to Guan et al., (2008).

Nano encapsulation:

The Nano encapsulation is a process through which a chemical is slowly but efficiently released to the particular host for insect pests control. "Release mechanisms include dissolution, biodegradation, diffusion and osmotic pressure with specific pH" (Vidhyalakshmi, et al., 2009).Encapsulated of TiO_2 tested nano-emulsion is prepared by high-pressure homogenization of 2.5% surfactant and 100% glycerol, to create stable droplets which that that increase the retention of Beauvericin and cause a slow release of the nano materials . The release rate depends upon the protection time; consequently a decrease in release rate can prolong insect pests protection time Nuruzzaman et al., (2016).

Laboratory experiments:

Six aqueous concentrations of were prepared: 2.000, 1.500, 0.750, 1.000, 0.500, 0.250, 0.125 mg/L. Olive leaves were dipped in each concentration for 10 seconds and left to dry at room temperature. Treated leaves were offered to third larval instars (20 flies /concentration). A parallel control of non-treated insects fed on olive leaves dipped in distilled water was run. Each treatment was replicated five times. The percentage of mortality was recorded after seven days of treatment and corrected against that of the control according to Abbott's formula (Abbott, 1925). Corrected mortality was subjected to probit analysis (Finney, 1971) to estimate the LC_{50} value. All experiments were run under laboratory conditions mentioned above.

Field experiments:

Field experiments were carried out at Ismailia and Ibn Malek starting from the first of July to end of August. Three random patches of olive trees were selected; each consisted of 12 trees for TiO_2 application, 12 trees for nano- application and 12 trees for control. Both TiO_2 and nano- TiO_2 were applied at the rate of 2.00 and 0.12 mg/L, respectively. Three applications were made at one week interval at the commencement of the experiment. Treatments were performed at sunset using a ten liter sprayer. Percentage of infestation/sample was calculated after 20, 50, 90 and 120 days of application. Each treatment was replicated four times. Four plots were treated with water and used as control. Random samples of olive leaves and fruits were weekly collected from each treatment and transferred to laboratory for examination. The infestation percentage of *B. oleae* was estimated in each case. After harvesting olive fruits, the yield of each treatment was weighed and expressed as Kg/Feddan.

Statistical analysis:

Data were statistically analyzed by *F*-test; LSD value was estimated, using SPSS statistical program software.

RESULTS

Table 1 show that nano- was about 1.2 times as toxic as TiO_2 to *B. oleae* third larval instars under laboratory conditions. Also, show the LC50s of TiO_2 which recorded 120 ppm and 38 ppm after treated *B. olae* with TiO_2 and nano TiO_2 respectively.

Field studies revealed that the rate of infestation of olive trees by *B. oleae* was significantly ($P < 0.05$) declined due to treatment with and nano- compared to control insects with the least infestation in case of treatment with nano- at both Ibn Malek and Ismailia regions (Table 2). The least infestation was attained after 20 and 120 days of treatment with and nano-TiO_2, respectively. The weight of harvested olive fruits was significantly ($P < 0.05$) enhanced after treatment olive trees with Imidacloprid and nano-Imidacloprid at Ibn Malek and Ismailia compared to control trees (Table 3). The weight of the olive fruits recoded 5499.0 ± 70.10 and 5566.0 ± 51.10 kg/feddan after nano-TiO2 treatments in Ibn Malek and Ismailia respectively. TiO_2 and nano-TiO_2 increased the crop yield by about 131 and 159% relative to control, respectively at Ibn Malek region.

Table 1. Susceptibility of *B. olea* third larval instars to TiO2 and nano-TiO2 under laboratory conditions

Treatment	LC_{50} ppm	95% Confidence limit	Slope
TiO_2	120.0	87.0 - 163.0	0.01
Nano- TiO_2	38.0	25.0 - 100.0	0.01

Table 2. Infestation of olive trees by *B. Oleae* after treatment with TiO2and nano-TiO2under field conditions at Ibn Malek and Ismailia regions

No. of infested plants ± SE			
Treatment	Days after treatment	Ibn Malek	Ismailia
Control	20	25.1 ± 5.7	25.1 ± 2.5
	50	7151 ± 2.3	77 ± 2.2
	90	93.0 ± 7.4	95.8 ± 3.6
	120	99.0 ± 6.2	99.6 ± 1.2
TiO_2	20	15.9 ± 9.1	16.1 ± 2.5
	50	25.1 ± 2.3	26.0 ± 2.2
	90	43.0 ± 4.4	46.0 ± 3.6
	120	79.9 ± 1.2	80.0 ± 1.2
Nano- TiO_2	20	8.1 ± 5.1	9.1 ± 2.5
	50	8.0 ± 2.3	9.0 ± 2.2
	90	9.0 ± 1.1	9.0 ± 3.6
	120	9.0 ± 5.1	9.0 ± 6.2
F-test		88	87
LSD (P = .05)		23	31

Table 3. Weight of harvested olive fruits treated with TiO2 and nano-TiO2 and infested by *B. oleae* at Ibn Malek and Ismailia regions

Weight of yield (Kg/Feddan)		
Treatment	Ibn Malek	Ismailia
Control	2122.0 ± 20.72[b]	2007.0 ± 81.50[b]
TiO_2	4844.0 ± 20.11[a]	5000.0 ± 31.18[a]
Nano- TiO_2	5499.0 ± 70.10[a]	5566.0 ± 51.10[a]
F-test	40.6	49.4
LSD (P = 0.05)	89	87

. At Ismailia region, such increase was about 151.3 and 198.4% relative to control in case of treatment with TiO_2 and nano- TiO_2, respectively.Thus, nano- TiO_2 increased olive crop by about 12.2 and 18.7% relative to Imidacloprid at Ibn Malek and Ismailia, respectively.

DISCUSSIONS

Our results agree with Sabbour 2013, the LC_{50} of the olive pests, *Ceratitis capitata* and *Pryas oleae*, was 221 and 200 mg/L, respectively (Sabbour, 2015a). Interestingly, the infestation decreased with the increase in time after treatment with nano-Imidacloprid. Similarly, Sabbour (2015a) reported that Imidacloprid and nano-Imidacloprid reduced the rate of infestation by *C. capitata* and *P. oleae* in olive trees. Again, Sabbour (2015b) recorded decreased infestation rate by potato tuber moth, *Phthorimaea operculella*, in plants treated with nano-fungi *Isaria fumosorosea* and *Metarhizium flavoviride*. Similar findings were also attained by Sabbour (2013) against *B. oleae*, *C. capitata* and *P. oleae* in olive trees treated with spinosad. Our field results match with Sabbour (2015a,b), El-Sayed and Sabbour 2017 and Sabbour 2013.These results are in consistence with those obtained by Sabbour (2013a,b) for olive trees treated with Imidacloprid and nano-Imidacloprid and infested by *C. capitata* and *P. oleae*. Also, treatment of potato plants, infested by *P. operculella*, with nano-fungi *I. fumosorosea* and *M. flavoviride* increased the yield (Sabbour, 2015b). Similar results were obtained by Sabbour (2013) for spinosad-treated olive trees that were infested by *B. oleae*, *C. capitata* and *P. oleae*. Sabbour (2017), found that the olive weight increased after bioinscticid applications and reported that nano-biopesticides application increase the productivity of the olive fruits under field conditions. The obtains by Sabbour (2013) a,b, Sabbour, 2012, Sabbour and Hussein (2016) and Sabbour and Shadia Abd El Aziz(2010) Sabbour and Shurab (2018a,b). Rouhani et al., (2011) reported that ZnO-TiO2-Ag nanoparticles has insecticidal activity on Fran *kliniella occidentalis* (Pergande) and showed the most mortality effect pertained to 28% ZnO-70% TiO2-2% Ag (LC50=195.27 mg/L). Nanoparticles help to produce new pesticides, insecticides and insect repellents (Owolade et al., 2008). Sabbour 2012 controlled Sitophilous *oryzae* by nano TiO2. Fubini et al., 2003, TiO2 is the most investigated semiconductor pho tocatalyst and has been widely studied during the past decade. Osman,et al., (2015), Sabbour and Solieman (2017,2018), Chippenadale et al., 2013] The mechanisms occurring on TiO2 surfaces exposed to light for the photodegradation of organic are presented below step-wise. Adsorption of light by TiO2 at wavelengths < 385 nm is followed by electron (e1)–hole (h+) pair generation. These charge carriers can migrate rapidly to the surfaces of catalyst particles, where they are ultimately trapped and undergo redox chemistry with suitable substrates. Thus, the trapped hole can react with chemisorbed OH1 or H2O to produce OH radical species or trapped by the organic substrate to produce organic radicals. Oxygen present in the system acts as an efficient electron scavenger, or any other oxidants such as OH1 can also trapped the electron EL-Sheikh et al., (2013),Sabbour(2017a,b,c). In our paper, the photocatalytic activity of Ag/TiO2 (Fig. 7a) was lower than that of TiO2 because excessive silver forms a coating on the surface of TiO2. Excessive silver hinders the adsorption of the reactant. The continuous degradation curves of nano-IMI to end under irradiation indicate the photocatalyst possesses the both adsorption and photocatalytic degradation activity for nano-IMI. Under UV irradiation, the photocatalytic activities of SDS/Ag/TiO2 and SDS/TiO2 exceed that of TiO2, the latter being known to be one of the best commercial photocatalysts. Thus, the advantage which combines the adsorption and photodegradation has some important applications for fast enrichment and effective degradation of insecticide pollutants in environment (Rawi, et al., 1995). The specific surface area of SDS/Ag/TiO2 is similar to that of SDS/TiO2; but the photocatalytic activity of SDS/Ag/TiO2 was highest among all photocatalysts. It is considered that the deposited silver contributes significantly to the promotion of the photocatalytic activity of SDS/TiO2. Our results are in agreement with the earlier reports available in the literature Knight, et al., 1972. SDS/Ag/TiO2 compares the photoformulate. The conventional method for processing such data is probit analysis El-Safyty et al., (2012). In this study dose–time–mortality relationship of the novel 50% nano-SDS/Ag/TiO2-IMI application in adult populations of *M. dermestoides* in laboratory bioassays was determined. While the wide use of pesticide ensures the agricultural production, the immense negative effect it brings to the environment cannot be ignored ‘‘High-efficiency, low-noxious, low-residue” has been a natural trend for the development of future pesticide. Therefore, it is an -important task for pesticide researchers to exploit a kind of pesticide which can both improve biological activities and reduce residue. The results of the research showed that the novel nano-pesticides particles is a kind of promising pesticide particles which conforms to the developing trend of future pesticide, will have a bright application prospect and bring obvious economic benefit, social benefit and environmental benefit.

CONCLUSION

In conclusion, nano-particles of TiO_2 was more effective than TiO2 in controlling *B*. *oleae*. These results encourage the extension in the use of nanotechnology for insect pest control.

CONFLICT OF INTEREST

There is no any conflict of interest in our present work.

ACKNOWLEGEMENT

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AUTHOR CONTRIBUTIONS

Sabbour, M.M., share in putting the idea, designed the experiments, make the laboratory and store experiments share in statistical analysis and writing the research, reviewed the manuscript. Mohamed Moursy Hussein, also, share in putting the idea, designed the experiments, make the laboratory and store experiments share in statistical analysis and writing the research, reviewed the manuscript. All authors read and approved the final version.

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