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Control of grasshopper *Hetiracris littoralis* (Orthoptera: Acrididae) by using nano-imidaclorprid in Corn fields

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Abstract: The effect of nano- imidaclorprid (IMI) against grasshoppers under laboratory conditions, which show that the newly hatched nymphs recorded 151 mg/l, Last nymphal stage recorded 176, the adult females and males recorded 166 and 176 mg/l after treated with IMI under laboratory condition , respectively. Under semi-field conditions, the half life time of grasshopper treated with nano-IMI recorded, 103, 108, 119 and 129 mg/l, for Newly hatched nymphs, Last nymphal stage, adult males and females respectively.
Under field conditions inside corn plantations, the number of infestations of grasshoppers were significantly decreased after nano- IMI application.
During field experiments, the results during season 2014, obtained, 3800± 81.6kg/ feddan in plots treated with nano- -IMI as compared to 2590± 10.2 kg/ feddan in the control. The yield loss recorded during 2014 was 31.1%. During season 2015, the weight of corn determined kg/ feddan in plots treated with nano-IMI as compared to 2200 ± 70.2 kg/ feddan in the untreated plots. The percentages of yield loss recorded during 2015 was 44.8 among control plots.
Key wards: Nano, imidaclorprid, *Hetiracris littoralis.*

Introduction

The substance Imidacloprid is a chloronicotinoid insecticide. Its chemical name is : 1-[(6-chloro-3-pyridinyl) methyl]-N-nitro-2-imidazolidinimineImidacloprid which is a systemic, chloronicotinoid insecticide, and kills insects by ingestion or contact their bodies. This substance is effective by causing disrupting to the nervous system of the insect pest. This substance were used for controlling harmful pests , sucking insects, store insects, soil insects, termites, and some chewing insects. The substance were applied as a soil and seed treatment, crop structural treatment control treatment on domestic pets [1].The Imidaclorprid is a broad-spectrum as an organic insecticide. Imiaclorprid, relatively non-toxic to most of the beneficial insects ,mammals and livestock . These substance were used carefully only against insects pests that actually causing a lot of damage to leaves and plants. This is different than a lot of other broad-spectrum insecticides which are toxic if the insect merely comes in contact with dry insecticide residues [2.3,4].

Maize (corn) is an very important crop all over the world especially Europe and also in Egypt. Its demand important to increases forever. Corn crop is subjected to attack by many harmful insect pests that affect on the yield quality and quantity every year. Among the most common harmful insect pest species surveyed in Egypt are: *Ostrinia nubilalis*, *Sesamia cretica* and *Chilo agamemnon*. *O. nubilalis*. These pest damaging corn fruit in the world as well as in Egypt [5]. *O. nubilalis* are found in the Mediterranean countries which had about 98% of the world's cultivated corn plants [6]. *C. Agamemnon* is also considered among the most important insect pests of corns in Egypt and the Mediterranean countries. The moth of these pests were developed three generations per year [6]. In Egypt the first generation of these insect pests moths appears in April were, the female lays its eggs on the corn flower buds after that newly hatched which feed on the buds and flowers of corn[6].

The grasshopper, *H. littoralis* considered among the most harmful insect pests to different cultivated crop plants in Egypt [7,8,9]. It is economic considered an important which attacking many vegetable plants among the cultivated areas even trees. These insect pests feed on the plant fruits, buds,…etc which causing great losses of the yield. Also, it causes a damage in quantity and quality of the attacked crops. In some cases many thousands of cultivated plants hectares may be attacked by the swarms of grasshopper leaving it as a divested empty lack desert. The very important economic injury of *H. littoralis* in Egypt that, causes a severe crop damages. The chemical insecticide are usually applied in the field to enhance the potency spectrum of this pest control when multiple pests are attacking the agriculture plants simultaneously. They are a seriously recommended to increase the efficacy of the control of a single pest to delay or at least decrease the development of insecticide resistance. The chemical insecticide resistance became a major obstacle to successful chemical control with conventional insecticides.

The present study aims to evaluate the pathogenicity of imidaclorprid, (bio-insecticide) against grasshoppers *Heteracris littoralis* under laboratory semi- field and field conditions.

2. Materials and Methods

2.1. Tested Insects:

The insect pests of *Heteracris littoralis* grasshopper **(**Orthoptera**:** Acrididae**)** was reared under laboratory condition for several generations on semi-artificial diet as mentioned by [10].

2.2. Preparation of the semi-artificial diet:

The materials of the components with exception of agar were blended with water. The agar material was separately dissolved in distilled water at 100°C, then cooled up to 60°Cand then mixed with other of the blended ingredients. These diet contents was poured in a laboratory plastic cups, then, leaved at the room temperature in order to solidification and then it kepts in the refrigeration till using nymphal period, longevity of both of the males and females, pre oviposition period, oviposit ion period, post oviposit ion period, the fecundity of females and percent of egg hatchability besides life span of both males and females [10].

2.3.Preparation of nano- imidaclorprid

The material used of imidaclorprid Nanoparticles were synthesized by hydrolyzing titanium tetra isopropoxide together in a mixture of 1:1 anhydrous ethanol and water. 9 ml of titanium tetra isopropoxide is mixed with about 41ml of anhydrous ethanol (A). 1:1 ethanol and water mixture were prepared. (B) Solution A is added in drop wise to solute ion B and were stirred vigorously for about 2hrs. At the room temperature the hydrolysis and condensation were performed, by using 1M of sulphuric acid and then stirred for about 2 hrs. Then, the ageing was undertaken for about 12hrs. The gel was transferred into the autoclave which tightly closed, and then the mixture contents were subjected to hydrothermal treatment at 353K for 24hrs. After the filtration process, the solid residue was washed thoroughly with the distilled water and the ethanol mixture, then dried at about 373K in an oven and calcined at 773K.

2.4.Efficacy of imidaclorprid against the target insect pests

The natural insecticide imidaclorprid were used at the 6 concentrations: 6 g, 5g ,4g,3g, 2g,1g (prepared according [11]. The Percentages of mortality were calculated according to Abbott's formula [12], while the LC50 values was calculated throughout probit analysis according to [13]. The experiment was carried out under laboratory conditions at 26±2°C and 60-70% RH

2.5.**Bioassays**

The insecticidal efficacy of nan- imidaclorprid were tested at three dose rates, 0.25, 0.50 and 1 g/kg wheat against the 3rd nymphal instar of *Hetiracris littoralis* **(**Orthoptera**:** Acrididae**)**. For each case of our experiments, four glass jars as replicates were used. Each replicate was treated as individually with the respective nano-imidaclorprid materials quantity and then shaken manually for one minute to achieve equal distribution of the imidaclorprid. Subsequently, ten ofthe 3rd nymphal instar of the two tested species were introduced into each glass jar and covered with muslin for sufficient ventilation. Twelve replicates glass jars containing untreated wheat served as control. Mortality was assessed after 7 d of exposure in the treated and untreated jars. Mortality was corrected according to [12]. Then, all tests experiments were conducted at 27 ± 2 °C and 65 ± 5% relative humidity (RH). All the experiments were repeated three times.

The ovipositional of the deterrent effects of nanoimidaclorprid were also examined. The nano-imidaclorprid were tested at the rate values of 0.5 g/kg corn. Four replicates of 100 g corn for each treatment were used. Each replicate was treated individually with the formulations for 1 min and then, they were put inside the glass jars. Four replicates of each experiments, in jars which were containing the untreated corn and they served as control. Subsequently, one paired of newly emerged adults of *Heteracris littoralis* were introduced into each jar. The number of deposited eggs on treated or untreated wheat/female was counted and the percent of the repellency values were calculated according to the equation of Lwande et al. (1985), D = (1 - T/C) x 100, where: T and C represent the mean number of deposited eggs per female of the treated and check set, respectively.

2.6. Efficacy of imidaclorprid, *nano*-imidaclorprid against target insects under Semi-field (green house) trials:

Maize (corn) (variety Giza-2) was planted in the green house in 40 pots in each artificial infestation . Imidaclorprid were applied as single treatments in randomize. 5g of imidaclorprid for each pots which was made by spraying the plant with the Imidaclorprid and nano- Imidaclorprid at different concentrations. Control samples were sprayed by water only. The plants were examined every two days, the percentage of infestation was calculated until the end of the experiment. Each treatment was replicated 4 times. The percent mortality was counted and corrected according to [12]; while LC50s were calculated through probit analysis after [13].

2.7. Field Trials:

Our field experiments were conducted at Nobaria region (Behera Governorate), Egypt during the two successive corn seasons 2014 and 2015 to study the effectiveness of the tested Imidaclorprid and Nano-Imidaclorprid on corn borers. Maize, (Corn variety Giza-2) was planted at the end of May during two successive seasons in an area of about half feddan. The tested, Imidaclorprid were applied as single treatments in randomize plots. 5g for imidaclorprid. Regular agricultural practices were performed and no chemical control was used during our study period. The weeds were removed by hand. Five plots of corn were sprayed with water as control treatments. Samples from each treatment were collected weekly and transferred to the laboratory in order to investigate. The Percentages of infection were calculated.

2.8. Yield Assessment:

Yield data in treated and untreated plots in the corn harvest seasons (2014and 2015), represented by weight in Kg were determined. The Yield loss was estimated according to the following equation:

$$\text{Yield loss} = \frac{\text{Potential yield} - \text{Actual yield Potential yield}}{\text{Potential yield}}$$

Potential yield was *Nano-* Imidaclorprid treatment (the best result among the tested pathogens) was considered the standard for comparison with the other ones.

3. Results

3.1. In-vitro effect of nano-IMI. on the target insects

Table 1 show the effect of nano- IMI against grasshoppers under laboratory conditions, which show that the newly hatched nymphs recorded 151 mg/l, Last nymphal stage recorded 176, the adult females and males recorded 166 and 176 mg/l after treated with IMI under laboratory condition, respectively.

Table 1.Effect of nano- IMI against the grasshopper *H. littoralis* under laboratory conditions.

Stages	LC_{50} (mg/L)	Slope	Variance	95% Confidence limits
Newly hatched nymphs	151	0.01	1.3	140-207
Last nymphal stage	176	0.01	0.2	100-211
Adult ♀	166	0.01	1.1	100-221
Adult ♂	178	1.01	0.2	110-210

Table 2. Effect of nano- IMI against the *H. littoralis* under semi-field conditions.

Stages	LC_{50} (mg/L)	Slope	Variance	95% Confidence limits
Newly hatched nymphs	103	0.01	1.3	99-148
Last nymphal stage	108	0.01	0.2	88-200
Adult ♀	119	0.01	1.1	87-107
Adult ♂	129	1.00	0.1	10-358

Under semi-field conditions, the half life time of grasshopper treated with nano-IMI recorded, 103, 108, 119 and 129 mg/l, for Newly hatched nymphs, Last nymphal stage, adult males and females respectively (Table2).

Under field conditions inside corn plantations , the number of infestations of grasshoppers were significantly decrease after nano- IMI application which recorded 1.0±0.1, 2±0.1, 3±3.0 and 6±2.9 individuals as compared to 25.2±5.7, 57±8.5, 79±9.6 and 99±9.7 individuals after 20, 50, 90 and 120 days of first applications (Table3).

Table (3): Effect of nano-IMI against *H. Littoralis* under field conditions

Treatments	Days after treatment	No .of infestations *H. littoralis* (Means ± S.E.)
Control	20 50 90 120	25.2±5.7 57±8.5 79±9.6 99±9.7
IMI	20 50 90 120	1.0±0.1 2±0.1 3±3.0 6±2.9
F –test	12.4	
LSD 5%	11.8	

Table 4. Assessments of damage caused in corn field after the nano-IMI treatment

Treatments	Season 2014		Season 2015	
	Wt of corn crop (kg/ feddan)	yield loss%	Wt of corn crop (kg/ feddan)	yield loss%
Nano-IMI	3800± 81.6	-	3989 ±80.4	-
Control	2590± 10.2	31.1	2200 ± 70.2	44.8
F value	31.1		44.9	
Lsd5%	120.7		120.5	

Table 4, show during season 2014, the weight of corn obtained, 3800± 81.6kg/ feddan in plots treated with nano- -IMI as compared to 2590± 10.2 kg/ feddanin the control. The yield loss recorded during 2014 was

31.1%. during season 2015, the weight of corn determined kg/ feddan in plots treated with nano-IMI as compared to 2200 ± 70.2 kg/ feddan in the untreated plots. The percentages of yield loss recorded during 2015 was 44.8 among control plots (Table4). Figure (1 & 2) show that the percentage of infestations were highly significantly decreased during both two seasons 1014 and 2015.

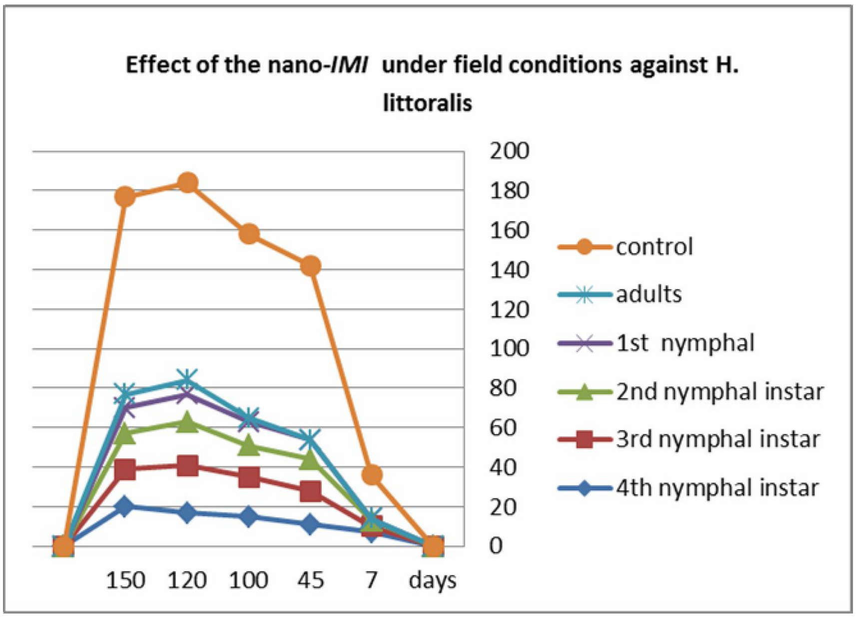

Fig (1). Effect of the nano-IMI under field conditions *against H. littoralis*

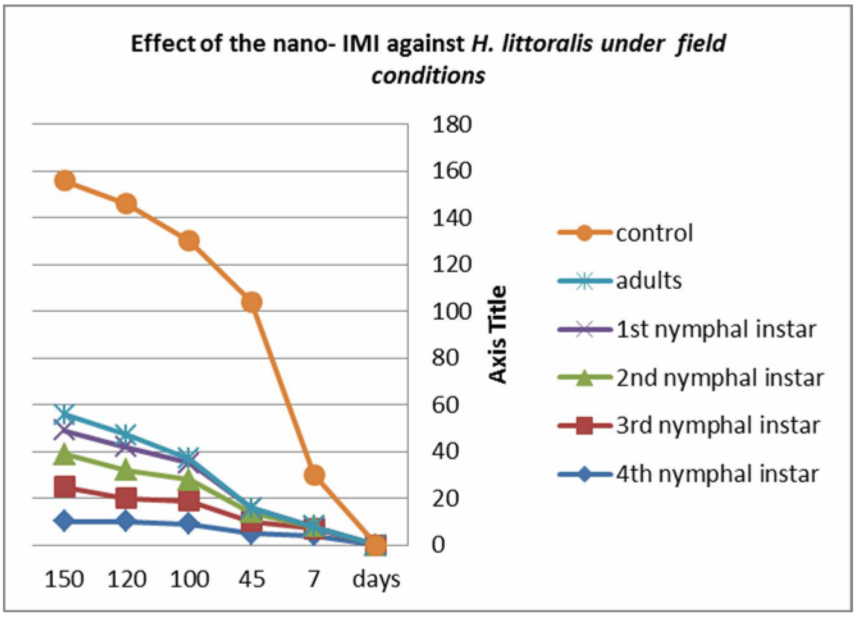

Fig (2) .Effect of the nano- IMI against *H. littoralis under field conditions*.

Economic evaluation of using nanotechnology for the maize crop in Egypt

The maize crop treatment by nanotechnology IMI subsequently leads to lessen the resulted in infection of locusts. Consequently, the crop acre will increase in the first and second production seasons by 3.8 tons and 3.9 tons. The increase is estimated by almost 31.8% and 81.3% compared to the control productivity amounted about 2.59 tons and 2.2 tons in the two production seasons respectively as shown in Table 4.

The economic evaluation of using nano on the maize crop entails investigating this evaluation at the farms and the republic levels. First, at the farms level: Table (5) indicates that treating maize by using the nano leads subsequently to increase the feddan productivity by 0.562 ton/feddan. The increase is estimated almost 16.8% compared to the republic average production amounted about 3.333ton/feddan. The increase includes as well the feddan net return by almost L.E. 1273 and the return on the invested pound by almost L.E. 0.3. The increase estimated about 39.5% and 17.2 successively compared to the feddan net return and the return on the invested pound at the republic level valued almost 3220 pound/feddan and about L.E. 1.74 as shown in the Table. Second, at the republic level, the feddan productivity increase subsequently leads to overall production increase amounted to 1.153 million tons. The total maize republic production reaches about 7.996 million tons contributing to reduce the amount and value of Egyptian maize imports estimated almost 22.2%. The imports amount and value reduced to 4.042 million tons and about $ US 1.455 billion Dollars[14]. The maize production increase contributed as well to increase the manufactured village from only the maize shanks and plants without stalks. It leads to the dried grains crop increase estimated about 4.09 ton/feddan. The increase is estimated almost 16.9% compared to the production amounted about 3.5 ton/feddan from the dried grains can be used as fodder for animals and poultry and thus increase the animal fodder production whose components depend on maize importing [15,16].

Table (5) Economic evaluation of using nano at the peasant level:

Return on invested pound	Net feddan return L.E	Total feddan costs L.E.	Total feddan revenues L.E.	Feddan revenue L.E.		Selling price		Feddan productivity		statement
				Value of secondary crop L.E	Value of main crop L.E	secondary L.E	main L.E	Secondary heap of hay /feddan	Main Feddan/ ton	
1.74	3220	4340	7560	346	7214	33	303	10.480	3.333	General average at the republic level*
2.04	4493	4340	8833	404	8429	33	303	12.243	3.895	Average of two production seasons**

Source :- (*)- Ministry of Agriculture - Research Center of Agricultural Institute of Agricultural Economics and Statistics Research - Bulletin of Agricultural Economics and Statistics in 2014. (**)-Calculated and collected from the table (4).

4. Discussion

The obtained results are similar to other studies which are carried out by [17] and [18] on their work on *C. capitata*. These results are also agree with work done by [19, 20, 21,22, 23, 24] Sabbour & Shadia Abd El-Aziz (2002, 2007, a&b, 2010, 2014 and 2015) they proved that the application with natural bioinsecticides against a lot insect pests could to increase the yield and decrease the infestation infestations with harmful insect pests. The same obtains meet with [2, 3,5, 25, 26, 27] who found that the usage of the nano natural products affect on the grasshoppers infestations and decreased the plant damages. Also, results were in accordance with [17] who reported that the virulence of *B. bassiana* against *C. capitata* ranged between 8 to 30% and decrease the infestation among the olive fruits. [18] recorded that *C. capitata* mortality ranged between 69 and 78% after bioinsecticides treatments [28, 29, 30].

The results were matched with those found by[31,32, 33, 34], when they controlled cereal aphids with entomopathogenic fungi. They found that the infestation was reduced after fungi applications under laboratory and field conditions. [23,24,25, 27], found that the fungi reduced insect infestations of cabbage and tomato pests under laboratory and field conditions.

[8, 25, 26] found that the natural product destruxin which extracted from the fungus *M. anisopliae* gave a good results in controlling *H. littoralis*. The finding in obtained by Sabbour, 2014 which recorded that the nano destruxin more effective on *H. littoralis* as compared with non nano.[9] used imidaclorprid against *H. littoralis* and decreased the infestation under semified and field conditions.

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