Plant Archives Vol. 19, Supplement 2, 2019 pp. 462-465 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

CONTROL OF BEET FLY *(PEGOMYA HYOSCYAMI)* (DIPTERA : ANTHOMYIDAE) USING CHITOSAN AND NANO CHITOSAN

Sabbour M.M.*[1] and Nayera Y. Soleiman[2]

[1,2] Department of Pests and Plant Protection, National Research Center, Egypt

[2]Economic, Department Agriculture Division, National Research Center, Egypt

*Corresponding author, e-mail: sabbourm@yahoo.com

Abstract

Sugar beet is considered one of the most important crops in Egypt because it was used in the production of sugar as it contains 15-20% sugar. *Pegomya hyoscyami* (*Diptera : Anthomyidae*); harmful insect pest causing a lot of damage of the sugar crop. Chitosan (CS)-g-poly (acrylic acid) (PAA) nanoparticles, which are well dispersed and stable in aqueous solution have been prepared by template polymerization of acrylic acid in chitosan solution which have an insecticidal effect on insect pests. The usage of chitosan and nano chitosan test against *P. hyoscyami*. Results showed that, the LC_{50} obtained 150 and 110 ppm after *P. hyoscyami* treated with different concentrations of chitosan and nano chitosan. Also, under field conditions when *P. hyoscyami* treated with the chitosan and nano chitosan, the number of eggs significantly 22±1.7 and 3±8.9 eggs/ female as compared to 266±8.7 eggs /female in the control. The percentage of egg hatching, larval mortality, malformed pupae and malformed adults significantly decreased in case of chitosan treatments and almost reduced after nano chitosan treatments. The weight of sugar beet significantly increased to 23.97±66.11 and 24.99±54.98 Ton/ feddan in case of chitosan treatments . the corresponding weight recorded 25.97±96.11 and 26.99±59.98 Ton/ feddan as compared to 1780±55.43 and 1220±45.09 Ton/ feddan in the control during season 2016 and 2017 respectively.

Keywords : Nano, chitosan, *Pegomya hyoscyami*, sugar beet, control.

Introduction

Sugar beet is considered one of the most important crops in Egypt because it was used in the production of sugar as it contains 15-20% sugar. The sugar beet has currently been infested with many insect pests which cause high losses in the crop yield and decrease its sugar content Bassyouny, (1993). Among these insects, *Pegomya hyoscyami* (***Diptera : Anthomyidae***). Chemical insecticides were used to control these insect pests, but they were always causing a lot of pollution to the environment (Goodwin *et al.,* 2007). Thereafter microbial control agents were advocated to be used against such pests. Chitosan (CS)-g-poly (acrylic acid) (PAA) nanoparticles, which are well dispersed and stable in aqueous solution have been prepared by template polymerization of acrylic acid in chitosan solution Sahab *et al.* (2014). The prepared CS-PAA had a white powder shape and was insoluble in water and diluted acid. Chitosan nanorod with minimum particle size of <100 nm was prepared by cross-linking low molecular weight chitosan with polyanion sodium tripolyphosphate and physicochemically characterized. Chitosan is a natural polysaccharide prepared by the N-deacetylation of chitin. It has been widely used in food and bioengineering industries, including the encapsulation of active food ingredients, in enzyme immobilization, and as a carrier for controlled drug delivery, due to its significant biological and chemical properties such as biodegradability, biocompatibility, bioactivity, and polycationicity. The aim of this work to evaluate the effectiveness of chitosan and nano chitosan against *Pegomya hyoscyami.*

Materials and Methods

Laboratory studies

The sugar beet insects *Pegomya hyoscyami;* was reared under laboratory conditions (26± 2 C^o and 60± 5 %RH) in cages 50X 50X 60 cm per each. The third larval stage was used in the experimental work.

Preparation of Nano-Chitosan

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

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 the Chitosan nanoemulsion is prepared by high-pressure homogenization of 2.5% surfactant and 100% glycerol, to create stable droplets which that increase the retention of the oil 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).

Efficacy of Chitosan Against the Target

The insecticide Chitosan and Nano chitosan were tested at the 6 concentrations: 6 ppm, 5ppm, 4ppm, 3ppm, 2ppm, 1ppm. The insecticide, prepared 6 concentrations. Percentages of mortality were calculated according to Abbott's formula, while the LC_{50} values were calculated throughout probit analysis (Abbott, 1925). The experiment was carried out under laboratory conditions at 26±2°C and 60-70% RH.

Field trials

The experiments were carried in El-Nobaryia), during the two successive seasons 2017 & 2018 starting from the 15th of November till the end of March to evaluate the efficacy of the tested Chitosan against the target insect pests under field conditions. Three random patches of sugar beet in an area about one feddan divided into plots each (40 m^2). four plots for each treatments and four for control (untreated). Chitosan were applied at 20 ppm, nano Chitosan applied at 5 ppm, control sprayed by water only. Examination were 40/plots/ treatments were carried out just before the first applications and seven days after last applications to calculate the average reductions percentage of target pests infestations. Twenty tuber of sugar beet transferred each week to the lab in order to investigate the infestations percentages after harvest, yield of each treatment was weighted as Kg/Feddan.

Statistical Analysis

Data obtained was statistical analysed using Duncan's multiple range tests according to (Finney, 1971) Data were statistically analyzed by *F*-test; LSD value was estimated, using SPSS statistical program software

Results and Discussion

Table 1 show that the LC_{50} obtained 150 and 110 ppm after *P. hyoscyami* treated with different concentrations of chitosan and nano chitosan. Table 2 show that when *P. hyoscyami* treated with the chitosan and nano chitosan, the number of eggs significantly 22±1.7 and 3±8.9 eggs/ female as compared to 266±8.7 eggs /female in the control decreased to 266±8.7 eggs/ female. The percentage of egg hatching, larval mortality, malformed pupae and malformed adults significantly decreased in case of chitosan treatments and almost reduced after nano chitosan treatments (Table 2).

The weight of sugar beet significantly increased to 23.97±66.11 and 24.99±54.98 Ton/ feddan in treated areas with chitosan. After sugar beet treated with nano chitosan the weight significantly increased to 25.97±96.11 and 26.99±59.98 Ton/feddan as compared to 17.80±55.43 and 12.20±45.09 Ton/ feddan in the control during season 2016 and 2017 respectively (Table 3).

The effect of different transactions on the expected economic and productivity efficiency of the sugar beet crop.

Productivity efficiency refer to the possibility of production increasing with using the same amount of productive resources, or obtaining the same production with using less of the productive resources ,which used in the production process. As shown in table (5), the treatment of sugar beet crop with using Chitosan and Nano chitosan can contribute to the productivity increasing of sugar beet crop feddan by about 12.503 tons/fed and about 16.081 ton/fed to reached about 34.172 tons/fed, and about 37.75 tons/fed with increasing rate of 57.7% and 74.21% in compared with the current productivity of fed which reached about 21.669 as shown in Table (4). The expected of productivity increasing contributes to the total production increasing of the crop by about 7 million tons and about 10 million tons, the total quantity produced reached about 19.1 million tons and about 22.1 million tons in compared with the total current production which reached about 12.1 million tons. Also the expected productivity of the feddan contributed to reduce the quantity of irrigation water by 67.5 m^3/ton and about 78.6 m^3/ton which contributing to the supply of about 2306.61 m^3/feddan and about 2967.15 m^3/feddan which representing about 42.3% and about 25.8% from the total irrigation water which needed by the total cultivated area which reached about 2.2 billion m^3 in case of treatment of sugar beet feddan with Chitosan and Nano chitosan respectively, as shown in Table (5).

While the economic efficiency expresses the acquisition of a larger amount of production with the same factors of production cost or access to the same production with lower production costs, as shown in Table (5) which the cost of producing tons of sugar beet crop decreased by 174.4 pounds / ton and about 203.1 pounds / ton in compared with the cost of ton in the current situation which reached about 476.7 pounds / ton, Which will result in a rise in the yield of the invested pound at about 0.605 pounds, and about 0.778 pounds, as well as the return of the pound value which reached about 83.353 pounds, and about 178.669 pounds in the case of treated beets beet fedan with Chitosan and Nano chitosan respectively, as shown in the table (5).

Economic returns of various transactions

Table (6) shows that the total production of sugar beet in 2017 reached about 12.107 million tons of beet which contributing to the production of about 1.114 million tons of sugar, while the treatment of fedan beet sugar using Chitosan and Nano chitosan contributed to increase the production of sugar quantity by 0.643 million tons, and about 0.827 million tons, Which could result in a surplus of sugar production of about 0.144 million tons, and about 0.328 million tons, which will be exported with an expected export value of about 88.239 million dollars, 201.15 million dollars.

Our findings meet with Sabbour and Nayera Soleiman 2014 who found that the bioinsecticides control the percentage of the sugar beet pests significantly decreased during both two successive season 2012 and 2013 after fungi treatments. Sabbour and Abd El Rahman (2007) found the bioinsecticide decrease *C. vaitta* under laboratory and field conditions. Sahab et al (2015) found that the nano chitosan have an insecticidal effect against *Aphis gossypii* under laboratory and field conditions.

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.

These results are in consistence with those obtained by Sabbour (2015a) 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 bioinsticid applications. Sabbour and Nayera Solieman 2017, reported that nano-biopesticides application increase the productivity of the olive fruits under field conditions. Also Sabbour and Nayera Soleiman (2016), control *Tuta absoluta* by nano chitosan and results showed a reduction in the infestation numbers. Sabbour (2016) use the nano chitosan against *Schistocerca gregaria* and found a loss of the number after treatments under laboratory and field conditions.

In conclusion, nano-formulation of chitosan was more effective than chitosan in controlling *Pegomya hyoscyami (*Diptera : Anthomyidae). These results encourage the extension in the use of nanotechnology for insect pest control.

Acknowledgment

National research center supported project No 11030139

Table 1: Evaluation of, tested chitosan and Nano chitosan on *Pegomya hyoscyami* under laboratory conditions

Treatments	LC_{50} *ppm*	*S*	*V*	95% C*onfidence limits*
chitosan	150	0.1	1.4	88-163
Nano chitosan	110	1.1	1.1	90-149

Table 2: Effect of the against the target insects *P. hyoscyami* biology

Treatments	No of eggs laid/female	% of egg hatching	% of larval mortality	% of malformed larvae	% of malformed pupae	% of emerged adults	% of malformed adults
chitosan	22±1.7[b]	4	61	66	77	3	78
Nano chitosan	3±8.9[c]	0	91	97	94	0	0
Control	266±8.7[a]	99	-	-	-	100	-
F value	33.4	2	5	5	22	21	21
Lsd5%	11.1	2	3	3	11	11	9

Table 3: Assessments of damage caused after treatment with the chitosan Nano chitosan

Target pest	Season 2016 Wt Ton. of sugar beet (Ton/F) feddan)	Season 2017 Wt.Ton. of sugar beet (Ton/ F)
Chitosan	23.97±66.11	23.97±66.11
Nano chitosan	25.97±96.11	26.99±59.98
Control	17.60±85.43	12.80±47.09

Table 4 : Comparison of the productivity of different transactions during the average of two agriculture seasons

Treatment	Season 2016	Season 2017	Average two seasons	Average% increase in productivity
Chitosan	23.97	23.97	23.97	57.70
Nano chitosan	25.97	26.99	26.48	74.21
Control	17.60	12.80	15.2	-

Source: Calculated and collected from the table (3)

Table 5 : The effect of Chitosan and Nano Chitosan using on the Productivity and Economic Efficiency of Sugar beet Crop

Statement		Treatment	
		Chitosan	Nano chitosan
The cultivated area/1000 feddan	558.687	558.687	558.687
Production of feddan/ ton	21.669	34.172	37.750
Total production/1000 tons	12106.661	19091.452	21090.434
The quantity of water/m^3 of ton beet	184.596	117.055	105.960
Quantity of water /m^3 of ton sugar	13.671	10.769	9.748
The amount of sugar production / 1000 tons	1113.813	1756.414	1940.320
production costs of ton	476.718	302.294	273.642
Return of tons	500.0	500.0	500.0
Net Revenue/Ton	23.282	197.706	226.358
Return of the investment pound	1.049	1.654	1.827
Cost of transaction/feddan	-	75	45
productivity increasing / feddan	-	12.503	16.081
Return output increasing/ pounds	-	6251.5	8040.1
Net return on production increasing	-	6176.5	7995.1
Return of the pound of value added		83.353	178.669

Source: Calculated and collected from the statistics of the Ministry of Agriculture and Land Reclamation-Annual Bulletin, the website of the Arab Organization for Agricultural Development, and the website of the Central Agency for Public Mobilization and Statistics

Table 6 : The economic returns for the using of different treatments on the sugar beet crop in Egypt

Statement 2017		**The expected production transaction**	
		Chitosan	**Nano chitosan**
The amount of sugar beet production / 1000 tons	12106.661	19091.452	21090.434
The amount of sugar production / 1000 tons	1113.813	1756.414	1940.320
The Quantity of sugar imports/ 1000 tons	498.89	-	-
The value of sugar imports / million dollars	422.81	-	-
The Quantity of sugar surplus / 1,000 tons	-	143.711	327.617
The value of sugar surplus / million dollars	-	88.239	201.157

Source: The Arab Organization for Agricultural Development (AOAD) website - FAO website - United Nations website

References

Abbbott, W.S. (1925). A method of computing the effectiveness of an insecticide. *J. Econ. Ent.,* 18: 265-267. (15) Finney, D. J., 1964. Probit analysis. 2nd Ed., Cambridge. Univ. Press. England. 318 PP.

Bassyouny, A.M. (1993). Studies on preferability and injury level of some main insects to certain sugar beet varieties in *Egypt. J. Appl*. Sci. 8: 213-219.

Finney, D.J. (1971). Probit Analysis, Cambridge: Cambridge University Press.

Goodwin, B.; Babb, T.; Kaffka, S. and Godfrey, L. (2007). Biorational management of beet armyworms in sugar beets in the Central Valley, Larry Godfrey and Tom Babb. http//sugar beet. Ucdavis.edu.2007.

Nurruzzmzn, N.; Rahman, M.M.; Liu, Y. and Nadidur, R. (2016). Nanoencapsulation, Nano-guard for Pesticides: A New Window for Safe Application. J Agric Food Chem. (7): 1447-83.

Sabbour, M.M. (2015a). Nano-Imidaclorprid Against Three Olive PestsUnder Laboratory and Field Conditions Open Science Journal of Bioscience and Bioengineering, 2(5): 45-49.

Sabbour, M.M. (2015b). The Toxicity Effect of Nano Fungi *Isaria fumosorosea* and *Metarhizium flavoviride* Against the Potato Tuber Moth, *Phthorimaea operculella* (Zeller). American Journal of Biology and Life Sciences. 3(5):155-160.

Sabbour, M.M. (2016). Observations of the effect of Chitosan and its nano compositions against the locust *Schistocerca gregaria* (Orthoptera: Acrididae). International Journal of Chem Tech Research., 9(06): 270-276.

Sabbour, M.M. and Abdel-Rahman, A. (2007). Evaluations of some terpenes and entomopathogenic fungi on three sugar beet insect pests. J. Boil. Pest. Cont., 17: 22-29.

Sabbour, M.M. and Nayera, Y.S. (2014). Determinations of the entomopathogenic fungus *Beauveria brongniartii* on three sugar beet pests. European Journal of Academic Essays, 2(10): 23-28.

Sabbour, M.M. and Nayera. Y.S. (2016). The efficacy effect of using chitosan and nano-chitosan against *Tuta absoluta* (Lepidoptera: Gelechiidae) Journal of Chemical and Pharmaceutical Research, 8(3): 548-554.

Sahab, A.F.; Waly, A.I.; Sabbour, M.M. and Lubna S.N. (2015). Synthesis, antifungal and insecticidal potential of Chitosan (CS)-g-poly (acrylic acid) (PAA) nanoparticles against some seed borne fungi and insects of soybean. International Journal of ChemTech Research, 8(2): 589-598.

Vidhyalakshmi, R.; Bhakyaraj, R. and Subhasree, R.S. (2009). Encapsulation "The Future of Probiotics"-A Review. Advances in Biological Research. (4): 96-103.