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Studies on the Nano chemicals and conventional chemicals against *Helicoverpa armigera* (Hubner) on chickpea (*Cicer arietinum* L.)

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Abstract
The present study entitled "Studies on the Nanochemicals and conventional chemicals against *Helicoverpa armigera* (Hubner) on Chickpea (*Cicer arietinum* L.)" was conducted to determine the efficacy and dose-response relationship of Nanochemicals in comparison to few conventional and widely used insecticides against IInd and Vth instar larvae of *Helicoverpa armigera* (Hub.). The efficacy of copper, silver, manganese and neem seed kernel extract (NSKE) in Nanoform (30-50nm) and conventional chemicals viz., imidacloprid and Neem Hakeem was assessed on IInd and Vth instar larvae of *H. armigera* (Hub.). The respective Nanochemicals were evaluated @ 1:10, 1:100, 1:200, 1:500, 1:1000 and 1:2000 dilutions by topical spray method. The lower dilutions were found more efficacious and produced the maximum mortality of both instar larvae. Among four Nanochemicals and two conventional chemicals, Nano-silver was found comparable to imidacloprid. The chemicals were found more toxic to IInd instar larvae, Nano-silver and imidacloprid caused 83.33% and 86.66% mortality at 1:10 dilution, which was maximum in all chemicals. The Vth instar larvae showed less susceptibility towards these chemicals and caused 70% and 76% mortality with respective chemicals. Nano NSKE and Neem Hakeem produced the minimum mortality i.e., 66% and 63% on IInd instar larvae and 53% and 56% mortality of Vth instar larvae at same dilution on 4th day of exposure. The other Nanochemicals like Nano-manganese and Nano-copper exhibited the intermediate effect on larval killing. The LC_{50} values computed for manganese, silver, copper and NSKE, neemhakeem and imidacloprid on IInd instars were 0.0032, 0.013, 0.012 0.047, 1.057, 0.054, respectively. Whereas the LC_{50} values of respective chemicals on Vth instar larvae were 0.098, 0.061, 0.078, 0.082, 1.573 and 0.058. During the periods of heavy infestation, Nanosilver and Nano NSKE (30-50 nm) can be applied as protective measures. Nanoparticles were found effective in this study, therefore the work on enhancing the usefulness and commercialization of Nanoparticles could be a better alternative over conventional insecticides.

Keywords: chickpea, nanochemicals, *helicoverpa armigera*, conventional chemicals

Introduction
Pulses are an integral part of Indian cropping system, economy and diet. They are the major source of dietary proteins for vegetarian peoples. Chickpea, (*Cicer arietinum* L.) is an important pulse crop in India and generally cultivated for its dried seeds. According to food and agricultural organization (FAO) statistics for 1996-2005, the chickpea area averaged nearly 11 million hectares worldwide (1.2% of total crop area) with 8 million tonnes (0.34%) production. India is one of the largest producers of field chickpea in the world, it contributes around 7% in the world's total produce with the production figures of chickpea (~13.1 MT),. Inspite of the suitable condition for the better cultivation of chickpea many factors are responsible for its low yield. Among the various factors, the insects major cause in depletion of chickpea production in the world. The most common insect of chickpea is gram pod borer (*Helicoverpa armigera*), which causes the most harm to the chickpea followed by pod fly; wilt and root rot (Begum *et al.*, 1992) [1]. Gram pod borer is a highly polyphagous pest feeds on chickpea (Ahmad *et al.*, 1989) [2], pigeon pea (Sreekanth and Lakshmi, 2012) [3], cotton, okra. The species is migratory and a key pest on all continents with minimum of 200 reported hosts (Pawar, 1998) [4]. Manjunath *et al.*, (1989) [5] reported 180 plant species from 45 different families as hosts including a number of important crops like cotton, tobacco, tomato, gram, grain, sorghum, maize, lucerne seed, sunflower, wheat and pea from India.

Damage potential of this pest is so great that an average infestation of single larva may destroy 30-40 pods/plant in chickpea and the pod damage fluctuates from 0-84% across India (Srivastava *et al*., 2005) [6].

Pesticides are often considered a quick, easy, and inexpensive solution for controlling insect pests. Application of pesticides on crops causes serious health hazards to man, contamination in the food stuffs, soil, water, vegetation and environment. In addition to killing insects, pesticides can be toxic to a host of other organisms including birds, fish, beneficial insects, and non-target organism, apart from the decline in soil fertility. Therefore, Nanotechnology would provide green and efficient alternatives for the management of insect pests in agriculture without harming the nature. This art is focused on traditional strategies used for the management of insect pests and potential of Nanomaterials in insect pest control as modern approaches of Nanotechnology (Ragaei *et al*., 2014) [7].

Material and methods

Geographical features of experimental site

The present study was carried out under field and laboratory conditions in the Department of Plant Protection, Aligarh Muslim University, Aligarh, during Rabi season of 2015-16. It is located in the western part of the state of Uttar Pradesh at a distance of about 126 km from Delhi, the capital of India. It spread from 2729 to 2810° N latitude and 7729° E latitude. The climate of region is of subtropical type, with hot and dry winters. The procedure adapted during the present studies is given following section.

Field preparation for chickpea cultivation

The experimental field was prepared by following all agronomic practices required, total 50 plots were used for sowing of two varieties of chickpea. The seeds of chickpea were sown on 24th of October, 2015. The row to row distance was maintained as 45 cm while plant to plant was 10 cm with a seed depth of about 10 cm. The crop was monitored regularly for the attack of the chickpea pod borer *Helicovera armigera* (Hub.).

Efficacy of Nanochemicals on mortality of *Helicovera armigera* (Hub.)

The Nanochemicals containing neem seed kernel extract, copper, silver and manganese were obtained from centre of Excellence in Material science, Department of Applied Physics, Aligarh Muslim University, Aligarh. The market available conventional chemicals like neem and imidacloprid were compared with the efficacy of Nanochemicals on pod borer larvae. In order to evaluate the bio-efficacy of supplied Nanochemicals various Nanoformulations (1:10, 1:100, 1:200, 1:500, 1:1000 and 1:2000) containing one ml of respective Nanochemicals with distilled water were prepared. The prepared Nanoformulations were tested under laboratory (25-27 ˚C, 60-70% RH) conditions and the efficacy was evaluated on IInd and Vth instar larvae. The stock culture of larvae was maintained in laboratory conditions. The individual larvae were kept in petri plates of size of size 90 × 12 mm in diameter. The respective grades of chemicals were sprayed on larval body with the help of hand atomizer and each experiment was replicated three times. The observations on mortality was taken after 2nd, 3rd and 4th day of exposure and the control experiment (water sprinkled) was operated parallel to the main experiment.

Table 1: Conventional chemicals

S. No	Formulation	Source	Type
1	Imidacloprid	Dhanuka Agritech Pvt. Ltd.	EC
2	Neem Hakeem	Reidel Chemicals Pvt. Ltd	EC

Table 2: Nanochemicals

S. No	Nanochemicals				Place of procurement
	Copper	Manganese	Silver	Neem seed kernel extract	
1	1:10	1:10	1:10	1:10	Centre of Excellence in Material Science, Department of applied Physics, Aligarh Muslim University, Aligarh, UP, India.
2	1:100	1:100	1:100	1:100	
3	1:200	1:200	1:200	1:200	
4	1:500	1:500	1:500	1:500	
5	1:1000	1:1000	1:1000	1:1000	
6	1:2000	1:2000	1:2000	1:2000	

Statistical analysis

The data collected on mortality was analysed by using MS excel, 2007, to calculate the per cent mortality. The data pertaining to mortality was subjected to Probit analysis and LC_{50} values of respective chemicals calculated by statistical software SPSS version 16.

Results and discussion

Bio-efficacy of chemicals on IInd instar larvae of *Helicoverpa armigera* (Hubner)

Nano-silver

The efficacy of silver Nanochemicals was assessed on second instar larvae of gram pod borer, *Helicoverpa armigera* (Hub.). Regarding concentrations, the low dilutions were observed highly effective, 1:10 concentration revealed significantly the maximum mortality (83.33±3.20%) followed by 1:100 (76.66±3.50%), 1:200 (70.00±2.00%), 1:500 (66.66±2.50%), 1:1000 (53.33±1.15%), 1:2000 (40.00±2.00%). While comparing the time factor, mortality was observed increasing with increase in days of application. The mortality was observed low at early (2nd day) stage (40.00±0.50) of exposure and increased in subsequent days (3rd and 4th day) of observations. The LC50 value was calculated 0.013 with regression coefficient 0.330.

Nano-manganese

With regard to efficacy, manganese produced 70.00±3.50% mortality at 1:10 dilution after 4th day of exposure. Whereas, it was recorded minimum 16.66±1.00% at 1: 2000 dilution after 2nd day of treatment. In subsequent day of exposure, manganese produced 50.00±0.00% mortality at 1:10 dilutions followed by 36.66±.058%, 36.66±1.52%, 26.66±2.51%, 23.33±0.20%, 20.00±2.08% at 1:100, 1:200, 1:500, 1:1000 and 1:2000 dilution, respectively. The LC_{50} for manganese was recorded 0.032 with 0.398 regression coefficient on final day of observation (4th day).

Nano Neem seed kernel extract (Nano NSKE)

The larvae showed a sort of resistivity towards Nano NSKE, and the results on efficacy revealed 23.33±1.52%, 33.33±0.58% and 66.66±1.52% mortality at 1:10 dilution after 2nd, 3rd and 4th day of exposure. On the other hand, it caused 10.00±0.10%, 13.33±1.52% and 16.66±1.15% mortality at 1:2000 dilution on respective days of treatment. The LC_{50} and regression coefficient computed for Nano NSKE was 0.047 and 0.546 respectively.

Nano-copper

Nano-copper showed very high mortality even at high dilutions. During first observations (2nd day), it exhibited 36.66±2.00% mortality, followed by 40.00±2.00% and 76.66±1.52% mortality on 3rd and 4th day of exposure period. With regard to dilution factor, Nano-copper produced maximum 76.66±1.52% mortality on at 1:10 dilutions, whereas, 33.33±1.54% mortality at 1:2000 concentration. The corresponding values of LC_{50} regression coefficient was calculated as 0.012 and 0.037.

Imidacloprid

The treated larvae were found highly susceptible against Imidacloprid, it exhibited maximum mortality 86.66±0.00% after 4th day of application. Regarding concentrations, 1:10 dilution caused 66.66±1.52% killing of 2nd instar larvae, however, 1: 2000 produced 30.00±1.73% mortality on 2nd day of exposure. On the other hand, it showed 86.66±0.00% and 46.66±1.52% mortality at recpective dilutions after 4th day of treatment. Imidacloprid illustrated 0.054 LC_{50} value with 0.038 as regression coefficient.

Neem Hakeem

The exposed larvae exhibited relatively resistant behavior against conventional Neem insecticide. It produced 3.00±0.00% mortality on next day of observation at 1: 2000 dilution, which raised to 10.00±1.00% in subsequent day of exposure. The maximum mortality was seen at 1:10 dilution after 2nd day of application, followed by 36.66±0.58% and 63.33±1.15% on 3rd and 4th day of exposure. The results revealed the maximum LC_{50} 1.057 for neem with 0.503 as regression coefficient value (Table).

Bioefficacy of chemicals against Vth instar larvae of *Helicoverpa armigera* (Hubner)

Nano-Silver

The performance of silver Nanochemical was evaluated on Vth instar larvae of *Helicoverpa armigera* (Hub.) under laboratory conditions. The exposed larvae exhibited high susceptibility with Nano-silver. At different concentrations, the mortality ranges between 10.00± 1.00% to 43.33±1.15% at 1:2000 dilution. On the other hand, it varied between 33.33±1.52% to 70.00±2.00% at 1: 10 dilutions. With regard to observations on exposure period, Nano-silver revealed the highest mortality (70.00±2.00%) at 1:10 dilution on 4th day of treatment. Whereas the minimum mortality 10.00±1.00% at 1: 2000 dilution on 2nd day of treatment. The LC_{50} value for Nano-silver was computed as 0.03 with 0.269 as regression coefficient.

Nano-manganese

Of all concentrations of Nano-manganese, the low dilution (1:10 to 1:200) exhibited the mortality in the range of 33 to 60%. It exhibited significant impact on mortality and produced 60.00±3.00% killing after 4th day of exposure, followed by 56.66±1.15%, 50.00±1.00%, 43.33±1.15%, 36.66±0.58% and 33.33±0.58% mortality, at 1:100, 1:200, 1:500, 1:1000 and 1:2000, respectively. The least LC_{50} value was calculated as 0.098, with 0.356 regression coefficient.

Nano NSKE

With regard to efficacy of Nano NSKE, it produced moderate mortality. The significant killing was achieved after 3 days of application. On 2nd day of exposure, only 6.66±0.58% mortality was recorded but subsequently increased to 10.00±1.00% and 23.33±0.58% after 3rd and 4th day, respectively at 1:2000 dilution. The time factor impacted well at 1:10 (26.66±1.00%) and 1:200 (16.66±1.15) dilutions resulting to insignificant difference of mortality after 4th day of treatment. The least susceptibility of larvae was observed at 1:2000 dilution, causing minimum mortality (23.33±0.58%). The LC_{50} value and regression coefficient calculated were 0.082 and 0.308.

Nano-copper

In general, the mortality produced by Nano-copper was significantly high at low dilutions (1:10, 1:100, 1:200). However, the highest mortality (30.00±1.00%) was recorded at 1: 10 dilutions after 2nd day of treatment (Table). The respective values after 3rd and 4th day of exposure were 40.00±3.50%, and 66.66±4.15%. The least impact was recorded at 1: 2000 dilution as evident from low range of mortality (10 to 36%). The LC_{50} and regression coefficient computed for Nano copper were 0.078 and 0.386, respectively.

Imidacloprid

As far as the efficacy of imidacloprid was concerned, it produced high mortality (63.33±1.52%) even at early stage (2nd day) of exposure. The results revealed the high efficacy at all concentrations, but it caused the maximum killing (76.66±5.70%) at 1:10 dilution. While comparing the time factor, the minimum mortality (26.66±2.50%) was observed on 2nd day of observation and maximum (43.33±3.00) on 4th day of exposure. The computation of LC_{50} and regression coefficient value revealed 0.051 and 0.280, respectively.

Neem Hakeem

When larvae were exposed to Neem Hakeem, the mortality varied between 16 to 56% at 1:10 dilution and 3 to 10% at 1:2000 dilution. On next day of observation, significantly the maximum (16.66±2.50) mortality was recorded at 1:10 dilution and minimum (03.33±0.50) at 1:2000 dilution. Interestingly, no significant variation was seen in per cent mortality at 1:1000 and 1:2000 dilution. Similarly, the mortality recorded in subsequent days witnessed the highest larval killing at 1: 10 dilutions, followed by 43.33±4.00%, 40.00±3.25%, 36.66±3.25%, 20.00±2.10%, 10.00±1.50% at 1:100, 1:200, 1:500, 1:1000 and 1:2000, respectively. The LC_{50} and regression coefficient values computed for this formulation were 1.573 and 0.465, respectively.

Synthetic insecticides have toxic effects and are dangerous to human health, these insecticides when applied to crops against some pests also remain in form of residues (Hussaina & Siddique, 2010) [8]. In addition to reduction in the environmental pollution, use of these natural chemicals in place of conventional pesticides would conserve non-target organisms and reduced pest resurgence as compared to the conventional compounds. While comparing the efficacy of Nanochemicals viz., silver, copper, manganese, and NSKE with conventional chemicals i.e., Imidacloprid and Neem Hakeem, the treated pod borer larvae were found susceptible against all Nanochemicals and conventional chemicals but, Nano-silver was recorded superior among all Nanochemicals and its efficacy found comparable to that of imidacloprid.

In present investigation, IInd and Vth instar larvae (treated) showed similar susceptibility for chemicals, imidacloprid showed the highest mortality of both larval stages. The chemicals exhibited the efficacy in order of imidacloprid> silver> copper> manganese> neem seed kernal extract> Neem

Hakeem. The high mortality due to these chemicals is in agreement with the findings of Subramanyam and Roesli (2000) [9] and Arthur (2002) [10]. While evaluating the performance of silver Nanoparticles on fungal pathogen (Gajbhiye *et al*., 2009) [11]; silver Nanoparticles on entomopathogenic nematode *Heterorhabditis bacteriophora* (Kucharska and Pezowicz, 2009) [12].

Regarding the morphological and behavioural changes in treated larvae were concerned, the IInd instar larvae became sluggish as immediate effect of chemicals, then the stoppage of feeding was recorded within few hours of exposure. The larval body showed shrinkage symptoms and blackening was exhibited at later stage of treatment. Similar morphological appearance in Vth instar treated individuals was seen with all Nano-chemicals except the size of larvae which was found relatively less affected due to the large body size of Vth instar larvae. On the other hand, Nano NSKE treated individuals didn't produced the colour variation and change in larval morphology which could have been due to their organic and less toxic nature. The results were in great conformity with findings of who mentioned the greater efficacy of due to its smaller particle size and greater surface to volume ratio, which could have increased the area of contact between the particle and the insect. The LC_{50} values calculated for each of Nanoformulations and conventional chemicals did not show remarkable variation both for IInd and Vth instar larvae of *Helicoverpa armigera* it however increased slightly from IInd instar to Vth instar larvae. The LC_{50} values followed the same order (NSKE > neem>manganese > copper > silver >imidacloprid) of toxicity on both larval stages.

The Nanochemicals and conventional chemicals have adverse effect on feeding habit of tested insect species towards the treated food source, the chemicals exhibit the antifeedant properties toward the juvenile forms of *Helicoverpa armigera* exposed to treated leaves, which provides a strong evidence that these chemicals can be used as insecticides which can act as feeding deterrent for insects. The larvae of *H. armigera* did not show any preference towards the food source. The juveniles undergo to pupation after feeding on the treated leaves but failed to be emerge and turned to dirty black in colour. The result suggests that conventional chemical imidacloprid and Nanochemicals of silver, manganese, NSKE, copper, and Neem Hakeem may provide a good alternative to manage this insect. Nanochemicals provides a broad area of research studies, understanding the toxicity effect and mode of action of applied chemical on target and non-target insect species. Study on Nanochemicals and conventional chemicals should be done to determine whether the particle size, mineral composition, or structure are responsible for the efficacy of tested formulations.

Table 1: Efficacy of chemicals on Vth instar larvae of *Helicoverpa armigera* (Hub.)

Chemicals	Concentration	2nd Day	3rd Day	4th Day
	1:10	33.33±1.52	46.66±1.52	70.00±2.00
	1:100	26.66±0.58	43.33±0.57	66.66±1.52
Nano-silver	1:200	20.00±1.00	40.00±1.00	63.33±0.58
	1:500	16.66±0.58	36.66±0.58	56.66±1.15
	1:1000	13.33±1.52	33.33±0.58	50.00±1.00
	1:2000	10.00±1.00	30.00±1.15	43.33±1.15
	1:10	26.66±0.58	36.66±0.58	60.00±3.00
	1:100	23.33±1.52	33.33±0.58	56.66±1.15
Nano-manganese	1:200	20.00±1.00	30.00±2.64	50.00±1.00
	1:500	16.66±1.15	26.66±2.51	43.33±1.15
	1:1000	13.33±0.58	20.00±0.20	36.66±0.58
	1:2000	10.00±1.00	16.66±2.08	33.33±0.58
	1:10	26.66±1.00	30.00±1.00	53.33±1,15
	1:100	20.00±1.15	30.00±1.73	50.00±1.00
Nano NSKE	1:200	16.66±1.15	26.66±1.15	46.66±0.58
	1:500	13.33±1.52	20.00±1.73	40.00±1.00
	1:1000	10.00±0.00	13.33±0.58	33.33±0.58
	1:2000	06.66±0.58	10.00±1.00	23.33±0.58
	1:10	30.00±1.00	40.00±3.50	66.66±4.15
	1:100	26.66±2.00	33.33±2.00	60.00±1.00
Nano-copper	1:200	23.33±0.58	30.00±1.00	56.66±0.57
	1:500	20.00±1.00	26.66±1.00	50.00±1.73
	1:1000	13.33±0.58	23.33±0.58	43.33±0.58
	1:2000	10.00±1.00	20.00±1.00	36.66±1.52
	1:10	63.33±4.52	70.00±1.00	76.66±5.70
	1:100	56.66±4.58	66.66±2.58	73.33±4.50
Imidacloprid	1:200	50.00±3.00	53.33±2.51	70.00±3.00
	1:500	40.00±3.73	46.66±2.30	63.33±3.15
	1:1000	30.00±2.50	40.00±1.00	56.66±2.50
	1:2000	26.66±2.50	36.66±2.58	43.33±3.00
	1:10	16.66±2.50	23.33±0.58	56.66±4.50
	1:100	13.33±1.58	20.00±1.73	43.33±4.00
Neem Hakeem	1:200	10.00±1.25	16.66±0.58	40.00±3.25
	1:500	06.66±0.50	13.33±1.54	36.66±3.25
	1:1000	03.33±0.50	10.00±1.00	20.00±2.10
	1:2000	03.33±0.50	06.66±0.58	10.00±1.50

Mean±S.D

Table 2: Efficacy of chemicals on II[nd]instar larvae of *Helicoverpa armigera* (Hub.)

Chemicals	Concentration	2nd Day	3rd Day	4th Day
	1:10	40.00±0.50	50.00±3.58	83.33±3.20
	1:100	36.66±0.58	40.00±3.58	76.66±3.50
Nano-silver	1:200	33.33±2.30	36.66±2.30	70.00±2.00
	1:500	33.33±0.57	33.33±1.58	66.66±2.50
	1:1000	20.00±1.00	33.33±1.5-0	53.33±1.15
	1:2000	16.66±1.00	30.00±2.50	40.00±2.00
	1:10	43.33±1.52	50.00±0.00	70.00±3.50
	1:100	26.66±1.52	36.66±.058	63.33±2.15
Nano-manganese	1:200	26.66±1.00	36.66±1.52	56.66±2.58
	1:500	20.00±1.54	26.66±2.51	46.66±3.00
	1:1000	18.66±0.58	23.33±0.20	40.00±2.00
	1:2000	16.66±1.00	20.00±2.08	33.33±2.58
	1:10	23.33±1.52	33.33±0.58	66.66±1.52
	1:100	20.00±2.00	33.33±2.51	50.00±1.00
Nano NSKE	1:200	16.66±1.52	30.00±1.73	43.33±1.15
	1:500	13.33±1.52	23.33±3.21	36.66±0.58
	1:1000	13.33±0.57	16.66±1.15	30.00±1.00
	1:2000	10.00±0.10	13.33±1.52	16.66±1.15
	1:10	36.66±2.00	40.00±2.00	76.66±1.52
	1:100	33.33±0.57	36.66±0.57	70.00±1.00
Nano-copper	1:200	30.00±1.52	36.66±1.52	66.66±1.15
	1:500	26.66±1.52	33.33±1.52	60.00±1.73
	1:1000	23.33±0.58	26.66±0.58	43.33±0.58
	1:2000	20.00±0.58	23.33±0.58	33.33±1.54
	1:10	66.66±1.52	73.33±0.58	86.66±0.00
	1:100	56.66±0.57	60.00±1.00	80.00±1.00
Imidacloprid	1:200	50.00±1.00	56.66±2.51	76.66±1.15
	1:500	40.00±1.73	46.66±3.78	73.33±0.58
	1:1000	33.33±1.52	40.00±1.00	60.00±1.73
	1:2000	30.00±1.73	36.66±2.51	46.66±1.52
	1:10	30.00±1.73	36.66±0.58	63.33±1.15
	1:100	30.00±1.00	30.00±0.30	46.66±1.52
Neem Hakeem	1:200	26.66±0.58	26.66±1.52	40.00±1.73
	1:500	20.00±1.00	26.66±1.73	40.00±1.00
	1:1000	13.33±0.58	16.66±0.58	23.33±0.58
	1:2000	03.00±0.00	10.00±1.00	10.00±0.10

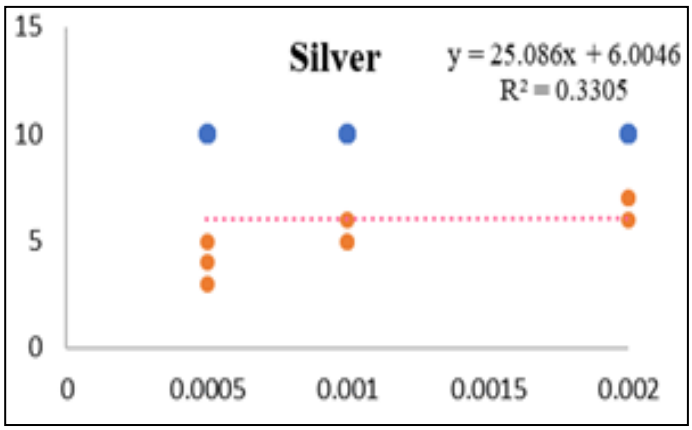
Mean±S.D

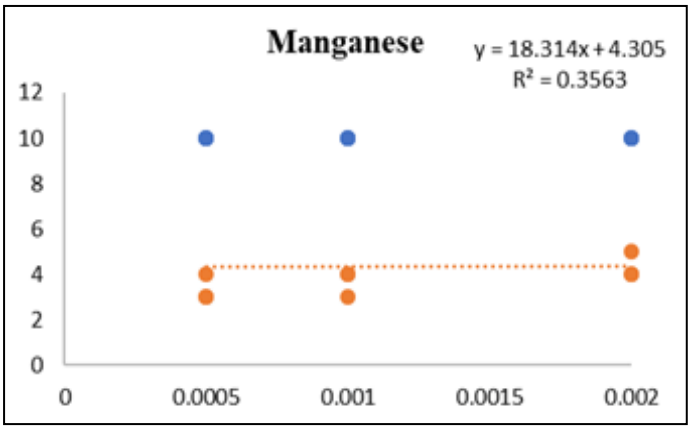
Table 3: Probit analysis of chemicals on II[nd] instar larvae of *Helicoverp aarmigera* (Hub.)

Chemicals	Equation	R^2	LC_{50}	X^2
Nano-silver	y = 25.086x + 6.0046	0.3305	0.013	8.94
Nano-manganese	y = 24.958x + 4.6738	0.3988	0.032	12.56
Nano NSKE	y=34.521x + 3.3738	0.5467	0.047	10.21
Nano-copper	y = 25.257x + 5.3345	0.3074	0.012	13.55
Imidacloprid	y = 22.069x + 6.6197	0.3081	0.054	11.69
Neem Hakeem	y = 34.628x + 3.0383	0.5039	1.057	12.89

Table 4: Probit analysis of chemicals on V[th] instar larvae of *Helicoverpa armigera* (Hub.)

Chemicals	Equation	R^2	LC_{50}	X^2
Nano-silver	y = 16.121x + 5.5149	0.2699	0.061	6.8
Nano-manganese	y = 18.314x + 4.305	0.3563	0.098	5.78
Nano NSKE	y = 16.945x + 3.7764	0.3081	0.082	6.37
Nano-copper	y = 19.555x + 4.836	0.3867	0.078	5.69
Imidacloprid	y = 17.769x + 6.038	0.2808	0.058	7.99
Neem Hakeem	y = 29.739x + 2.8571	0.4651	1.573	11.51





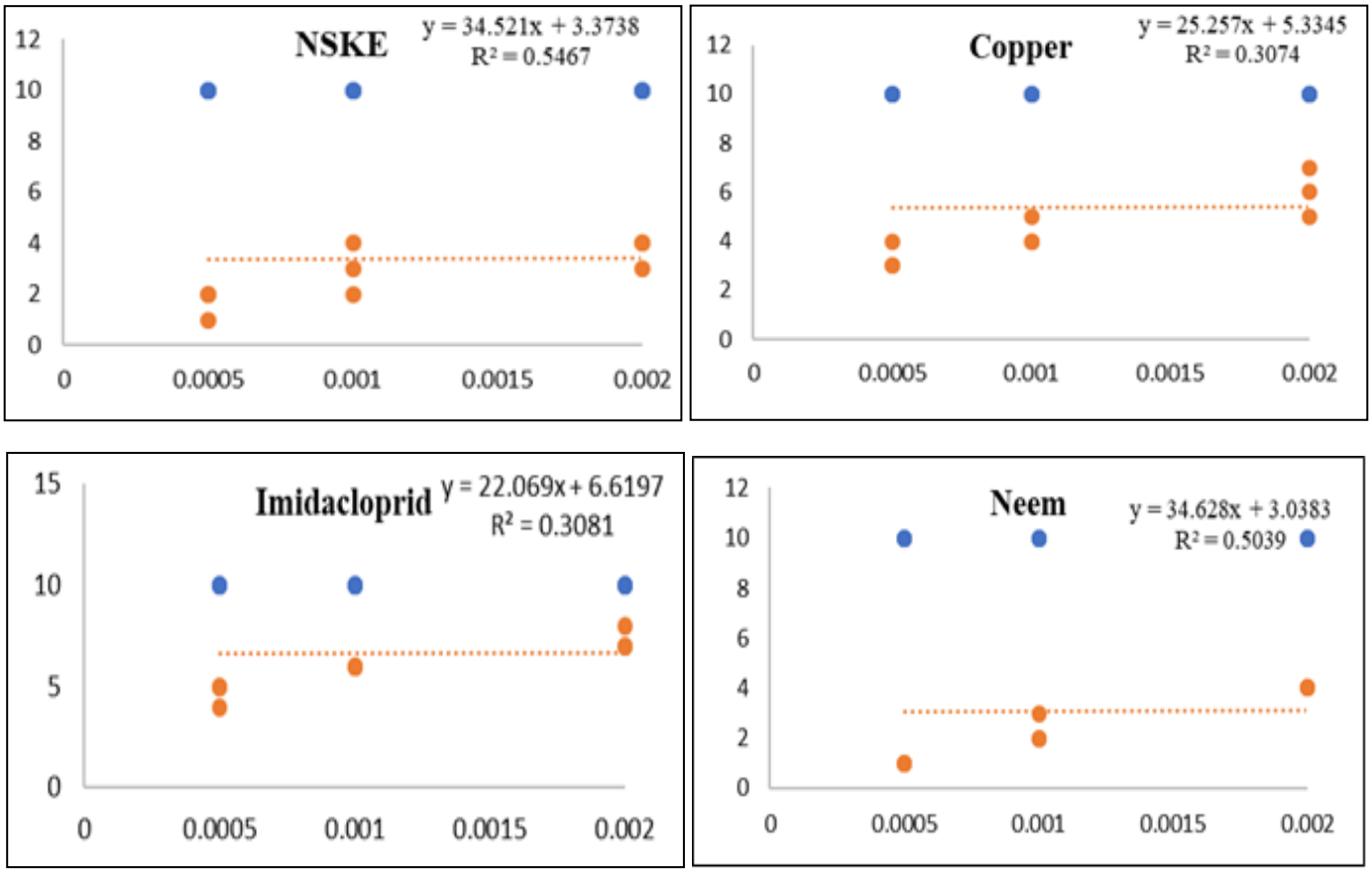
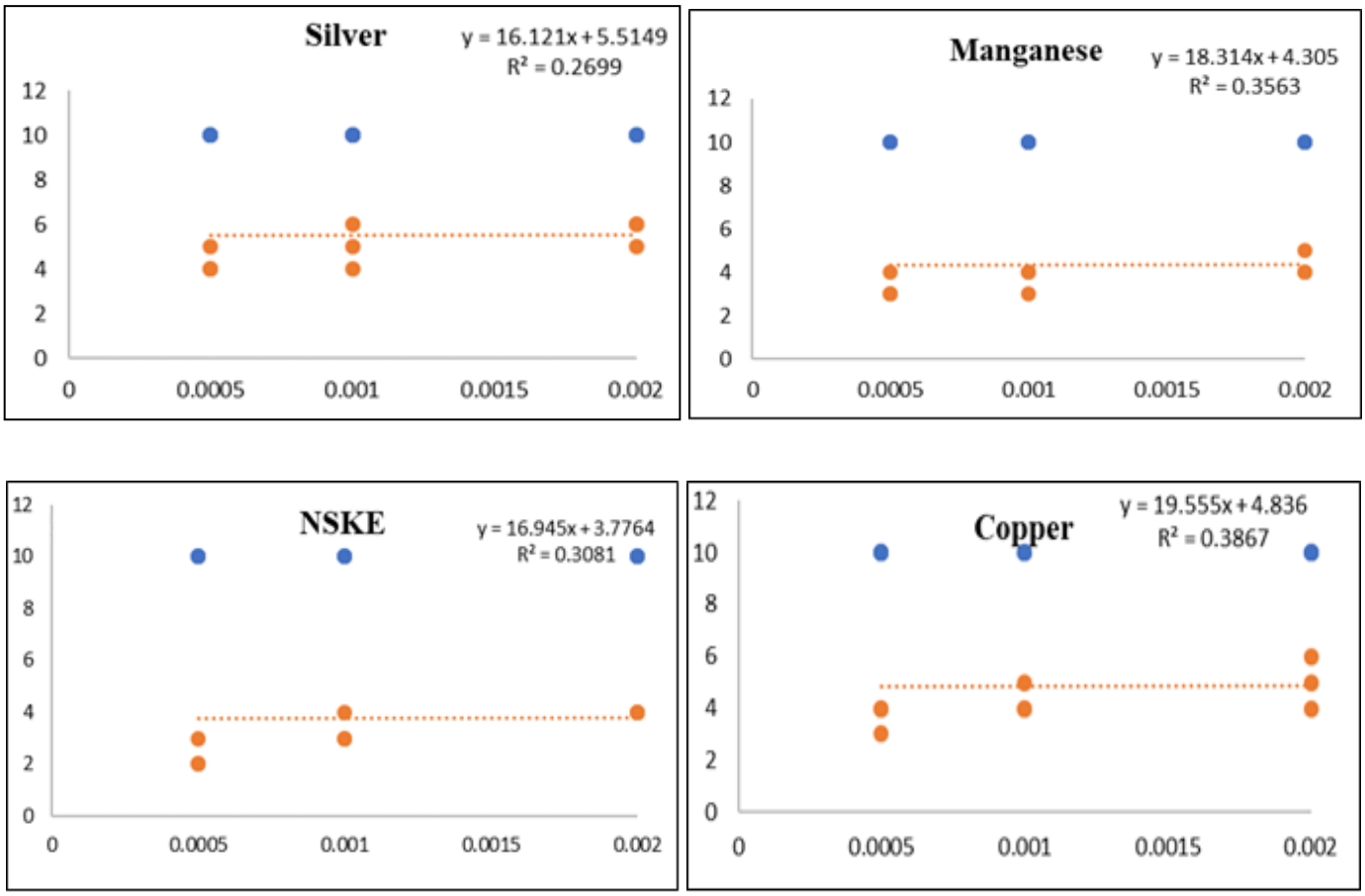


Fig 1: Graphical representation of mortality of chemicals on II[nd] instar larvae of *Helicoverpa armigera* (Hub.)



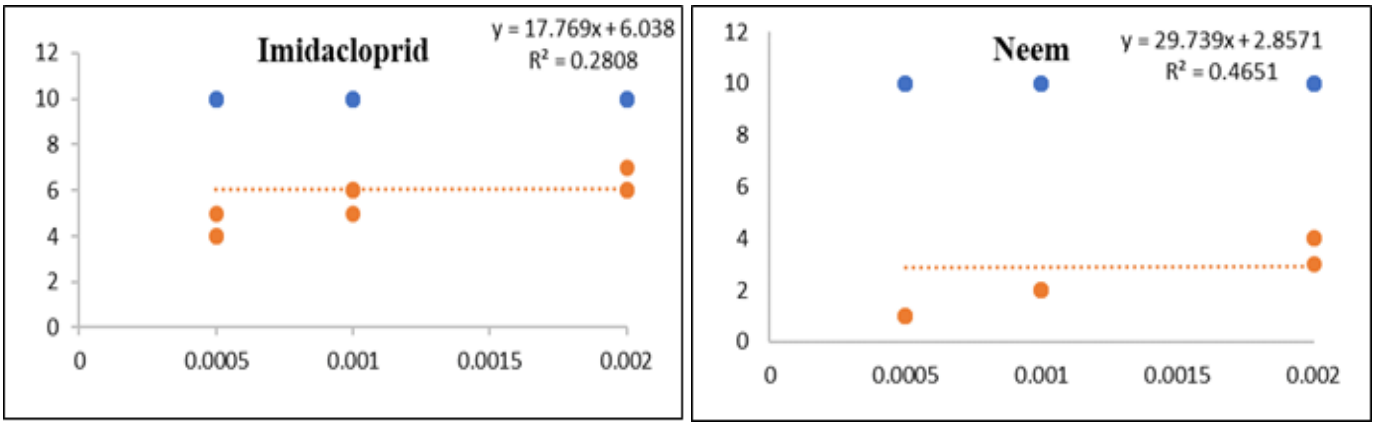


Fig 2: Graphical representation of mortality of chemicals on Vth instar larvae of *Helicoverpa armigera* (Hub.)

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