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Research Paper

EVALUATION OF EFFECTIVE DOSES OF NEEM BASED BIOPESTICIDES AGAINST DIFFERENT STAGES OF *Heliothis armigera (HUBNER)*

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Abstract

The bioefficacy of different neem based biopesticides was evaluated against neonate (1 day), 7 days, 13 days and neonate (1 day), 7 days old larvae of ***H. armigera***by film residue and feeding methods, respectively.The LC_{50} values for neonate varied from 0.104 to 4.20 per cent by film residue and 0.116 to 4.98 per cent by feeding method. The LC_{50} values for 7 days old larvae varied from 0.135 to 5.42 per cent by film residue and 0.131 to 5.06 per cent by feeding method. The LC_{50} values for 13 days old larvae varied from 0.406 to 13.187 per cent of formulation by film residue method. The NSKME at almost all stages proved best biopesticide followed by neemazal and neem EC.The LC_{50} values of all these neem based biopesticides were also worked out against the eggs of ***H. armigera.***The LC_{50} values varied from 0.134 to 5.197 per cent. The relative toxicity varied from 2.535 to 38.783 times in comparison to NSKWE. The NSKME was most toxic followed by neemazal.

Key words: NSKWE, neem based biopesticides, *H. armigera*.

INTRODUCTION

Heliothis armigera (Hubner) (Lepidoptera; Noctuidae), commonly called as gram pod borer, is the important major pest of pulses, tomato, cotton and other crops of economic importance. It is a polyphagous pest of sporadic nature and inflicts losses of various magnitudes to cotton, pigeonpea, sorghum and other crops of economic importance. It is widely distributed throughout India and has been recorded feeding on 181 cultivated and uncultivated plant species belonging to 45 families (Manjunath*et al.,* 1989).Quantitative yearly losses varying from 5 to 70 per cent to gram crop have been estimated by Bhatnagar*et al.,* 1981. As high as 50-100 per cent damage to tomato fruits (Mathur*et al.,*1974; Singh and Singh, 1975; Kakar*et al.,* 1980; Sithanathan*et al.,* 1983 and Tewari and Krishnamoorthy, 1984), about 40 per cent to cotton (Sundramurthy, 1990), 10 to 80 per cent to safflower (Panchabhavi and Krishnamurthy, 1978 and Margal, 1990) has been reported by *H. armigera* in the different parts of the country.In order to protect the crop against gram pod borer infestation a number of conventional insecticides such as endosulfan, quinolphos, carbonyl etc. have been recommended all over the country. Since, the indiscriminate and continuous use of these conventional insecticides has possed serious problems, like emergence of resistant strains of insect pests, adverse effects on parasites and predators and residual hazards to man and domestic animals etc. Alternatives like

the use of less hazardous and short lived insecticides and manipulation of the biology of the pest through the use of insect growth regulators, antifeedants, growth disruptants and food attractants, ovicidal&ovipositional deterrents etc. have to be tried. In India the insecticidal properties of neem *(Azadirachataindica*A. Juss) is known since times of immemoral. No plant or the synthetic material is known to have such diverse effects on insects as neem. Neem extracts and pure compounds have been reported as feeding deterrent, ovipositional deterrent, growth disrupter, repellent, sterilants and insecticides. About 80 compounds from neem have biological activity against insects. The most effective bioactive compound is Azadirachtin, a tetraterpenoid, on which all the commercially available formulations are based. Neem can play a special role in the management of pesticides resistant population of pests like *Spodoptera litura* Fab.,*Heliothis armigera* (Hubner) and *Plutellaxylostella*(L.). In India alone, neem has been evaluated against more than 105 insects, 12 nematode and 9 fungi (Singh and Kataria, 1991). The application of neem based biopesticides is economically viable, environmentally safe and alternative to the synthetic pesticides which cause environmental pollution. It minimise ecological disturbance and delay the development of insect resistance. Now a days, neem based biopesticides are available in the market in different formulations and farmers are also adopting them.

MATERIALS AND METHODS:

Maintenance of culture of *Heliothis armigera:*The initial culture of *H. armigera* was raised from the moths captured from light trap during the month of Feb., 1999. Two to three pairs of the moths were engaged for egg laying in egg laying cage (Kumar and Ballal, 1990). The cage consists of cylindrical frame (50 cm height and 80 cm dia.) made up of a 5 mm thick galvanized iron wire. A circular stout plastic mesh disc rests on a support 5 cm above the base of the frame. At the top of the frame, a rubber band support the feeding vial. A white cotton cloth (90 x 50 cm) encloses the frame of the cage. To keep the cage cool and to maintain a relative humidity (RH) of 60-80 per cent, it was placed in an enamelled tray provided with a 3 cm thick sponge sheet soaked in water. Hundred pupae, ready to emerge were kept in a petridish over the disc. A 20 ml plastic cup containing 5 per cent honey solution was kept on top of the frame and on the disc for feeding of the emerging moths. The eggs were laid all over the inner surface of the cloth cover and on both the sides of the cloth strip. For the collection of the eggs, the moths were transferred to another cage. The cover and strip bearing eggs were soaked in 0.05% sodium hypochlorite (NaOCl) for five minutes and run the washing machine for five minutes and collect the eggs threw sieve and wash with water. After collection of the eggs, they were kept at 24±1° and RH 60 per cent in a incubator. After hatching, the newly emerged larvae were transfered to artificial diet (Singh and Rembold, 1992). Because of the problem of cannabalism after second instar, the larvae were raised individually into the glass tube (25 x 90 mm). The larvae were provided fresh diet daily. The battery jars (37.5 x 25 cm) were prepared for pupation by placing four inch thick layer of fine sandy soil at the bottom. The sand layer was covered with blotting paper to absorb excess moisture. The full grown last instar larvae were placed for pupation (10 larvae per jar). Two days after, the pupae were recovered from the sand and were placed in new glass jars lined with blotting paper at the bottom. The jars were placed under controlled condition after covering them with muslin cloth, to avail the emergence of adults. According to duration the pupae then transferred to the egg laying chamber.

Preparation of Neem Seed Kernel Extracts and Neem Oil:

Methanolic: To obtain methanolic extracts of neem seed kernel, 100 g of seed kernel powder was mixed with 100 ml of methanol then stirred with a magnetic stirrer for 3 hours and filtered through Whatman No. 1. The marc was stirred again for 1 hour followed by filtration. The combined extracts were freed of methanol under reduced pressure at 50 °C in a rotary vaccum evaporator. The dense form of extract was obtained and stored.

Aqueous : To obtain aqueous extract of neem seed kernel, 100 g of powdered and NSK was mixed with 100 ml of distilled water, stirred with a magnetic stirrer for 3 hours a:id filtered through Whatman No. 1. The marc was stirred again for 1 hour followed by Alteration. The combined extracts were freed of water in evaporating dishes at 60°C using a rotary vaccum

evaporator. The prepared extract was the stock solution and the extract of desired concentrations as prepared by adding the required amount of water.

Neem oil extractoin: For the extraction of neem oil soxhlet extraction technique was used. Neem seeds were taken and dehusked carefully so that the inner kernel is not damaged. These kernel were utilized within 2 days because if kept for longer duration, the fatty acids present undergo spontaneous degradation. The kernels were than grinded in fine particles.

Procedures: Five fresh sample were weighed and transferred .in separate paper thimbles. Paper thimbles were inserted in soxhlets. Soxhlets were attached to water condensers, which were supplied water continuously. Oil was extracted using petroleum ether as solvent. After 20-24 hours of rigorous extraction, the petroleum ether extract was removed from the flasks, and subjected to moderate temperature evaporation under reduced pressure (with the help of vacuum pump). On cooling, the process was repeated again and again. During the whole operation temperature was kept within a permissible limit so that oil contents doesn't suffer chemical change. The dense form of neem oil was obtained in the end, which contained negligible amount of petroleum ether.

Table 1. List of neem based biopesticides

Biopesticides	Concentration	Manufacturers
Nimbicidine	0.03 % Aza.	T. Stanes, 22-23 Race Course Road, Coimbatore
Nico neem	0.03 % Aza.	NicoOrgo Manures, Opp. Railway Station, Dakor, Gujarat
Amrutguard	0.03 % Aza.	Ocian Agrochemicals, Azadpur, New Delhi
Neem EC 1500	0.15 % Aza.	Sunny Neem Ext. Pvt. Ltd., 3, Dwarakapuri, Hyderabad
Neemoline plus	0.15 % Aza.	KhatauAgrotech Ltd., Khatau House, Mougul Lane, Mahim, Mumbai
Achook	0.15 % Aza.	Godrej, Agrovate Division
Neemazal T/S	1.0 % Aza.	EID, Perry's
Neem oil	-	Lab preparations
Neem seed kernel water extract (NSKWE)	-	Lab preparations
Neem seed kernel methanol extract (NSKME)	-	Lab preparations

Film residue method: In a petridish of 5 cm diameter 1 ml solution of desired concentration was poured on the lower surface with the help of pipette and swirlled gently to cover the whole surface. It was then allowed to dry under electric fan at low speed to get a residue film (Pradhan, 1967). Theffewere ten treatments replicated thrice. Five concentration of each biopesticides were made and in each replication twenty larvae was exposed to the residue film of biopesticide in a individual petridish. These studies were carried out against neonate 7 and 13 day old larvae. In each petridish one larvae of known age was allowed to crawl in for 2 hours. They were than transferred with the help of a camel hair brush to the untreated petridishes containing artificial diet. Parallel control experiments were also conducted with acetone in three replications.

Feeding methods: The artificial diet treated with different concentration of treatements were fed to the larvae for during larval period. The observation on the mortality were recorded after different interval (days). Moriband insects were treated as dead. The experiment was terminated after achieving 95 per cent motaiity in any concentration.

Statistical analysis

Mortality counts were taken 24 hrs. after treatment. The moribund insects were considered as dead. The mortality data so obtained were converted into corrected per cent mortality using the Abbott's formula (Abbott, 1925) as given below:

$$p'' = {}^{p/''C}X\,100\ 100 - c$$

Where,

P^1	Corrected per cent mortality in the test insect
F	Observed per cent mortality in the test insect
C	Per cent mortality in control

The corrected per cent mortality data thus obtained were subjected to the probit analysis (Finney, 1971) to compute LC_{50} value for each neem based bio pesticides.

Ovicidal effects: To find out the effects of neem based bio pesticides against the eggs of test insect. The experiment was laid in complete randomized design (CRD). One day old laid egg were fixed on a card with help of carnal hair brush. Each card contains 25 eggs and this was replicated four times for each concentrations. Observations were taken on the mortality of these treated eggs and LC_{50} value for each neem biopesticides was worked out.

Ovipositionaldeterrency: The ovipositional deterrent effect of neem based biopesticides for female of *H. armigera* was tested by paired plant tests in cages (30 x 30 cms). Fresh and clean chickpea plants were cut and sprayed by the hand automizer with different concentrations and allowed to dry at room temperature under electric fan for 15 to 20 minutes. The treated plants and controls (untreated plants) were kept inside the test chamber or cage. The laboratory reared single pair of adults was released for egg laying on test plant. The experiment was replicated 10 times for each concentration and the following observations were recorded 24 hours after release of moths. Number of eggs laid on the treated plants. Number of eggs laid on the untreated plants. From these observations, the oviposition index was calculated by using following formula (Bajpai and Sehgal, 2000):

$$\textit{Oviposition Index} = \frac{\textit{Av. No of eggs laid by female on treated surface}}{\textit{Av. No. of eggs laid by female on untreated surface}}$$

The data were also analyzed in 2 factor completely randomized design. The square root transformation was also used in analysis by adding factor of 0.5.

RESULTS AND DISCUSSION

Experiments on bioefficacy of ten neem based biopesticides viz. neemazal, amrutguard, nimbecidine, neem EC, achook, neemoline plus, niconeem, NSKME, neem oil and NSKWE against different stages of larvae [neonate (1 day), 7 and 13 days] of ***H. armigera***were conducted in the laboratory. Two methods of bioassay namely film residue and feeding method were used to determine the toxicity of biopesticides.

Film Residue Method:

Neonate Larvae

The toxicity of neem based biopesticides was determined by bioassay method against neonate larvae of *H*. ***armigera***in laboratory by film residue deposit. The results obtained are presented in Table 1. Against neonate larvae the LC_{50} (%) value of neemazal, amrutguardnimbecidine, neem EC, achook, neemoline plus, niconeem, neem oil, NSKME and NSKWE was found to be 0.104, 1.346, 1.016, 0.292, 0.402, 0.349, 1.235, 1.38, 0.122 and 4.20 per cent respectively. The relative toxicity values of all the treatments in comparison to NSKWE were 40.384, 3.120, 4.133, 14.383, 10.447, 12.034, 3.400, 30.484 and 34.426, respectively.

Seven Days Old Larvae

The LC_{50} values of neemazal, amrutguard, nimbecidine, neem EC, achook, neemoline plus, niconeem, neem oil, NSKME and NSKWE found to be 0.250, 1.963, 1.236, 0.917, 1.071, 1.140, 1.525, 2.078, 0.135 and 5.428 per cent respectively. The relative toxicity of all the treatment was 20.992, 2.673, 4.245, 5.723, 4.900, 4.603, 3.441, 2.525, 38.874 and 1.00 times respectively (Table 2).

Thirteen Days Old Larvae

The data of LC_{50} value, heterogeneity, regression equation, fiducial limit and relative toxicity of 13 days old larvae of ***H. armigera***to neemazal, amrutguard, nimbecidine, neem EC,

achook, neomolin plus, niconeem, neem oil, NSKME and NSKWE are presented in Table 10. The results revealed that LC_{50} values were 0.671, 3.142, 2.937, 1.656, 1.857, 2.017, 3.007, 2.580, 0.406 and 13.187, respectively. The relative toxicity values in comparison to NSKWE against all treatments were 19.552, 4.197, 4.489, 7.963, 7.101, 6.537, 4.385, 5.111 and 32.480 times respectively (Table 3).

Feeding Method: The relative toxicity of different neem based biopesticides was evaluated by feeding method. The observations on mortality could be recorded only after 48 hrs. Initially, the larvae did not feed on the treated food until 24 hrs. The comparisons among the different biopesticides were made for the neonate larvae and seven days old larvae by this method of bio assay.

The comparative toxicity against neonate larvae showed that NSKME was most toxic with a LC_{50} value 0.116 and relative toxicity value 42.931, whereas neem oil had the lowest relative toxicity (3.055) in comparison to NSKWE, taken as the standard (Table 4).

The descending order of toxicity against the neonate larvae as observed by feeding method was NSKME >neemazal> neem EC >achook>neemoline plus >nimbecidine>niconeem>amrutguard> neem oil, when compared with the standard NSKWE.

DISCUSSION:

The bio efficacy of ten neem based biopesticides ***viz.,***neemazal, amrutguard, nimbecidine, neem EC, achook, neemoline plus, niconeem, neemoil, neem seed kernel water extract (NSKWE) and neem seed kernel methanol extract (NSKME) were tested against 1, 7 and 13 days old larvae of ***Heliothisarmigera***in laboratory by film residue and feeding (artificial diet) method and LC_{50} values were worked out. The different concentration of neem formulations were prepared and probit analysis was done by adopting the method suggested by Finney (1971).

The data presented in Table 8 revealed that there was a variation in the bioefficacy of different biopesticides, as the LC_{50} value of each biopesticide was different than the other. The LC_{50} value varied from 0.104 to 4.20 and 0.25 to 5.428 and 0.671 to 13.187 against neonate (1 days old), 7 days and 13 days old larvae, respectively. Neemazal was found highly toxic to neonate larvae of ***H.armigera***with LC_{50} value of 0.104 per cent while NSKWE was found least effective with LC_{50} value of 4.20 per cent, while, NSKME was found most effective against 7 and 13 days old larvae with the lowest LC_{50} of 0.135 and 0.406 per cent, respectively followed by neemazal. The bioassay of these biopesticides was also studied by feeding method against neonate and 7 day old larvae. The observation against 13 days old larvae could not be recorded because two days prior to pupation the larvae stoped feeding. The LC_{50} value of different biopesticides varied from 0.116 to 4.98 and 0.134 to 5.06 per cent against neonate and 7 days old larvae, respectively. On the basis of LC_{50} value NSKME was found highly effective against neonate and 7 day old larvae with LC_{50} value of 0.116 per cent and 0.134 per cent, respectively. While NSKWE was found least toxic with the highest LC_{50} value of 4.98 per cent and 5.06 per cent, respectively.

On the basis of LC_{50} values worked out by film residue method for neonate larvae, the order of toxicity of biopesticides in descending order was : neemazal> NSKME > neem EC >neemoline plus >achook>nimbecidine>niconeem>amrutguard> neem oil > NSKWE.

However, relative toxicity of biopesticides against 7 and 13 days old larvae of ***H.armigera***was slightly different than the neonate larvae and was arranged as : NSKME >neemazal> neem EC >achook>neemolin plus >nimbecidine>niconeem>amrutguard> neem oil > NSKWE for 7 day old larvae. The order of toxicity of biopesticides against 13 days old larvae was almost similar except neem oil which was found more toxic than niconeem, nimbecidine and amrutguard.

The LC_{50}value were also worked out by feeding method. On the basis of LC_{50} value the order of toxicity of bio-pesticide against neonate larvae of ***H. armigera***was NSKME >neemazal> neem EC >achook>neemoline plus >nimbecidine>niconeem>amrutguard> neem oil > NSKWE. The relative toxicity of biopesticides against 7 day old larvae of ***H. armigera*** was almost similar to those against neonate except that neemoline plus was more toxic to 7 days old larvae than

achook and the order of toxicity was as under : NSKME >neemazal> neem EC >neemoline plus >achook>nimbecidine>niconeem>amrutguard> neem oil > NSKWE. NSKME extract was found most effective biopesticide against all the stages of test insect followed by neemazal. In the present investigation all the biopesticides were sown insecticidal property under laboratory condition irrespective of method used.

Many earlier reports on the toxicity of different neem based biopesticides have also shown their conventional insecticidal propertv. These reports fully support the findings of present investigation. As early as in 1960, Sinha demonstrated the contact toxicity of non-fatty alcoholic extract of the neem seed cake and its LC_{50} value against ***Lipaphiserysimi***was 0.202 per cent. Later Goyal***et al.***(1971) reported toxic effect of alcoholic extract of neem cake against ***R. nymphae.***Attri and Ravi Prasad (1980) reported the effectiveness of neem oil extractives which caused instant mortality of larvae of ***Culexfatigans***at 0.04 per cent concentration. In the present investigation the neem oil was less toxic than the neemazal, NSKME, neem EC, achook and neemoline plus and its LC_{50} value for all tested stages of test insect ranged from 1.38 to 2.58 per cent. Almost similar results were earlier reported by Singh ***et al.***(1988) against ***L. erysimi,***they found that the LC_{50} value gradually decreased from neem oil (0.674 %) to ethanolic extract of neem oil (0.328 %).

In the present study NSKME, neemazal neem EC, achook and neemoline plus were found comparatively more toxic than the remaining biopesticides with a relative toxicity of C4.42, 38.87, 32.48; 40.38, 20.99, 19.65; 14.38, 5.72, 7.96; 10.44, 4.90, 7.10 and 12.03, 4.60, 6.53 by film residue method against neonate, 7 days old and 13 day old larvae, respectively. While by feeding method relative toxicity of values were 42.93, 38.62; 32.98, 25.17; 21.46, 12.65; 13.75, 10.36 and 12.65 and 11.02 against neonate and 7 days old larvae of test insect, respectively.

Krishnaiah***et al.***(2000) assessed the relative toxicity of eight neem formulations against three hopper pests of rice and neemazal was found most effective against green leaf hopper. The work carried out by Krishnaiah***et al.***(2000) fully support the result of present investigation.

In the present investigation effective dose of different neem based biopesticides was also worked out on the basis of their azadirachtin content. The effective dose of different biopesticides by feeding method against neonate larvae ranged from 0.0001692 per cent Aza (nimbecidine) to 0.00151 per cent aza (neemazal) which is equivalent to 1.69 and 15.1 ppm respectively. Likewise, against 7 days old larvae it ranged from 0.000231 per cent aza to 0.00201 per cent aza equivalent to 2.31 and 20.10 ppm (azadirachtin).

Almost similar results were also recorded when the toxicity tests were carried out for film residue method. On the basis of actual azadirachtin, required to kill 50 per cent of the test insect, it is concluded that nimbecidine was effective at lower azadirachtin content followed by niconeem, amrutguard, neem EC, achookneemoline plus and neemazal. Work carried out by Krishnaiah***et al.***(2000) fully support the present findings. They also worked out the LC_{50} as concentration of azadirachtin ranging from 0.93 ppm incase of nimbecidineto 10.21 ppm in rakshak, 1.59 ppm nimbecidine to 96.16 ppm neemazal and 1.77 ppm nimbecidine to 78.02 ppm neemazal against GLH, BPH and WBPH, respectively. Similar results on aqueous extract against ***H. armigera***were also reported by Khoja (1993). Shukla and Kumar (2000) also reported LC_{50} values against larvae of ***Spodoptera litura***for nimbecidine (16.96 ppm), econeem (23.12 ppm), achook (19.81 ppm) and neemolin plus (22.46 ppm).

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Table 1: Comparative toxicity of different neem based biopesticides against neonate larvae of H*armigera* by film residue method

Biopesticides	Heteroginity	Regression equation	LC_{50} (%)	Fiducial limit	Relative toxicity
Neemazal	0.315	Y = 1.8721x + 1.221	0.104	0.121 0.089	40.384
Amrutguard	0.618	Y = 1.5804x + 0.05	1.346	1.631 1.110	3.120
Nimbecidine	1.430	Y = 1.8646x + 0.607	1.016	1.187 0.870	4.133
Neem EC	0.579	Y = 1.8318x + 0.483	0.292	0.346 0.246	14.383
Achook	2.248	Y = 1.6341x + 0.744	0.402	0.476 0.339	10.447
Neemoline plus	0.826	Y = 1.7058x + 0.661	0.349	0.412 0.296	12.034
Niconeem	0.919	Y = 1.6154x + 0.005	1.2356	1.477 1.033	3.400
Neem oil	6.322	Y = 2.3783x + -2.468	' 1.38	1.587 1.201	30.484
NSKME	7.900	Y = 1.5031x + 1.861	0.122	0.149 0.100	34.426
NSKWE	19.542	Y = 3.7118x + -8.523	4.20	4.601 3.841	1.00

Table 2: Comparative toxicity of different neem based biopesticides against seven days old larvae of *H. armigera* by film residue method

Biopesticides	Heteroginity	Regression equation	LC_{50} (%)	Fiducial limit	Relative toxicity
Neemazal	0.6389	Y = 1.9085x + 0.422	0.250	0.311 0.201	20.992
Amrutguard	0.6334	Y = 1.9130x + -1.299	1.963	2.382 1.618	2.673
Nimbecidine	0.6215	Y = 1.9778x + -1.115	1.236	1.498 1.019	4.245
Neem EC	0.3209	Y = 1.8115x + -0.367	0.917	1.196 0.703	5.723
Achook	0.3193	Y = 1.9920x + -1.036	1.071	1.293 0.887	4.900
Neemoline plus	0.1557	Y = 1.9561x + -0.984	1.140	1.388 0.946	4.603
Niconeem	0.7461	Y = 2.0874x + -1.645	1.525	1.834 1.268	3.441
Neem oil	10.490	Y = 2.0727x + -1.876	2.078	2.409 1.792	2.525
NSKME	2.577	Y = 1.5406x + 1.717	0.135	0.164 0.110	38.874
NSKWE	1.944	Y = 2.5666x + -4.586	5.428	6.049 4.871	1.000

Table 3: Comparative toxicity of different neem based biopesticides against thirteen days old larvae of *H. armigera* by film residue method

Biopesticides	Heteroginity	Regression equation	LC_{50} (%)	Fiducial limit	Relative toxicity
Neemazal	0.5501	Y = 1.7659x + 0.008	0.671	0.837 0.538	19.652
Amrutguard	2.1427	Y = 2.1454x + -2.503	3.142	3.801 2.597	4.197
Nimbecidine	3.4507	Y = 2.2465x + -2.791	2.937	3.511 2.457	4.489
Neem EC	0.3831	Y = 1.8324x + -0.899	1.656	2.029 1.352	7.963
Achook	0.3485	Y = 1.7283x + -0.650	1.857	2.288 1.508	7.101
Neemoline plus	0.2237	Y = 1.8743x + -1.195	2.017	2.448 1.663	6.537
Niconeem	3.1858	Y = 2.2605x + -2.862	3.007	3.599 2.512	4.385
Neem oil	0.1692	Y = 1.8440x + -1.291	2.580	3.167 2.102	5.111
NSKME	0.1376	Y = 2.1209x + -0.534	0.406	0.490 0.337	32.480
NSKWE	1.5267	Y = 2.1409x + -3.821	13.187	15.760 11.035	1.000

Table 4:Comparative toxicity of different neem based biopesticides against neonate larvae of *H. armigera* by feeding method

Biopesticides	Heteroginity	Regression equation	LC_{50} (%)	Fiducial limit	Relative toxicity
Neemazal	0.355	Y = 1.9869x + 0.669	0.151	0.183 0.124	32.980
Amrutguard	0.1647	Y = 1.9297x + -0.604	0.801	0.969 0.662	6.217
Nimbecidine	1.1401	Y = 2.1553x + -0.930	0.564	0.678 0.469	8.829
Neem EC	0.3893	Y = 2.0619x + 0.121	0.232	0.285 0.189	21.465
Achook	0.0469	Y = 1.8138x + 0.359	0.362	0.442 0.296	13.756
Neemoline plus	0.245	Y = 1.8048x + 0.314	0.394	0.481 0.323	12.639
Niconeem	1.0892	Y = 2.1206x + -0.906	0.609	0.730 0.507	8.177
Neem oil	1.140	Y = 2.2443x + -2.214	1.63	1.90 1.40	3.055
NSKME	2.244	Y = 1.6603x + 1.568	0.116	0.139 0.097	42.931
NSKWE	2.914	Y = 2.5661x + -4.4488	4.98	5.580 4.448	1.000

Table 5: Comparative toxicity of different neem based biopesticides against seven days old larvae of *H. armigera* by feeding method

Biopesticides	Heteroginity	Regression equation	LC_{50} (%)	Fiducial limit	Relative toxicity
Neemazal	0.0140	Y = 1.8752x + 0.679	0.201	0.236 0.171	25.174
Amrutguard	0.693	Y = 1.9012x + -0.649	0.935	1.098 0.797	5.411
Nimbecidine	1.879	Y = 2.0116x + -0.807	0.770	0.906 0.654	6.571
Neem EC	1.9462	Y = 2.1329x + -0.550	0.400	0.470 0.340	12.650
Achook	4.231	Y = 1.9729x + -0.304	0.488	0.573 0.415	10.368
Neemoline plus	4.635	Y = 2.0457x + -0.447	0.459	0.539 0.392	11.023
Niconeem	4.137	Y = 1.8966x + -0.571	0.865	1.019 0.735	5.849
Neem oil	7.767	Y = 2.0158x + -1.647	1.980	2.300 1.707	2.555
NSKME	2.277	Y = 1.4860x + 1.854	0.131	0.160 0.107	38.625
NSKWE	1.423	Y = 2.6015x + 4.638	5.06	5.646 4.546	1.000

Table 6: Comparative toxicity of different neem based biopesticides against eggs of *H. armigera*

Biopesticides	Heteroginity	Regression equation	LC_{50} (%)	Fiducial limit	Relative toxicity
Neemazal	2.568	Y = 1.9499x + 0.180	0.296	0.353 0.248	17.557
Amrutguard	2.404	Y = L7127x + -0.175	1.050	1.262 0.874	4.949
Nimbecidine	2.036	Y = 2.0659x + -0.999	0.801	0.953 0.673	6.488
Neem EC	0.425	Y = 2.2487x + -0.882	0.412	0.482 0.353	12.614
Achook	2.850	Y = 2.0451x + -0.543	0.513	0.611 0.431	10.130
Neemoline plus	0.187	Y = 2.0301x + -0.269	0.393	0.462 0.335	13.223
Niconeem	2.506	Y = 2.1667x + -1.379	0.879	1.040 0.743	5.912
Neem oil	5.113	Y = 1.7167x + -0.685	2.050	2.496 1.683	2.535
NSKME	6.152	Y = 2.0399x + 0.654	0.134	0.163 0.111	38.783
NSKWE	1.146	Y = 3.0912x + -6.486	5.197	5.766 4.684	1.000