

Effect of Bio-pesticides on mortality of Greater wax moth *Galleria mellonella*

ABSTRACT

Different concentration of three bio-pesticides viz., Btk (1, 1.5 and 2%), custard apple seed extract (2, 4 and 6%) and Neem Oil (1, 2 and 3%) were used against the *Galleria mellonella* to assess the effect of larval mortality at 24, 48, 72 and 96 hours after treatment application. The overall larval mortality data reveal that the 24 hours after treatment application there was no significant effect showed in all the treatments. Maximum significant larval mortality was found in Btk 2% concentration (46.67, 87.08 and 96.67%) and it was at par with custard apple seed extract 6% concentration (45.83, 85.0 and 93.75%) followed by the neem oil 3% concentration (38.33, 75.42% and 87.50%) after 48, 72 and 96 hours treatment application respectively whereas, minimum larval mortality was recorded in Neem Oil 1% (22.08, 37.08 and 56.25%) after 48, 72 and 96 hour treatment application respectively.

Keywords: Btk, custard apple seed extract, *Galleria mellonella*, neem oil, mortality.

INTRODUCTION

Currently four honeybee species viz., Rock bee (*Apis dorsata* F.), Little honey bee (*Apis florea* F.), Indian honey bee (*Apis cerana indica* F.) and European honey bee (*Apis mellifera* L.) are found in India out of all four species, the Rock and Little honey bees are wild bees these two bees are not suitable for domestication whereas the last two species Indian and European honey bees are suitable for domestication and managed in Bee hives. Two species of wax moths, Greater wax moth (*Galleria mellonella* L.) and Lesser wax moth, (*Achroia grisella* F.) occur worldwide. Wax moth caterpillars feed on wax, pollen and honey and damage the combs within active bee colonies and storage conditions, resulting in massive losses worldwide. (Williams, 1997; Milam, 1970). *G. Mellonella* leads to greater losses compared to *A. grisella*. (Kapil and Sihag, 1983). Greater wax moth larvae can bore tunnel and feed around the midrib base of the wax comb. Larvae produce silk fibers that can trap bee brood cells. Comb is completely covered with webbing and excreted matter of the

larvae condition described as "*Galleriasis*". In the severe infestation of the wax moth the bee colonies are weak, in strong colonies the number of bees is decreased rapidly and the colonies were completely destroyed by GWM attacked (Swamy, 2005). For the management of greater wax moth best way is use of natural products it's more sustainable option because of their lower toxicity to the environment and the beecolony. Therefore, we evaluated the efficacy of three natural products for greater wax moth management: *B. thuringiensis* var. *kurstaki*, custard apple seed extract and neem oil at different concentrations.

MATERIALS AND METHODS

The study was conducted in the RVSKVV ZARS- Krishi Vigyan Kendra Morena Laboratory, during season 2019-20. The treatments *Bacillus thuringiensis* var. *kurstaki*(1, 1.5 and 2 %), custard apple seed extract (2, 4 and 6 %) and neem oil (1, 2 and 3%) and untreated use as a check. For the preparation of custard apple seed extract the custard apple seeds was collected from fully ripened fruits and washed with water and shade dried, the dried seeds were crushed by using hammer mill and the grinded material was screened through fine mesh sieve. For preparation of 2 percent aqueous custard apple seed extract, the 20 g of seed powder was mixed with 1-liter distilled water and this mixture was soaked overnight. It was then screen through muslin cloth and the volume of the passing liquid (extract) was maintained to 980 milliliters by adding distilled water. Similarly, 4 & 6 per cent aqueous seed extracts were also prepared and the freshly prepared extracts were used for laboratory evaluation. The various concentrations of bio pesticides were prepared in water. Cut piece of old combs of *A. mellifera* was dipped in this different type of solutions of respective concentrations for two minutes and shake gently to remove the excess of suspension from the piece comb, treated comb piece was be shade dried. Individual treated comb piece was put in separate jars. The ten numbers of second instar larvae of *G. mellonella* were released separately into jars containing the treated combs and record the mean mortality of the larva

was observed 24, 48, 72 and 96 hours of the various larval stages. The experiment was conducted in completely randomized design (CRD) with ten treatments and four replications. Making the ANOVA after suitable transformations and separated by least significant difference (LSD) at $p=0.05$ level.

RESULTS AND DISCUSSION

The results of present studies are given in table 1, 2 and 3.

Mortality of second instar of *Galleria mellonella*

Effect of different concentration of bio pesticides on the second instar larvae of *Galleria mellonella* at 24, 48, 72 and 96 hours after treatments were showed in Table-1. Finding revealed that mean maximum mortality was recorded in BtK 2% (63.75%) and it was at par with custard apple seed extract 6% (63.12%) and Neem Oil 3% (59.37%) followed by BtK 1.5% (48.75%), but BtK 1.5% also at par with custard apple seed extract 4% (47.5%), custard apple seed extract 2% (41.87%) and Neem Oil 2% (41.25%) and the minimum mortality was recorded in Neem Oil 1% (36.25%) except untreated check (5%). At 24 hours after the treatment application there was no significant effects showed by the all treatment but maximum mortality was recorded in BtK 2% (7.5%). After 48, 72 and 96 hours after treatment application showed significant effect on larval mortality. Maximum mortality was recorded in BtK 2% at 72 hours (95.0%) and 96 hours (97.50%) but at 48 hours after treatment maximum mortality noticed in custard apple seed extract 6% (50.0%). Treatment BtK 2%, Custard apple seed extract 6% and Neem Oil 3% at par with each other at 48, 72 and 96 hours after treatment application respectively. The minimum mortality was observed in Neem Oil 1% at 48 hours (35.0%), 72 hours (55.0%) and 96 hours (55.0%).

Mortality of third instar of *Galleria mellonella*:

The data of different concentration of bio pesticides on the effect of third instar larvae of *Galleria mellonella* revealed that the mean maximum mortality was recorded in BtK 2% (61.87%) and custard apple seed extract 6% (61.87%) similar mortality and it was at par with Neem Oil 3% (56.25%) followed by BtK 1.5% (45.0%) but it was similar with

custard apple seed extract 4% (45.0%) Neem Oil 2% (43.75%) and custard apple seed extract 2% (41.25%) and the minimum mortality was recorded in BtK 1% (34.37%) except untreated check (4.37%). At 24 hours after treatment application there was no significant effect showed among the treatments but maximum mortality was recorded in BtK 1%, BtK 2% and custard apple extract 6% (5% respectively). After 48 hours treatments showed significant effect on third instar larval mortality. The maximum and similar mortality was recorded in Btk 2% (55.0%) and custard apple seed extract 6% (55.0%) and it was at par with Neem Oil 3% (45.0 %), custard apple seed extract 4% (45.0%) and custard apple seed extract 2% (42.5%), whereas minimum mortality was recorded in BtK 1% (25.0%). At 72 hours maximum mortality was observed in custard apple seed extract 6% (92.5%) and it was similar with Btk 2% (90.0%) and Neem Oil 3% (85.0%). After 96 hours of treatments application maximum mortality was noticed in BtK 2% (97.5%) and it was at par with custard apple seed extract 6% (95.0%), Neem Oil 3% (92.5%) and BtK 1.5% (87.5%), whereas minimum mortality was recorded in BtK 1 % (55.0%).

Mortality of fourth instar of *Galleria mellonella*:

The data revealed that mean maximum mortality was observed in BtK 2% (61.25%) and it was similar with custard apple seed extract 6% (56.87%) and Neem Oil 3% (55.62%) followed by custard apple seed extract 4% (46.25%) but custard apple seed extract 4% also similar effective with BtK 1.5% (43.75%), custard apple seed extract 2% (40.62%) and the minimum larval mortality was recording in Neem Oil 1% (32.5%). At 24 hours after treatment application there was no significant effect showed by the all treatments but the maximum and similar mortality was recorded in BtK 2% (5.0%) custard apple seed extract 6% (5.0%) and neem oil 3% (5.0%). After 48, 72 and 96 hours of treatments application showed significant effect on fourth instar larval mortality. The maximum mortality was found in BtK 2% (57.5%) at 48 hours (87.5%) at 72 hours and (95%) at 96 hour and it was at par with custard apple seed extract 6% (50.0%, 80.0% and 92.5%), Neem Oil 3% (50%, 77.5% and 90%) at 48, 72 and 96 hours after treatment respectively. The minimum mortality was recorded in BtK 1% (27.5%) at 48 hours (40.0%) at 72 hours and (60%) at 96 hours.

Mortality of fifth instar of *Galleria mellonella*:

The mean maximum mortality of fifth instar *Galleria mellonella* was observed in BtK 2% (56.25%), it was at par with custard apple seed extract 6% (55%) and Neem Oil 3% (52.5%)

followed by BtK 1.5% (43.12%) but BtK 1.5% also similar with custard apple seed extract 4% (38.75%) Neem Oil 2% (37.5%) and custard apple seed extract 2% (33.57%) and the minimum mortality was noticed in Neem Oil 1% (28.12%). At 24 hours after the treatment application there was no significant effect showed among the treatments. After 48, 72 and 96 hours after treatment showed significant effects on fifth instar larval mortality. Maximum mortality was recorded in BtK 2% (45.0% and 97.5%) it was at par with custard apple seed extract 6% (42.5% and 92.5%) and Neem Oil 3% (35.0% and 90.0%) at 48 and 96 hours respectively. But at 72 hours maximum mortality was found in Neem oil 3% (82.5%) and it was similar with custard apple seed extract 6% (80.0%) and BtK 2% (77.5%). The minimum larval mortality was observed in BtK 1% (25.0%) at 48 hours and Neem Oil 1% (32.5% and 52.5%) at 72 and 96 hours respectively.

Mortality of sixth instar of *Galleria mellonella*:

The data revealed the mean maximum mortality of sixth instar larvae of *Galleria mellonella* was recorded in BtK 2% (53.12%) and custard apple seed extract 6% (53.12%) followed by Neem Oil 3% (41.25%) but neem oil 3% also similar with BtK 1.5% (40.62%) and minimum mortality was observed in Neem Oil 1% (18.75%). After 48, 72 and 96 hours of treatment application show significant effect on sixth instar larval mortality. At 48 hours maximum mortality was recorded in custard apple seed extract 6% (35.0%) and it was at par with BtK 2% (30.0%) and Neem Oil 3% (25.0%) followed by BtK 1.5 (22.5%). At 72 and 96 hours after treatment maximum mortality was found in BtK 2% (85% and 95% respectively) and it was similar with custard apple seed extract 6% (80%) at 72 hours and (92.5%) at 96 hours followed by BtK 1.5% (60.0%) at 72 hours and Neem Oil 3% (80.0%) at 96 hours.

Mortality of Seventh instar of *Galleria mellonella*:

The mean data of seventh instar larval mortality showed that maximum mortality was found in BtK 2% (55.62%) and it was at par with custard apple seed extract 6% (53.12%) followed by Neem Oil 3% (40.62%) but it was also similar with BtK 1.5% (40.62%) and the minimum mortality was noticed in custard apple seed extract 2% (20.62%). After 48, 72 and 96 hour of treatment application showed significant effect on seventh instar larval mortality. Maximum mortality was recorded in Btk 2% (37.5%) at 48 hours, (87.5%) at 72 hours and (97.5%) at 96 hours after treatment. At 48 hours treatment BtK 2% at par with the custard apple seed extract 6% (32.5%), custard apple seed extract 4% (27.5%), BtK 1.5 % (25.0 %)

and Neem Oil 3% (25.0%). At 72 hours and 96 hours after treatment BtK 2% was found similar effective with custard apple seed extract 6% (85% and 95% respectively). The minimum mortality was recorded in Neem Oil 1% (12.5%) at 48 hours and (22.5%) at 72 hours but custard apple seed extract 2% was recorded minimum mortality (40.0%) at 96 hours after treatment.

Overall mortality of *Galleria mellonella*:

The data of different concentration of bio-pesticide on the overall mortality of *Galleria mellonella* larvae at 24, 48, 72 and 96 hours after treatment were given in table 3. The overall mortality data revealed that 24 hour after treatment application there was no significant effect showed by all the treatments but maximum mortality was recorded in BtK 2% (4.17%) and custard apple seed extract 6% (4.17%). After 48, 72 and 96 hours of treatment application showed significant effect on overall larval mortality, The maximum overall mortality was recorded in BtK 2% (46.67%) at 48 hours, (87.08%) at 72 hours and (96.67%) at 96 hours, it was at par with custard apple seed extract 6% (45.83%, 85.0 % and 93.75%) at 48, 72 and 96 hours respectively. Overall mortality was observed in Neem Oil 3% (38.33%) at 48 hours, (75.42%) at 72 hours and (87.50%) at 96 hours. Minimum overall mortality was noticed in treatment Neem Oil 1% (22.08%, 37.08% and 56.25%) at 48, 72 and 96 hours respectively,

The present finding supports from the findings of Viraktamath *et al.*, (2005), Gowda and Roopa (2001) and Burges (1978) who reported that small larvae of greater wax moth were more susceptible to *Bt* than the older larvae. Verma (1995), MC Killup and Brown (1991), Cantwell and Shieh, (1981), Izhar-ul-Haq *et al.*, (2008). Swamy *et al.*, (2003) and Kapil and Sihag (1983) also studied the effect of *Bt* as a bio-control agent against *G. mellonella* and effective to controlling *G. mellonella* without any adverse effect on the honey bees. Goodwin (1985) and Molin *et al.* (1987) also found adequate control of *G. mellonella* by using B 401 (a formulation of Bt spores and crystals) for a longer period. Verma (1995) also witnessed a similar efficacy of Dipel on *G. mellonella* larvae in *Apis cerana indica* colonies. The data recorded on effect of different concentration of biopesticides on the overall mortality of greater wax moth larvae after 48, 72 and 96 hours of treatments application showed

significant effect on overall larval mortality, maximum mortality was recorded in *B. thuringiensis* var. *kurstaki* @ 2 % con. and it was at par with custard apple seed extract @ 6 % con. followed by neem oil @ 3 % con. Viraktamath *et al.* (2005), Kuusik *et al.* (1993) and Swamy *et al.*, (2003) are support the above findings. The different concentrations of the custard apple seed extract was used for management of other lepidopteron pest at field and laboratory levels but there is no work and review found on greater wax moth management. Custard apple seed extract was showing significant effect on the all-larval stage of greater wax moth management at laboratory level in present studies.

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REFERENCES

- Burges, H. D. (1978). Control of wax moths: Physical, Chemical and Biological Methods. *Bee World.*,**59** (4):129-138.
- Cantwell, G. E. And Shieh, T. A., (1981). Certan- A new bacterial insecticide against greater wax moth, *Galleria mellonella* L. *Am. Bee J.*, **121**: 424-426,430-431.
- Goodwin, W. D. (1985). A unique method for the prevention and amelioration of greater wax moth infestations in honey combs and wax foundations. *South African Bee J.*, **2**:36-41.
- Gowda, G. D., And Roopa, A. N., (2001). Effect of Bt protein on larval and adults of Indian honey bee, *Apis cerana*. Proceedings of 6th Asian Apiculture Association International Conf. Bangalore, India, 24th Feb-1st march., **57** (2): 36-41.

- Izhar-Ul-Haq, M., Saleem, M., And Ahmed, S. (2008). Effect of neem (*Azadirachta indica*) seed extracts against greater wax moth (*Galleria mellonella* L.) larvae. *Pak. J. of Ento.* **30**:137-140.
- Kapil, R. P. and Sihag, R. C. (1983). Wax moth and its control. *Indian Bee J.*, **45** (2-3):47-49.
- Kuusik, A., Metspalu, L., Hiisaar, K., Kogerman, A. And Tartes, U. (1993). Changes in muscular and respiratory activity patterns in yellow meal worm (*Tenebrio molitor*) and Greater wax moth (*G. mellonella*) pupae caused by some plant extracts, Juvenile hormone analogues and a pyrethroid. *Eesti Teaduste Akadeemia Toimetied Biologia.*,**42**:94-107.
- Mc Killiup, And Brown D. G. (1991). Evaluation of formulation of *Bacillus thuringiensis* against greater wax moth in stored honey combs. *Aus. J. Exp. Agri.*, **31**(5): 709-711.
- Milam, V.G. (1970). Moth pests of honeybee combs. *Glean. Bee Culture.***68**: 824 – 428.
- Molin, M. J. L.; Perez, G. F. and Gomez, P. A. (1987). Comparative study of the activity of 3 substances (Sulphur dioxide, Comesan L. S. and B 401) in the control of wax moth, *Galleria mellonella* L. in honey combs. *Vida apicola*, **26**:23-31.
- Swamy, B. C. H.; Rajagopal, D. and Gowda, B. L. V. (2003c). Management of greater wax moth (*Galleria mellonella*: Pyralidae; Lepidoptera). *Asian BeeJ.*, **5**(1&2):207-212.
- Swamy, H.B.C., Rajagopal, D. and Kencharddi (2005). Seasonal incidence of greater wax moth, *Galleria mellonella* in Indian honeybee colonies. *Indian bee J.*, **67**(4): 176-186.
- Verma, S. K., (1995). Studies on the control of greater wax moth, *G. mellonella* in *Apis cerana* colonies with biological insecticide, Dipel. *Indian bee J.*, **57**:121-123.

Viraktamath, S., Basalingappa, S. And Lingappa., (2005). Efficacy of commercial formulations of *Bacillus thuringiensis* against the larvae of the greater wax moth, *Galleria mellonella*. *Indian Bee J.*, **67**: 72-77.

Williams, J.L. (1997). Insects: Lepidoptera (moths). Honey bee pests, predators, and diseases, **3**, pp.119-142.

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Table-1: Effect of bio-pesticides on mortality of Greater wax moth (II, III, IV and V instar larval stage)

Treatment	Percent mortality of different larval instar of <i>G. mellonella</i>															
	II Instar				III Instar				IV Instar				V Instar			
	24 hr.	48 hr.	72 hr.	96 hr.	24 hr.	48 hr.	72 hr.	96 hr.	24 hr.	48 hr.	72 hr.	96 hr.	24 hr.	48 hr.	72 hr.	96 hr.
T1- <i>B. thuringiensis</i> var. <i>kurstaki</i> @ 1.0 %	0.00 (0.00)*	27.50 (31.63)	50.00 (45.00)	72.50 (58.37)	5.00 (12.92)	25.00 (30.00)	52.50 (46.43)	55.00 (47.87)	0.00 (0.00)	27.5 (31.63)	40.00 (39.23)	60.00 (50.77)	0.00 (0.00)	25.00 (30.00)	37.50 (37.76)	55.00 (47.87)
T2- <i>B. thuringiensis</i> var. <i>kurstaki</i> @ 1.5 %	2.50 (9.10)	45.00 (42.13)	60.00 (50.77)	87.50 (69.30)	2.50 (9.10)	40.00 (39.23)	50.00 (45.00)	87.50 (69.30)	2.50 (9.10)	42.50 (40.69)	55.00 (47.87)	75.00 (60.00)	2.50 (9.10)	37.50 (37.76)	52.50 (46.43)	80.00 (63.44)
T3- <i>B. thuringiensis</i> var. <i>kurstaki</i> @ 2.0 %	7.50 (15.89)	55.00 (47.87)	95.00 (77.08)	97.50 (80.9)	5.00 (12.92)	55.00 (47.87)	90.00 (71.57)	97.50 (80.90)	5.00 (12.92)	57.50 (49.31)	87.50 (69.3)	95.00 (77.08)	5.00 (12.92)	45.00 (42.13)	77.50 (61.68)	97.50 (80.9)
T4- Custard apple seed extract@ 2 %	0.00 (0.00)	37.50 (37.76)	57.50 (49.31)	72.50 (58.37)	0.00 (0.00)	42.50 (40.69)	57.50 (49.31)	65.00 (53.73)	0.00 (0.00)	35.00 (36.27)	52.50 (46.43)	75.00 (60.00)	0.0 (0.00)	25.00 (30.00)	42.50 (40.69)	67.50 (55.24)
T5- Custard apple seed extract @ 4 %	0.00 (0.00)	50.00 (45.00)	62.50 (52.24)	77.50 (61.68)	0.00 (0.00)	45.00 (42.13)	57.50 (49.31)	77.50 (61.68)	0.00 (0.00)	37.50 (37.76)	65.00 (53.73)	82.50 (65.27)	2.50 (9.10)	30.00 (33.21)	47.50 (43.57)	75.00 (60.00)
T6- Custard apple seed extract @ 6 %	5.00 (12.92)	60.00 (50.77)	92.50 (74.11)	95.00 (77.08)	5.00 (12.92)	55.00 (47.87)	92.50 (74.11)	95.00 (77.08)	5.00 (12.92)	50.00 (45.00)	80.00 (63.44)	92.50 (74.11)	5.00 (12.92)	42.50 (40.69)	80.00 (63.44)	92.50 (74.11)
T7- Neem oil @ 1.0 %	0.00 (0.00)	35.00 (36.27)	55.00 (47.87)	55.00 (47.87)	0.00 (0.00)	27.50 (31.63)	45.00 (42.13)	70.00 (56.79)	0.00 (0.00)	25.00 (30.00)	42.50 (40.69)	62.50 (52.24)	0.00 (0.00)	27.50 (31.63)	32.50 (34.76)	52.50 (46.43)
T8- Neem oil @ 1.0 %	0.00 (0.00)	42.50 (40.69)	55.00 (47.87)	67.50 (55.24)	2.50 (9.10)	40.00 (39.23)	57.50 (49.31)	75.00 (60.00)	2.50 (9.10)	30.00 (33.21)	55.00 (47.87)	75.00 (60.00)	2.50 (9.10)	25.00 (30.0)	50.00 (45.00)	72.50 (58.37)
T9- Neem oil @ 1.0 %	2.50 (9.10)	50.00 (45.00)	90.00 (71.57)	95.00 (77.08)	2.50 (9.10)	45.00 (42.13)	85.00 (67.21)	92.50 (74.11)	5.00 (12.92)	50.00 (45.00)	77.50 (61.68)	90.00 (71.57)	2.50 (9.10)	35.00 (36.27)	82.50 (65.27)	90.00 (71.57)
T10- Untreated check	2.50 (9.10)	5.00 (12.92)	5.00 (12.92)	7.50 (15.89)	2.50 (9.10)	5.00 (12.92)	5.00 (12.92)	5.00 (12.92)	0.00 (0.00)	2.50 (9.10)	5.00 (12.92)	5.00 (12.92)	0.00 (0.00)	2.50 (9.10)	2.50 (9.10)	2.50 (9.10)
SEm±	3.36	3.01	4.41	4.27	4.31	2.78	4.29	4.36	3.56	2.81	3.45	4.03	3.76	2.95	3.2	4.06
CD	NS	8.68	12.73	12.33	NS	8.04	12.41	12.61	NS	8.13	9.96	11.65	NS	8.54	9.24	11.75

(*) Figures in parenthesis are arcsine transformed value, NS=Non-Significant

Table-2: Effect of bio-pesticides on mortality of Greater wax moth (VI and VII instar larval stage)

Treatment	Percent mortality of different larval instar of <i>G. mellonella</i>								Overall Per cent Mortality			
	VI Instar				VII Instar				24 hr.	48 hr.	72 hr.	96 hr.
	24 hr.	48 hr.	72 hr.	96 hr.	24 hr.	48 hr.	72 hr.	96 hr.				
T1- <i>B. thuringiensis</i> var. <i>kurstaki</i> @ 1.0 %	0.00 (0.00)*	12.50 (20.7)	40.00 (39.23)	55.00 (47.87)	0.00 (0.00)	17.50 (24.73)	40.00 (39.23)	60.00 (50.77)	0.83 (5.24)	22.50 (28.32)	43.33 (41.17)	59.58 (50.53)
T2- <i>B. thuringiensis</i> var. <i>kurstaki</i> @ 1.5 %	2.50 (9.10)	22.50 (28.32)	60.00 (50.77)	77.50 (61.68)	0.00 (0.00)	25.00 (30)	62.50 (52.24)	75.00 (60)	2.08 (8.3)	35.42 (36.52)	56.67 (48.83)	80.42 (63.73)
T3- <i>B. thuringiensis</i> var. <i>kurstaki</i> @ 2.0 %	2.50 (9.10)	30.00 (33.21)	85.00 (67.21)	95.00 (77.08)	0.00 (0.00)	37.50 (37.76)	87.50 (69.3)	97.50 (80.9)	4.17 (11.78)	46.67 (43.09)	87.08 (68.94)	96.67 (79.48)
T4- Custard apple seed extract @ 2 %	0.00 (0.00)	15.00 (22.79)	27.50 (31.63)	35.00 (36.27)	0.00 (0.00)	12.50 (20.7)	30.00 (33.21)	40.00 (39.23)	0.00 (0)	27.92 (31.89)	44.58 (41.89)	59.17 (50.28)
T5- Custard apple seed extract @ 4 %	0.00 (0.00)	22.50 (28.32)	35.00 (36.27)	52.50 (46.43)	0.00 (0.00)	27.50 (31.63)	45.00 (42.13)	55.00 (47.87)	0.42 (3.7)	35.42 (36.52)	52.08 (46.19)	70.00 (56.79)
T6- Custard apple seed extract @ 6 %	5.00 (12.92)	35.00 (36.27)	80.00 (63.44)	92.50 (74.11)	0.00 (0.00)	32.50 (34.76)	85.00 (67.21)	95.00 (77.08)	4.17 (11.78)	45.83 (42.61)	85.00 (67.21)	93.75 (75.52)
T7- Neem oil @ 1.0 %	0.00 (0.00)	5.00 (12.92)	25.00 (30)	45.00 (42.13)	0.00 (0.00)	12.50 (20.7)	22.50 (28.32)	52.50 (46.43)	0.00 (0)	22.08 (28.03)	37.08 (37.51)	56.25 (48.59)
T8- Neem oil @ 1.0 %	2.50 (9.10)	15.00 (22.79)	37.50 (37.76)	60.00 (50.77)	2.50 (9.1)	20.00 (26.57)	35.00 (36.27)	60.00 (50.77)	2.08 (8.3)	28.75 (32.42)	48.33 (44.04)	68.33 (55.76)
T9- Neem oil @ 1.0 %	2.50 (9.10)	25.00 (30.00)	57.50 (49.31)	80.00 (63.44)	0.00 (0.00)	25.00 (30.00)	60.00 (50.77)	77.50 (61.68)	2.50 (9.1)	38.33 (38.25)	75.42 (60.28)	87.50 (69.3)
T10- Untreated check	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.83 (5.24)	2.50 (9.1)	2.92 (9.83)	3.33 (10.52)
SEm±	3.36	2.68	2.29	2.98	1.46	2.79	2.45	3.09	2.85	1.38	1.16	1.48
CD	NS	7.75	6.61	8.62	NS	8.06	7.07	8.91	NS	3.99	3.35	4.27

(*) Figures in parenthesis are arcsine transformed value, NS=Non-Significant

Table-3: Efficacy of different concentration of bio-pesticides on mortality of Greater wax moth

Treatment	Mean mortality of different larval instar of <i>G. mellonella</i> (%)						
	I	II	III	IV	V	VI	Over all mean larval mortality
T1- <i>B. thuringiensis</i> var. kurstaki @ 1.0 %	37.50 (37.76)*	34.38 (35.9)	31.88 (34.37)	29.38 (32.82)	26.88 (31.23)	29.38 (32.82)	31.56 (34.18)
T2- <i>B. thuringiensis</i> var. kurstaki @ 1.5 %	48.75 (44.28)	45.00 (42.13)	43.75 (41.41)	43.13 (41.05)	40.63 (39.6)	43.13 (41.05)	43.65 (41.35)
T3- <i>B. thuringiensis</i> var. kurstaki @ 2.0 %	63.75 (52.98)	61.88 (51.87)	61.25 (51.5)	56.25 (48.59)	53.13 (46.79)	56.25 (48.59)	58.65 (49.98)
T4- Custard apple seed extract @ 2 %	41.88 (40.32)	41.25 (39.96)	40.63 (39.6)	33.75 (35.52)	19.38 (26.11)	33.75 (35.52)	32.92 (35.01)
T5- Custard apple seed extract @ 4 %	47.50 (43.57)	45.00 (42.13)	46.25 (42.85)	38.75 (38.5)	27.50 (31.63)	38.75 (38.5)	39.48 (38.93)
T6- Custard apple seed extract @ 6 %	63.13 (52.61)	61.88 (51.87)	56.88 (48.95)	55.00 (47.87)	53.13 (46.79)	55.00 (47.87)	57.19 (49.13)
T7- Neem oil @ 1.0 %	36.25 (37.02)	35.63 (36.65)	32.50 (34.76)	28.13 (32.03)	18.75 (25.66)	28.13 (32.03)	28.85 (32.49)
T8- Neem oil @ 1.0 %	41.25 (39.96)	43.75 (41.41)	40.63 (39.6)	37.50 (37.76)	28.75 (32.42)	37.50 (37.76)	36.88 (37.39)
T9- Neem oil @ 1.0 %	59.38 (50.4)	56.25 (48.59)	55.63 (48.23)	52.50 (46.43)	41.25 (39.96)	52.50 (46.43)	50.94 (45.54)
T10- Untreated check	5.00 (12.92)	4.38 (12.07)	3.13 (10.18)	1.88 (7.87)	0.00 (0)	1.88 (7.87)	2.40 (8.9)
SEm±	2.08	1.89	1.80	1.97	1.17	1.97	0.76
CD	6.01	5.46	5.21	5.71	3.39	5.71	2.18

(*) Figures in parenthesis are arcsine transformed value

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