SELECTIVITY OF ABAMECTIN AGAINST*CHRYSOPERLA CARNEA* (STEPHENS) (CHRYSOPIDAE,NEUROPTERA)

ABSTRACT

Relative toxicities of abamectin along with spinosad, cypermethrin and chlorpyrifos currently used in cotton fields to control bollworms on the general predator, *Chrysoperlacarnea* (Stephens) at egg, larvae and adult stages were evaluated under laboratory conditions in Tamil Nadu, India. The insecticide concentrations studied were equivalent to those prescribed for field application inclusive of various doses for abamectin. The results revealed that there was no significant adverse effect on hatchability of *C. carnea* caused by abamectin 1.9 EC. However, the fecundity and longevity of adults were significantly reduced at higher concentrations (2 and 2.4 ml l^{-1}) of abamectin. The larva upon direct exposure to insecticides recorded a maximum 40.0 per cent mortality at the highest dose of abamectin (2.4 ml l^{-1}). When the larva were fed with the insecticides treated eggs at 2.4 ml l^{-1}, the larval mortality was 36.7 per cent and the pupation and adult emergence were 68.4 and 61.5 per cent, respectively. Abamectin at lower doses had caused very little impact upon *C. carnea*. All the doses of abamectin were comparatively safer than chlorpyrifos and cypermethrin. Thus, abamectin is found harmless to *C. carnea* and can provide selectivity in an integrated control programme for cotton bollworms.

Key words: Abamectin,Safety, *Chrysoperlacarnea*, IPM

INTRODUCTION

The family Chrysopidae includes many species that could be considered important biological control agents. Chrysopid larvae and the adults of certain species are polyphagous predators and feed on several pests of economic importance. *Chrysoperlacarnea* (Stephens)

(Neuroptera, Chrysopidae) is an important predator of cotton bollworms. In the context of biological control, most attempts have evaluated the efficacy of *C.carnea* in augmentation releases in the field or in the greenhouses (Ridgway and McMuphy, 1984; Hagen et al., 1999; Nordlund et al., 2001). In Integrated Pest Management (IPM) programs, biological pest control with chrysopids could be efficiently combined with the use of selective pesticides. Carlos Ail and Marisol Galicia Juárez (2022) reported that abamectin killed fewer *Chrysoperlacarnea* than profenofos. There are many studies focusing on the effects of pesticides commonly used in agriculture on certain life-history traits of chrysopid species (Hassan, 1989;Silva et al., 2005, 2006; Nadel et al., 2007; Rezaei et al., 2007; Giolo et al., 2009; Mandour, 2009; Schneider et al., 2009).Diafenthiuron was found most safe where as Clothianidin was found most harmful (Rahangdale*et al*., 2017). some compounds are toxic; mostly suggesting the relatively broad tolerance of chrysopids to many pesticides. Use of *Brevibacilluslaterosporus* for pest management in the agroecosystem, appears to be compatible with chrysopids. (Luca Ruiu*et al*., 2020)

Selective insecticides could play a role in conserving natural enemies associated with cotton. So safety evaluation of a chemical to important natural enemies is as important as that of toxicity evaluation. Abamectin, one of the broad spectrum microbial insecticides derived from the soil actinomycetes, *Streptomyces avermitilis* Burg., has been reported to possess excellent performance against the pests of cotton (Birah, 2008). Keeping in view, the present study was taken up to assess the relative toxicity of the abamectin to *C.carnea*.

MATERIALS AND METHODS

Mass production of *C. carnea*

Mass rearing of *C. carnea*was done with *Corcyra cephalonica* Stainton eggs as feed following the method described by Swamiappan (1996).

Larval rearing

Larva of *C. carnea*were reared in galvanized iron (GI) basins (28 cm dia) at 250 larvae basin^{-1} covered with kada cloth. The eggs of C. *cephalonica*were provided as feed for the larva. About 25cc of *C. cephalonica*eggs basin^{-1} were provided on alternate days. After five feedings, the larvae pupated into white coloured round silken cocoon. The cocoons were collected and transferred into one litre plastic container with wire mesh window for emergence of adults.

Adult rearing

The adults were collected and transferred to GI troughs (30 cm dia x 12 cm ht), wrapped inside with brown sheets for collecting the eggs. The trough was covered with nylon cloth and kept firm with the help of a rubber band. Over the cloth covering, two bits of foam sponge (2.5 cm^2) dipped in water were kept; besides an artificial protein rich diet in the form of semi solid paste was smeared. This diet consisted one part of yeast powder, one part of fructose, one part of honey and one part of Protinex® . Water was mixed to make it a paste. The adults laid eggs on the brown sheet wrapped inside the trough. The adults were collected daily and allowed into fresh rearing troughs with fresh feed. From the old troughs the brown paper sheets along with chrysopa eggs were removed.

Insecticide bioassays

Laboratory experiments were conducted to assess the selectivity of abamectin 1.9 EC, spinosad 45 SC, cypermethrin 10 EC and chlorpyrifos20 EC to *C. carnea* in Tamil Nadu Agricultrual University. The experiments were conducted in a completely randomized design with ten treatments replicated thrice. The treatments were abamectin1.9 EC at 9,11,13,15,18.5 and 22.5 g a.i ha^{-1} , spinosad 45 SC at 75 g a.i ha^{-1} , cypermethrin10 EC at 70 g a.i ha^{-1} , chlorpyrifos20 EC at 220 g a.i ha^{-1} ,and untreated check. The different treatment doses were obtained by dissolving 1.0, 1.2, 1.4, 1.6, 2.0 and 2.4 ml of abamectin 1.9 EC and 0.3 ml of spinosad 45 SC, 1.5 ml of cypermethrin 10 EC and 2.4 ml of chlorpyrifos20 EC in one litre of

distilled water and used. The percentage values were converted to arcsine percentage. The mean values of treatments were then separated by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez 1976, 1984).

Eggs of *C. carnea*

Studies were conducted to assess the effect of abamectin 1.9 EC and other insecticides on the eggs of *C. carnea*as per the method described by Krishnamoorthy (1985). The eggs along with stalks on brown paper strips were sprayed with different concentration of insecticides using an atomizer with 100 eggs per treatment. Untreated check was maintained by spraying distilled water. The number of larva hatched from each treatment was recorded and per cent hatchability worked out by the formula,

$$\text{Per cent hatchability} = \frac{\text{No. of larva hatched}}{\text{Total number of eggs}} \times 100$$

Larva of *C. carnea*

a. Larval feeding method

Eggs of *C. cephalonica* were exposed to UV radiation of 15 W for 15 min to kill the embryo. The UV killed *Corcyra* eggs were sprayed with different concentrations of the insecticides dose with an atomizer. The treated eggs were shade dried for 15 min. and then transferred to test tubes @ 1 cc per test tube. The untreated check was maintained by spraying distilled water. Second instar *C. carnea*larva were transferred to these test tubes @ 10 per test tube. After the larva completely fed the insecticide treated eggs, the larva were provided with untreated *Corcyra* eggs till pupation. Observations were made on the grub mortality (12, 24 and 48 h after treatment), pupation and adult emergence.

$$\text{Per cent mortality} = \frac{\text{No. of larva dead}}{\text{Total Number of larva}} \times 100$$

b. Dry film method

The bioassay method described by McCutchen and Plapp (1988) was adopted with modifications (Chelladurai, 1999). The insecticidal concentrations were prepared using acetone and water in a ratio of 80: 20. Glass scintillation vials of 20 ml capacity were evenly coated with 1 ml of insecticide formulations dissolved in acetone - water and dried by rotating the tube horizontally on a table with palm. Second instar larva were released into the vials @ 10 per vial and covered with muslin cloth secured with a rubber band. After 24 h exposure of the larva, 1 cc *Corcyra* eggs were given as feed and observations on the mortality of the larva made. Per cent mortality of the larva was worked out. Likewise, pupation (%) and adult emergence (%) were also worked out.

Adults of *C. carnea*

Five pairs of freshly emerged *C. carnea* adults were allowed in separate plastic containers. The adults were fed with 10 per cent sucrose solution containing different concentrations of insecticide formulation. In the untreated check, the adults were fed with 10 per cent sucrose solution alone. The eggs laid in each treatment were collected daily by keeping a brown paper sheet of 21 x 6 cm size along the inner side of the plastic container. Observations were made on the adult longevity and fecundity by recording the number of days the adults were alive and the number of eggs laid per five females.

RESULTS AND DISCUSSION

a. Eggs

The hatchability of the eggs varied from 96.7 per cent for untreated check and 86.7 - 93.3 per cent for different doses of abamectin. Abamectin at all doses were less toxic to *Chrysoperla* eggs. Maximum hatching was recorded in untreated check (96.7 %), whereas the lowest was observed in cypermethrin 10 EC at 1.5 ml l^{-1} (80.0 %) (Table 1)

b. Larva

The results on the influence of abamectin to *C. carnea* larva determined by larval feeding method revealed that abamectin at higher concentrations tested caused significant mortality. The maximum mortalities of the larva were noticed in cypermethrin (46.7 %). In abamectin doses, the mortality ranged between 6.7 and 36.7 per cent, which implies that abamectin is safe to the larva. Spinosad and chlorpyrifos at 0.3 and 2.4 ml l^{-1} recorded 20.0 and 30.0 per cent mortality respectively(Table 2)

In the dry film method, the mortality was somewhat higher than in larval feeding method. Among the abamectin doses, abamectin at high dose (2.4 ml l^{-1}) recorded higher per cent mortality of 40.0 followed by abamectin at 2.0 ml l^{-1} (33.3 %). Among the treatments, cypermethrin recorded the highest mortality of 50.0 per cent. The untreated check registered higher percentage of pupation (100%) in both the tests followed byabamectin at 1.0 ml l^{-1} (96.4 and 92.9 %). Spinosad, chlorpyrifos and cypermethrin recorded 87.5 and 82.6, 76.2 and 70.0 and 56.3 and 53.3 in both the tests, respectively. Cent per cent adult emergence was observed in untreated check and abamectin @ 1ml l^{-1}. Cypermethrin (1.5 ml l^{-1}) registered the lowest adult emergence of 44.4 and 37.5 per cent followed by abamectin at higher doses with 61.5 and 58.3 per cent in both the tests, respectively.(Table 2)

c. Adults

The results revealed that the adult longevity was maximum days in untreated check (14.7 days), while it was 7.5, 8.3, 8.8, 9.3, 9.7 and 10.3 days when abamectin was applied at 2.4, 2.0, 1.6, 1.4, 1.2 and 1.0 ml l^{-1} respectively. The adult longevity was reduced significantly in cypermethrin (3.5 days) and chlorpyrifos (5.9 days). Likewise, significantly more number of eggs was laid in untreated check (253 eggs per 5 females). However, the fecundity was reduced to 185.0, 173.7, 161.7, 149.7, 138.0 and 116.0 eggs per 5 females, when the adults were exposed to abamectin 1.0, 1.2, 1.4, 1.6, 2.0 and 2.4 ml l^{-1}, concentrations, respectively. (Table 1)

The insecticidal effect on non-target organisms are categorized according to the recommendations of the International Organisation for Biological Control, West Palaearctic Regional Section (IOBC/WPRS) working group (Hasan 1989; Nasreen *et al.* 2000) as harmless (< 50% mortality), slightly harmful (50 to 79% mortality), moderately harmful (80 to 89 % mortality) and harmful (> 90% mortality) when tested at the field recommended dose. The natural egg mortality recorded in the untreated check was 3.3 per cent and mortality due to the application of abamectin varied from 6.7 to 13.3 per cent and hence, it can be categorized as a harmless insecticide. The longevity and the fecundity of adults decreased as the concentration of abamectin increased. Spinosad was also found to come under harmless category.

Carlos Ail and Marisol Galicia Juárez (2022) reported that abamectin killed fewer *Chrysoperlacarnea* than profenofos. Enzymatic activity of α and β-esterase was greater for *C. carnea* compared with *Bactericeracockerelli* exposed to abamectin and profenofos. Activity of the enzyme glutathione S-transferases (GSTs) and oxidase content where greater for *B. cockerelli* than *C. carnea*. The study demonstrated that abamectin was less toxic to *C. carnea* and more to *B. cockerelli*, suggesting the insecticide was very selective, which could be related to greater esterase enzymatic activity. Badawy and Arnaouty (1999) reported that abamectin was safer than all tested conventional insecticides to *Chrysoperla* eggs at the recommended dose. It caused only seven per cent mortality of third instar larvae of *C. carnea*. Spinosad was safe to predators (predatory bugs, spider and green lace wing) and parasitoids (*Trichogrammachilonis*Ishii) whereas conventional insecticides caused higher mortality (Dhawan, 2000).

The present finding was in agreement with the report of Bueno and Freitas (2004) that *Chrysoperla externa* Hagen egg viability was not affected by abamectin. Neonate larvae from abamectin sprayed eggs as well as first, second and third instar larvae that were directly treated, developed normally and yielded normal adults. Likewise, the present finding was in tune with Giolo*et al.* (2009) who reported that abamectin was slightly harmful to *C. carnea* larvae when

exposure to fresh pesticide residue on glass plates and found harmless after direct spraying on eggs and pupae. Alexandre et al. (2010) concluded that abamectin, sulfur, and trichlorfon were harmless when applied to adults, while carbaryl, fenitrothion, and methidathion were harmful, according to the IOBC classification.

Abamectin has translaminar activity which provides residual activity against foliage feeding insects, but the surface residues degrade rapidly, making it less hazardous to beneficial organisms (Aston et al., 2001). This is in line with the finding of Giolo et al. (2009) who reported that abamectin was classified as short lived in the persistence tests, and therefore it could be considered for use in Integrated Pest Management (IPM) programs under special conditions (i.e. reduced direct contact).

Conclusion

In the present study, chlorpyrifos and cypermethrin recorded 13.3 and 20.0 per cent unhatched eggs, respectively, besides reduced adult longevity and fecundity. This finding is in conformity with the results of Krishnamoorthy (1985) who reported that the newly hatched larvae of *C. carnea* were more susceptible to organophosphates, carbamates and pyrethroids when compared to the egg stage. Shour and Crowdar (1980) stated that fenvalerate affected the larval survival, adult emergence, fecundity and female life span of *C. carnea*. Our findings deviated from the findings of Singh and Varma (1986) who stated that that chlorpyrifos caused 74 per cent larval mortality over a 72-h period when freshly emerged larvae of *C. carnea* were released on insecticide-treated food (eggs of *C. cephalonica*) for 24 h, whereas cypermethrin recorded 38.1 per cent.

A selective insecticide is one that is more toxic to the pests than to non targets (Croft, 1990). The low level of adverse impact of abamectin to natural enemy observed in the laboratory will not be the same in the field. Care should be taken while spraying abamectin in the field when *C. carnea*is there and the parasitoid releases should not coincide with the insecticide spray. Abamectin, however, was found harmless to *C. carnea*.

References

Alexandre P. M., Carvalho, G. A. Moscardini, V. F. Lasmar, O. Rezende D. T. and Marques,M. C. 2010. SelectivityofPesticidesused in Integrated Apple ProductiontotheLacewing, *Chrysoperla externa*. *JournalofInsectScience***10**(121): 1-20.

Aston, S., Streit, L. McKee K.and Clarke. C. 2001. Field selectivitymakesemamectinsuitablefor IPM. In: Proc. 10th AustralianAgronomy Conf., Hobart. pp.41-47.

Badawy, H.M.A and Arnaouty. S.A.E. 1999. Direct and indirecteffectsofsomeinsecticideson*Chrysoperla carnea* (Stephens) (Neuroptera:Chrysopidae). *JournalofNeuropterology*, **2**: 67-74.

Birah, A. 2008. Effectofabamectinagainstbollwormcomplex and yield response in cotton. *International JournalofOperationalResearch***70**(1):75-79

Bueno, A.F and Freitas. S.2004. Effectoftheinsecticidesabamectin and lufenurononeggs and larvaeof*Chrysoperla externa*underlaboratoryconditions. *BioControl*, **49**(3): 277-283.

Carlos Ail and Marisol Galicia-Juárez.2022.Toxicity and Enzymatic Activity of Reduced Doses of Insecticides in Chrysoperlacarnea and Bactericeracockerelli.Southwestern Entomologist 47(4):835-844.DOI:10.3958/059.047.0405

Chelladurai, M. 1999. *Studies on bioefficacy of betacyfluthrin against Helicoverpaarmigera (Hub.) and Spodopteralitura (Fab.) (Noctuidae: Lepidoptera) on groundnut (Arachishypogaea L.) and determination of residues.*Unpub. M.Sc. (Ag.) Thesis, Tamil Nadu Agric. Univ., Coimbatore, India, 126p.

Croft, B.A. 1990. Arthropodbiological control agents and pesticides. Wiley International SciencePublication, New York. 130 p.

Dhawan, A.K. 2000. Impactofsome new insecticideson natural enemycomplexofcottonecosystem. *Pestology*, **24**(5): 8-14.

Giolo, F.P., Medina, P. Grutzmacher A.D. and Vinuela, E. 2009. Effectsofpesticidescommonlyused in peachorchards in Brazilonpredatorylacewing*Chrysoperla carnea*underlaboratoryconditions. *Bio Control*, **54**: 625-635.

Gomez, K.A andGomez A.A. 1976. StatisticalProceduresforAgri-culturalResearchwithSpecialEmphasison Rice. Int. Rice Res. Institute, Los Banos, Philippines, 368 pp.

Gomez, K.A andGomez A.A. 1984. StatisticalProceduresforAgriculturalResearch. Wiley, New York, 680 pp.

Hagen, K.S., Mills, N.J. GordhG and McMurtry, J.A. 1999. TerrestrialArthropodPredatorsofInsect and Mite Pests, Chrysopidae. In: HandbookofBiological Control: Principles and ApplicationsofBiological Control, Bellows T.S. and T.W. Fisher (Eds.). AcademicPress, San Diego, California, pp: 415-423.

Hassan, S.A. 1989. Testingmethodology and theconceptsofthe IOBC/WPRS Workinggroup. p. 1–18. In: "Pesticides and Non Target Invertebrates" (P.C. Jepson, ed.). Intercept, Wimborn, Dorset, 240 pp.

Krishnamoorthy, A. 1985. Effectofseveralpesticidesoneggs, larvae and adultsofthegreenlacewing*Chrysopascelestes* (Banks). *Entomon*, **10**(1): 21-28.

Luca Ruiu, Anna Marta Lazzeri, Maria Tiziana Nuvoli, Ignazio Floris, Alberto Satta.2020.Safety

evaluationoftheentomopathogenicbacterium Brevibacilluslaterosporus forthegreen

lacewing Chrysoperlaagilis (Neuroptera: Chrysopidae). JournalofInvertebrate

Pathology, 169, 107281 https://doi.org/10.1016/j.jip.2019.107281

Mandour, N.S., 2009. Influenceofspinosadonimmature and adultstagesofChrysoperla carnea (Stephens) (Neuroptera: Chrysopidae). *Bio Control*, **54**: 93-102.

Mccutchen B.F andPlapp. F.W. 1988. Monitoringprocedureforresistancetosyntheticpyrethroids in tobaccobollwormlarvae. p. 356–358. In: Proc. Beltwide Cotton Prod. Res. Conf., New Orelans. Natl. Cotton Council ofAmerica. Memphis Teen, 3–8 January 1988.

Nadel, H., Johnson, M.W. GerikM.andDaane, K.M. 2007. Ingestionofspinosadbait GF-120 and resultingimpactonadult*Chrysoperla carnea* (Neuroptera: Chrysopidae). *BiocontrolScience and Technology*, **17**:995-1008.

Nasreen, A., Ashfaq, M.andMustafa, G.2000. Intrinsictoxicityofsomeinsecticidestoeggparasitoid, *Trichogrammachilonis* (Hymenoptera:Trichogrammatidae). Bull. Inst. Trop. Agri. Kyushu Univ. **23**: 41–44.

Nordlund, D.A., Cohen A.C. and Smith,R.A.2001. Mass-Rearing, ReleaseTechniques, and Augmentation. In: Lacewings in theCropEnvironment, McEwen P.K., T.R. New and A.E. Whittington (Eds.). Cambridge UniversityPress, Cambridge, pp: 303-319.

Rahangdale LS, Neharkar PS, Dhurve NG, Sawai HR and NV Lavhe. 2017. Safety of some newer insecticides on egg hatchability and fecundity of Chrysoperlacarnea under laboratory condition. Journal of Entomology and Zoology Studies; 5(6): 1820-1823

Rezaei, M., Talebi, K. Naveh V.H. and Kavousi, A. 2007. Impactsofthepesticides imidacloprid, propargite, and pymetrozineon*Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae): IOBC and life table assays. *Bio Control*, **52**: 385-398.

Ridgway, R.L. and McMuphy, W.L. 1984. Biological Control in the Field. In: BiologyofChrysopidae, Canard, M., Y. Semeria and T.R. New (Eds.). W. Junk Publisher, Boston, TheHague, pp: 220-228.

Schneider, M.I., Sanchez,N. Pineda, S. Chi H. and Ronco,A. 2009. Impactofglyphosateonthedevelopment, fertility and demographyof*Chrysoperla externa* (Neuroptera: Chrysopidae): Ecologicalapproach. *Chemosphere***76**: 1451-1455.

Shour, M.H and Crowdar. L.A. 1980. Effectsofpyrethroidinsecticidesonthecommongreen lace wing. *JournalofEconomicEntomology***73**(2): 306-309.

Silva, R.A., Carvalho, G.A. Carvalho, C.F. Reis, P.R. Pereira A.M.A.R. and Cosme, L.V. 2005. Toxicityofpesticidesused in coffeecropstolarvaeof*Chrysoperla externa* (Hagen) (Neuroptera: Chrysopidae) and theireffectsonsubsequentstagesofthepredator. *NeotropicalEntomology.*,**34**: 951-959.

Silva, R.A., CarvalhoG.A. Carvalho, C.F. Reis, P.R Souza B and Pereira, A.M.A.R. 2006. Actionofpesticidesused in coffeecropsonthepupae and adultsof*Chrysoperla externa* (Hagen, 1861) (Neuroptera: Chrysopidae). *Cienc. Rural*,**36**: 8-14.

Singh P. P. and VarmaG. C. 1986.Comparativetoxicitiesofsomeinsecticidesto*Chrysoperla carnea* (Chrysopidae: Neuroptera) and *Trichogrammabrasiliensis* (Trichogrammatidae: Hymenoptera), twoarthropod natural enemiesofcottonpests. *Agriculture, Ecosystems& Environment.***15**(1): 23-30.

Swamiappan, M. 1996. MassproductionofChrysopa. In: National training onmassmultiplicationofbiocontrolagents, Training division, DDE, Tamil Nadu Agric. Univ., Coimbatore, India. 95p.

Table 1 Safety of abamectin 1.9 EC to eggs and adults of green lacewing *Chrysoperlacarnea*Stephens

(Mean of three observations)

Treatments	Per cent egg hatchability*	Per cent unhatched eggs*	Adult longevity (days)#	No. of eggs laid by five pairs of adults #
Abamectin 1.9 EC @ 1.0 ml l^{-1}	93.3 (75.17)^{b}	6.7 (14.95)^{b}	10.3 (3.28)^{b}	185.0 (13.62)^{b}
Abamectin 1.9 EC @1.2 ml l^{-1}	93.3 (75.17)^{b}	6.7 (14.95)^{b}	9.7 (3.20)^{b}	173.7 (13.20)^{bc}
Abamectin 1.9 EC @ 1.4 ml l^{-1}	93.3 (75.17)^{b}	6.7 (14.95)^{b}	9.3 (3.12)^{bc}	161.7 (12.73)^{cd}
Abamectin 1.9 EC @1.6 ml l^{-1}	90.0 (71.64)^{bc}	10.0 (18.42)^{c}	8.8 (3.05)^{bc}	149.7 (12.25)^{de}
Abamectin 1.9 EC @ 2.0 ml l^{-1}	90.0 (71.64)^{bc}	10.0 (18.42)^{c}	8.3 (2.97)^{bc}	138.0 (11.76)^{e}
Abamectin 1.9 EC @ 2.4 ml l^{-1}	86.7 (68.62)^{c}	13.3 (21.40)^{d}	7.5 (2.82)^{cd}	116.0 (10.79)^{f}
Spinosad 45 SC @ 0.3 ml l^{-1}	93.3 (75.17)^{b}	6.7 (14.95)^{b}	9.1 (3.10)^{bc}	153.3 (12.40)^{de}
Cypermethrin 10 EC @ 1.5 ml l^{-1}	80.0 (75.17)^{d}	20.0 (26.55)^{e}	3.5 (2.00)^{e}	47.0 (6.87)^{h}
Chlorpyrifos 20 EC @ 2.4 ml l^{-1}	86.7 (68.62)^{c}	13.3 (21.40)^{d}	5.9 (2.53)^{d}	100.3 (10.03)^{g}
Untreated check	96.7 (79.93)^{a}	3.3 (10.51)^{a}	14.7 (3.90)^{a}	253.0 (15.93)^{a}

In a column means followed by a common letter are not significantly different at P = 0.05 by DMRT

*Figures in parentheses are arcsine $\sqrt{P}$ transformed values

#Figures in parentheses are $\sqrt{x+0.5}$ transformed values

Table 2. Safety of abamectin 1.9 EC to grubs of green lacewing *C. carnea*

(Mean of three observations)

Treatments	Larval feeding method			Dry film method		
	Per cent mortality	Per cent pupation	Per cent adult emergence	Per cent mortality	Per cent pupation	Per cent adult emergence
Abamectin 1.9 EC @ 1.0 ml l^{-1}	6.7 (15.00)^{b}	96.4 (79.61)^{b}	100.0 (89.43)^{a}	6.7 (15.00)^{b}	92.9 (74.65)^{b}	100.0 (89.43)^{a}
Abamectin 1.9 EC @1.2 ml l^{-1}	13.3 (21.37)^{c}	92.3 (74.05)^{c}	95.8 (78.63)^{b}	16.7 (24.11)^{c}	88.0 (69.80)^{c}	95.5 (78.04)^{b}
Abamectin 1.9 EC @ 1.4 ml l^{-1}	16.7 (24.05)^{d}	92.0 (73.71)^{c}	91.3 (72.96)^{c}	20.0 (26.51)^{cd}	87.5 (69.46)^{cd}	90.5 (72.12)^{c}
Abamectin 1.9 EC @1.6 ml l^{-1}	23.3 (28.85)^{e}	87.0 (68.98)^{cd}	85.0 (67.33)^{d}	26.7 (31.11)^{e}	81.8 (64.83)^{d}	83.3 (65.98)^{d}
Abamectin 1.9 EC @ 2.0 ml l^{-1}	30.0 (33.21)^{f}	81.0 (64.20)^{de}	70.6 (57.20)^{e}	33.3 (35.24)^{f}	75.0 (60.05)^{e}	66.7 (54.78)^{e}
Abamectin 1.9 EC @ 2.4 ml l^{-1}	36.7 (37.28)^{g}	68.4 (55.84)^{f}	61.5 (51.66)^{f}	40.0 (39.23)^{g}	66.7 (54.78)^{f}	58.3 (49.79)^{f}
Spinosad 45 SC @ 0.3 ml l^{-1}	20.0 (26.56)^{de}	87.5 (69.46)^{c}	85.7 (67.91)^{d}	23.3 (28.85)^{de}	82.6 (65.44)^{cd}	84.2 (66.69)^{d}
Cypermethrin 10 EC @ 1.5 ml l^{-1}	46.7 (43.10)^{h}	56.3 (48.60)^{g}	44.4 (41.78)^{g}	50.0 (45.00)^{h}	53.3 (46.90)^{g}	37.5 (37.74)^{g}
Chlorpyrifos 20 EC @ 2.4 ml l^{-1}	30.0 (33.18)^{f}	76.2 (60.85)^{e}	68.8 (56.04)^{ef}	33.3 (35.22)^{f}	70.0 (56.82)^{ef}	71.4 (57.72)^{e}
Untreated check	3.3 (10.51)^{a}	100.0 (89.43)^{a}	100.0 (89.43)^{a}	3.3 (10.47)^{a}	100.0 (89.43)^{a}	100.0 (89.43)^{a}

In a column means followed by a common letter are not significantly different at P = 0.05 by DMRT

Figures in parentheses are arcsine $\sqrt{P}$ transformed values