International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 01-06-2021, Accepted: 16-06-2021, Published: 01-07-2021
Volume 6, Issue 4, 2021, Page No. 01-05

Toxicity of selected insecticides to the weaver ant, *Oecophylla smaragdina* fabricius (Hymenoptera: Formicidae)

K Selvam[1*], T Nalini[2]
[1] Phd, Research Scholar, Department of Entomology, Faculty of Agriculture, Annamalai University, Chidambaram, Tamil Nadu, India
[2] Assistant Professor, Department of Entomology, Faculty of Agriculture, Annamalai University, Chidambaram, Tamil Nadu, India

Abstract
Safety of selected insecticides to *Oecophylla smaragdina* workers (minor-major) (Hymenoptera: Formicidae) was evaluated using dry film method at 1, 4, 8, 12, 16, 20 and 24 hours after treatment (HAT). Results showed that Lambda cyhalothrin and Thiamethoxam caused 100 per cent mortality within 1h in both the minor and major workers, which was significantly higher than untreated check. Imidacloprid was comparatively safer and caused 100 per cent mortality of both the castes of the weaver after 12h. However, Azadirachtin caused 100 per cent mortality only after 12h with low death rates indicating that it is the safest of all the insecticides tested for both the castes of weaver ants and hence might be the first choice for weaver ant used pest management strategy.

Keywords: insecticides, toxicity, dry film technique, bioassay, minor and major workers of *Oecophylla smaragdina*

Introduction
Weaver ants (Oecophylla spp) are utilized for biological control of pest insects in tropical plantation crops (Van Mele, 2008) [37]. The tree-inhabiting weaver ant Oecophylla effectively protects tropical tree crops as it actively patrols canopies and preys upon or deters a wide range of potential pests. Recent research showed that Vietnamese citrus farmers who took care of weaver ants spent, on average, half the amount of money on agrochemicals compared with those farmers who did not have Oecophylla in their orchard, yet obtained similar yields (Van Mele and Cuc, 2000) [38]. Weaver ants are arboreal and build woven leaf nests in canopies of trees and shrubs and may control pest insects in plantations and forestry (Offenberg, 2014) [22]. A search for alternatives to the chemical control has led to increased appreciation of the role of weaver ants, *O.* smaragdina in managing populations of several pests in a number of crops like cashew, mango etc., (Van Mele, 2008) [37]. Most biological control agents, including predators, parasitoids and spiders, at work in the agricultural and urban environments are naturally occurring ones, which provide excellent regulation of many pests with little or no assistance from humans. Selective insecticides that target pest species could play a role in conserving this wide diversity of natural enemies. The existence of naturally occurring biological control agents is one reason that many plant-feeding insects do not ordinarily become economic pests. The importance of such agents often becomes quite apparent when pesticides applied to control one pest cause an outbreak of other pests because of the chemical destruction of important natural enemies. Several insecticides that are widely used to suppress various pests can disrupt the effectiveness of these beneficial agents. It is less clear to what degree insecticides are disruptive with other non-target organisms (Halappa, 2011) [11]. Several new generation insecticides show very strong toxicity to pollinators and natural enemies (Boli, 2014) [7]. There is great potential for increasing the benefits derived from naturally occurring biological controls, through the elimination or reduction in the use of pesticides toxic to natural enemies (El-Wakeil *et al*., 2013) [10]. Therefore, studies on toxicity of certain commonly used insecticides on weaver ants (minor and major workers) under laboratory conditions are a prerequisite for avoiding the insecticides which cause high ecological damage to them. With this background, the present study focused on the toxicity of important insecticides used in cowpea and bhendi to *Oecophylla smaragdina*.

Materials and Methods
Collection of O. smaragdina
Oecophylla smaragdina workers (minor-major) were collected from the nests on the Ixora coccinea L. in the garden of Faculty of Agriculture. The workers of 5mm and 8mm in length were considered as minor and major workers respectively (Bharti and Silla, 2011) [5] were used in bioassays which was carried out in the Department of Entomology, Faculty of Agriculture, Annamalai University.

Insecticides
The following insecticides used in the present study were obtained as commercially available formulations: Imidacloprid 17.8% (100 ml/ha), Quinalphos 25% EC (2000ml/ha), Lambda cyhalothrin 5% (300ml/ha), Thiamethoxam 25% WG (200gm/ha) Azadirachtin 0.03% (2500-5000 ml/ha), Untreated check (distilled water).

Treatment procedure
Dry film coating technique was followed to evaluate the toxicity of insecticides to O. smaragdina (minor and major

workers) as per Plapp and Vinson (1977) [23]. Different concentrations of insecticide solutions were prepared using distilled water and used for bioassay. Each replication had ten pairs of worker ants and each treatment was replicated three times. Glass beakers of 12 cm high and 9.5 cm dia were cleaned by soaking overnight with soap, rinsed with distilled water and air-dried for at least 4 hours prior to use in the experiment. They were coated evenly with 5 ml of the prepared insecticide solutions (as mentioned in Table 1) and allowed to dry thoroughly and covered with muslin cloth dipped in the same insecticide solutions and dried. For untreated, 5ml of distilled water was used. Weaver ant nest was collected from the Ixora coccinea L., using scissors. The nest collected was placed carefully inside the polythene bags and secured using rubber band. For easy handling, counting and transferring the ants, were kept in freezer (4^0C) for 15 minutes and transferred into glass beakers in which ants become active after 5 minutes. Ten pairs of worker ants were released in each of the glass beakers. Cellophane tape (2 mm^2) was fastened inside the beaker and 2-3 drops of sugar solution (50%) was placed on the tape as food. Mortality of the workers was noted at 1, 4, 8, 12, 16, 20 and 24 hours after treatment. Per cent mortality was calculated. Natural mortality was corrected using Abbott's formula (Abbott, 1925). The data were subjected to completely randomized block design (CRD) and analyzed using SPSS 16 statistical software.

Results and Discussion

The data on per cent corrected mortality of *Oecophylla smaragdina* (minor and major workers) due to different insecticides are presented in Table 1 and Table 2 respectively. After 1h exposure, the lowest mortality (15.00 %) was observed in azadirachtin, the mobility of minor workers was normal and moderate mortality (27.00%) was caused by imidacloprid. The mean difference between azadirachtin and imidacloprid was greater than the critical difference so azadirachtin was significantly different from imidacloprid.

In azadirachtin and imidacloprid treatments, mortality of minor ants ranged 15–100.0 and 27.0–100.0 per cent (Table 1) during 24h of exposure, respectively. According to Ahmed *et al.* (2011) field sprayed leaves exposure proved imidacloprid the least toxic insecticide**.** In residual film method, acetamiprid was the least toxic but most toxic in glass vial method against Coccinella undecimpunctata. Prabhakar *et al.* (2011) stated that the two predators, Geocoris punctipes *(*Say*)* and Orius insidiosus *(*Say*)*, were variably susceptible to imidacloprid and thiamethoxam after 96-h exposure**.** However, toxicity to these predators may be related to their feeding on foliage and not just contact with surface residues**.**

In major worker after 1h exposure, the lowest mortality *(*11.67 *%)* was observed in azadirachtin followed by moderate mortality *(*28.33*%)* in Imidacloprid. In azadirachtin and imidacloprid treatments, the per cent mortality of major workers ranged from 11.67–100**.**0 and 28.33– 100**.**0 (Table 2) during 24h of exposure, respectively**.** Carvalho *et al.* (2010) [8] have proven that acetamiprid and imidacloprid along with lufenuron, and triflumuron were harmless *(*class 1*)* to Trichogramma pretiosum Riley and are recommendable for integrated pest management programs aiming at the preservation of this parasitoid species.

There was a significant difference between imidacloprid and azadirachtin treatments on the behaviour of the major and minor workers. After 1h, weaver ants in imidacloprid treated glass containers showed the cramps (sudden, involuntary contractions of muscles) symptoms, this is similar to the reports of Nagata *et al.,* (1997) [18] and Bloomquist (2009cal) [6] whom observed that imidacloprid induced overstimulation of the synapses, which resulted in hypertension, convulsions, paralysis, and death. The present findings are also in agreement with the findings of Mizell and Sconyers (1992) [17] and Awasthi *et al.* (2013) [37].

Azadirachtin caused 100*%* mortality only after 24h in both the major and minor workers**.** This is in agreement with the reports of Lowery and Isman *(*1995) [16]; Naumann and Isman *(*1996) [21] and Tang *et al. (*2002) [35] whom also confirmed that neem formulations have minimal toxicity to non-target organisms and negative effect on parasitoid survival and emergence. Sundari *(*1998) [33] tested five insecticides for their effects on Cryptolaemus montrouzieri and observed that acephate and dimethoate found to be highly toxic compounds, while azadirachtin and dichlorvos showed the lowest toxicity and fenvelarate was intermediate**.**

In azadirachtin treatment active movements were found even up to 12hr in both minor (15.00 % to 43.00 %) and major (11.67 % to 20.00 %) workers and reached 100.00 % mortality after 12hrs. Similarly, Nalini and Manickavasagam (2011) stated that nimbecidine caused 100% mortality only after 24h indicating that it is the safest of all the insecticides tested for Aenasius bambawalei Hayat and *A.* advena Compere. Schmidt and Pesel *(*1987) [30] reported that worker ants were resistant when sprayed with neem products**.** On the other hand, feeding of AZTVR- K and MTB*/*H20-K- NR to the red forest ant Formica polyctena led to a stimulation of egg production when low concentrations were used**.** Use of neem-based products with predatory ants, *Oecophylla smaragdina*, gave excellent control of fruit flies, Bactrocera cucurbitae, in organic agriculture system, but it was not sufficiently active to manage Aulacophora spp**.** *(*Rohan, 2000) [28].

Lambda cyhalothrin and Thiamethoxam caused 100*%* mortality within 1h in both the minor and major workers of O. smaragdina**.** These two treatmental mean differences were less than critical differences, thus statistically these two treatments does not differ significantly.

Both the minor and major workers became erect and stopped their mobility, shivered and died immediately after few minutes. This is in conformity with NPIC (2001), He *et al.* (2008) and Sahar *et al.* (2021). And also, the results were in corroboration with earlier findings of Seenivasan and Muraleedharan (2009*(* whom found that Lambda**-**cyhalothrin is more persistent in nature and has both contact and ingestion activity. Lambda**-**cyhalothrin is regarded as harmful to the natural enemies (Tillman and Mulmooney (2000). Also, it has harmful effect on natural enemies due to both lethal and sublethal doses *)*Desneux *et al.*, 2004 **.***(*

Thiamethoxam is thought to have different mode of action and it is more toxic to natural enemies than imidacloprid, especially when applied systemically (Prabhaker *et al.*, 2011; Wang *et al.*, 2013; Wang et *al.*, 2014). Although thiamethoxam and other neonicotinoids were considered to be environmentally–friendly at first, their potential negative impacts on pollinators have recently led to great concern over environmental impact (Goulson, 2013).

In quinalphos, in both minor and major workers active movements were observed for first one hour and the toxic effects began only after one hour of the treatment in which 100 per cent death were recorded in both cases which was substantially supported by Gupta (2016) [12] who stated that OP compounds is widely distributed within both the central and peripheral nervous systems, chemicals that inhibit AChE are known to produce a broad range of well-characterized symptoms of Ach poisoning (both muscarinic and nicotinic symptoms). In the present study, both the minor and major workers of O. smaragdina in distilled water sprayed beakers (untreated check) were alive for 24h. Present findings were supported by Sunitha devi (2003) [34] who observed 100 per cent mortality of larval Chrysoperla carnea on the first day of quinalphos treatment and its toxicity was continued up to 15 days. Balasubramani and Swamiappan (1997) [4] whom observed 100 per cent mortality in larval Chrysoperla carnea on zero day of spraying. This was in line with findings made by Reddy and Divakar (199) [25] whom reported that quinalphos was harmful to *C.* carnea larvae, when applied at field recommended / dose. This observation was further supported by Reddy and Manjunatha (2000) [26] whom found 100 per cent mortality in C. carnea on the day of application. Insecticide treatment, ant sub-caste, and hours after treatment affected percent mortality. However, these factors interacted in different ways to affect both minor and major workers. For both minor and major workers, quinalphos, lambda cyhalothrin, thiamethoxam were highly toxic. In contrast, imidacloprid and azadirachtin had weak toxicity. Imidacloprid showed greater per cent mortality in major workers than minor workers up to 16 hours may be due to its stage specific toxicity on larger instar.

Similar to present findings Yue *et al.* (2003) [41] reported that toxicity variation was depending on larval age, with higher concentrations and longer exposure periods of thiamethoxam (neonicotinoids) required to provide 100% mortality of Indian meal moth, Plodia interpunctella (Hübner).

In the present study, in azadirachtin the mortality per cent started from 15.00 to 43.33 in minor workers whereas it is weak against major worker ants (11.67 to 20.00 per cent) as it lost toxicity with residual age.

Supportive to the present study results Rodriguez-Saona *et al.* (2016) [27], reported that insecticides were in general more selective i.e., stage-specific, than conventional broad-spectrum insecticides, and will thus require more intensive scouting and precise timing of application. Liu *et al.* (2003) [15] also reported that no toxic effect was observed in indoxacarb on eggs of the diamondback moth, Plutella xylostella L., but a high efficacy, comparable to spinosad, against larvae. Srinivasa babu and Sharma (2003) [32] stated that neem oil was the safest chemical and imidacloprid was also relatively safer than conventional organophosphates to coccinellids. Hence, it is concluded that in organic pest management weaver ant as major component azadirachtin can be recommended to manage pests.

Table 1: Evaluation of different insecticides for their safety against minor workers of *Oecophylla smaragdina*

Treatments	Corrected Mortality % of minor workers after*						
	1h	4hr	8h	12h	16 h	20 h	24 h
Imidacloprid 17.8% % (100 ml/ha)	27.00 (31.07)	36.67 (37.20)	48.33 (44.04)	68.33 (55.85)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Quinalphos 25% EC (2000ml/ha)	30.00 (33.03)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Lambda cyhalothrin 5% (300ml/ha)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Thiamethoxam 25% WG (200gm/ha)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Azadirachtin 0.03% (2500-5000 ml/ha)	15.00 (22.59)	23.33 (28.85)	41.67 (40.13)	43.33 (41.13)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Untreated check	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)
Sed	2.4531	2.8054	3.2631	0.00	0.00	0.00	0.00
CD (P=0.05%)	7.5591	8.6443	10.0547	0.00	0.00	0.00	0.00

*Mean of three replications Data in parentheses are arc sine transformed values

Table 2: Evaluation of different insecticides for their safety against major workers of *Oecophylla smaragdina*

Treatments	Corrected Mortality % of major workers after*						
	1h	4hr	8h	12h	16 h	20 h	24 h
Imidacloprid 17.8% (100 ml/ha)	28.33 (32.14)	40.00 (39.04)	50.00 (44.96)	61.67 (51.83)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Quinalphos 25% EC (2000ml/ha)	31.67 (34.23)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Lambda Cyhalothrin 5% (300ml/ha)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Thiamethoxam 25% WG (200gm/ha)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)	100.00 (88.35)
Azadirachtin 0.03% (2500-5000 ml/ha)	11.67 (16.45)	20.00 (26.45)	20.00 (26.45)	20.00 (26.45)	100.00 (88.35)	100.00 (88.35)	100.0 (88.35)
Untreated check	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)	0.00 (1.65)
Sed	2.6352	3.7883	4.1387	0.00	0.00	0.00	0.00
CD (P=0.05%)	8.1199	11.6731	12.7529	0.00	0.00	0.00	0.00

*Mean of three replications Data in parentheses are arc sine transformed value

References

1. Abbott WS. A method of computing the effectiveness of an insecticide. Journal of Economic Entomology,1925:18:265–267.
2. Ahmad M, Rafiq M, Arif MI and Sayyed AH. Toxicity of some commonly used insecticides against *Coccinella* undecimpunctata (Coleoptera: Coccinellidae). Pakistan Journal of Zoology,2011:43(6):1161-1165.
3. Awasthi NS, Barkhade UP, Patil SR and Lande G K. Comparative toxicity of some commonly used insecticides to cotton aphid and their safety to predatory coccinellids. Bioscan,2013:8(3):1007-1010.
4. Balasubramani V and Swamiappan M. Persistent toxicity of some insecticides to the green lacewing Chrysoperla carnea (Chrysopidae: Neuroptera). Journal of Ecotoxicology and Environmental Monitoring,1997:7:197-200.
5. Bharti H and Silla S. Notes on the life history of

Oecophylla smaragdina (Fabricius) and its potential as biological control agent. Halteres,2011:3:57-64.
6. Bloomquist, JR. Insecticides: chemistries and characteristics. Radcliffe's IPM World Textbook. University of Minnesota, St. Paul, Minnesota, 2009.
7. Boli R. Safety of new generation insecticides to bee pollinators (Doctoral dissertation, Department of agricultural entomology, College of agriculture, Vellayani). Retrieved from https://krishikosh.egranth.ac.in, 2014.
8. Carvalho GA, Godoy MS, Parreira DS, Lasmar O, Souza JR and Moscardini VF Selectivity of growth regulators and neonicotinoids for adults of Trichogramma pretiosum (Hymenoptera: Trichogrammatidae). Revista Colombiana de Entomologia,2010:36(2):195-201.
9. Desneux N, Pham-Delègue MH and Kaiser L. Effects of sub-lethal and lethal doses of lambda-cyhalothrin on oviposition experience and host-searching behaviour of a parasitic wasp, Aphidius ervi. Pest Management Science,2004:60:381-389.
10. El-Wakeil N, Gaafar N, Sallam A and Volkmar C. Side effects of insecticides on natural enemies and possibility of their integration in plant protection strategies. Insecticides: Development of Safer and More Effective Technologies Agricultural and Biological Sciences (S. Trdan, ed.). InTech Open Access Publisher, 2013, 1-56.
11. Goulson D. REVIEW: an overview of the environmental risks posed by neonicotinoid insecticides. Journal of Applied Ecology,2013:50: 977–987.
12. Gupta PK. Fundamentals of toxicology: essential concepts and applications. Academic Press, 2016.
13. Halappa B. Safety Evaluation of Newer Molecules of Insecticides Against Promising Parasitoid and Predators of Crop Pests (Doctoral dissertation, UAS, Dharwad). Retrieved from https://krishikosh.egranth.ac.in, 2011.
14. He, Troiano LM, Wang J and Goh K. Environmental chemistry, ecotoxicity, and fate of lambda-cyhalothrin. Reviews of environmental contamination and toxicology, 2008, 71-91.
15. Liu TX, Sparks AN and Chen W. Toxicity, persistence and efficacy of indoxacarb and two other insecticides on *Plutella xylostella* (Lepidoptera: Plutellidae) immatures in cabbage. International Journal of Pest Management,2003:L49(3):235-241.
16. Lowery DT and Isman MB. Toxicity of neem to natural enemies of aphids. Phytoparasitica,1995:23:297–306.
17. Mizell RF and Sconyers MC. Toxicity of imidacloprid to selected arthropod predators in the laboratory, The Florida entomologist.1992:75:277-280.
18. Nagata K, Iwanaga Y, Shono T and Narahashi T. Modulation of the neuronal nicotinic acetylcholine receptor channel by imidacloprid and cartap. Pesticide Biochemistry and Physiology,1997:59:119–128.
19. Nalini T and Manickavasagam S. Toxicity of selected insecticides to mealybug parasitoids, Aenasius bambawalei Hayat and Aenasius advena Compere (Hymenoptera: Encyrtidae),2011:25:14–17.
20. National Pesticide Information Center (NPIC). Lambda-cyhalothrin technical factsheet. Available at: http://npic.orst.edu/factsheets/l_cyhalotech.pdf, 2001.
21. Naumann K and Isman M. Toxicity of neem (Azadirachta indica A. Juss.) seed extracts to larval honeybees and estimation of dangers from field application. American Bee Journal,1996:136:518–520.
22. Offenberg J. The use of artificial nests by weaver ants: a preliminary field observation. Asian Myrmecology,2014:6:119–128.
23. Plapp FWJR and Vinson SB. Comparative toxicities of some insecticides to the tobacco bud worm and its ichneumonid parasite, *Campoletis sonorensis* (Cameron). Environmental Entomology,1977:6:381–384.
24. Prabhaker N, Castle SJ, Naranjo SE, Toscano, NC and Morse JG. Compatibility of two systemic neonicotinoids, imidacloprid and thiamethoxam, with various natural enemies of agricultural pests. Journal of Economic Entomology,2011:104(3):773-781.
25. Reddy GRS and Divakar BJ. Relative toxicity of nine insecticide to Bracon kirpatriki and Chrysoperla camea. Plant Protection Bulletin,1998:50:9-10.
26. Reddy GVP and Manjunatha M. Laboratory and field studies on the integrated pest management of Helicoverpa armigera (Hubner) in cotton, based on pheromone trap catch threshold level. Journal of Applied Entomology,2000:124 (2):13-22.
27. Rodriguez-Saona C, Wanumen AC, Salamanca J, Holdcraft Rand Kyryczenko-Roth V. Toxicity of insecticides on various life stages of two tortricid pests of cranberries and on a non-target predator. Insects,2016:**7**(2):15.
28. Rohan R. The management of major insect pests Bactocera cucurbitaceae and Aulacaphora spp. in cucurbits under 3 intensive systems: integrated chemical and organic agriculture in Southern Sri Lanka. British Crop Protection Council,2000:3:981-985.
29. Sahar S, Xue J, Rashid A, Mei Q and Hua R. In situ monitoring of chlorothalonil and lambda-cyhalothrin by polyethylene passive samplers under fields and greenhouse conditions. Environmental Science and Pollution Research, 2021, 1-10.
30. Schmidt G. and Pesel E. Studies on the sterilizing effects of neem extracts in ants, in natural pesticides from neem tree and other tropical plants. Procurement III International Neem Conference, 1987, 361–373.
31. Seenivasan S and Muraleedharan NN. Residues of lambda-cyhalothrin in tea. Food and Chemical Toxicology,2009:47:502-505.
32. Srinivasa Babu K and Sharma AK. Compatibility of a newer insecticide, imidacloprid (Confidor) with propiconazole (Tilt 25EC) against foliar aphids and their coccinellid predators of wheat ecosystem. Indian Journal of Entomology,2003:65:287–291.
33. Sundari MSN. Residual toxicity of insecticides against Cryptolaemus montrouzieri Mulsant (Coleoptera: Coccinellidae). Insect Environment,1998:4:45.
34. Sunitha devi, R. Effect of selected insecticides on predatory green lacewing, *Chrysoperla carnea* stephens (Doctoral dissertation, Professor Jayashankar Telangana State Agricultural university hyderabad). Retrieved from https://krishikosh.egranth.ac.in, 2003.
35. Tang YQ, Weathersbee AA and Mayer RT. Effect of neem seed extract on the brown citrus aphid (Homoptera: Aphidiidae) and its parasitoid Lysiphlebus testaceipes (Hymenoptera: Aphidiidae). Environmental

Entomology,2002:31:172–176.
36. Tillman PG and Mulrooney JE. Effect of selected insecticides on the natural enemies Coleomegilla maculata and Hippodamia convergens (Coleoptera: Coccinellidae), Geocoris punctipes (Hemiptera: Lygaeidae), and Bracon mellitor, Cardiochiles nigriceps, and Cotesia marginiventris Hymenoptera: Braconidae) in cotton. Journal of Economic Entomology,2000:93:1638-43.
37. Van Mele P. A historical review of research on the weaver ant Oecophylla in biological control. Agricultural and Forest Entomology,2008:10(1)13-22.
38. Van Mele P. and Cuc NTT. Evolution and status of *Oecophylla smaragdina* (Fabricius) as a pest control agent in citrus in the Mekong Delta, Vietnam. International Journal of Pest Management,2000:46:295–301.
39. Wang Y, Chen L, An X, Jiang J, Wang Q, Cai L, Zhao X. Susceptibility to selected insecticides and risk assessment in the insect egg parasitoid Trichogramma confusum (Hymenoptera: Trichogrammatidae). Journal of Economic Entomology,2013:106:142–149.
40. Wang Y, Wu C, Cang T, Yang L, Yu W, Zhao X, Wang Q, and Cai L. Toxicity risk of insecticides to the insect egg parasitoid Trichogramma evanescens Westwood (Hymenoptera: Trichogrammatidae). Pest Management Science,2014:70:398–404.
41. Yue B, Wilde GE and Arthur F. Evaluation of thiamethoxam and imidacloprid as seed treatments to control European corn borer and Indian meal moth (Lepidoptera: Pyralidae) larvae. Journal of economic entomology,2003:96(2):503-509.
42. Tchoudjin GL, Tadu Z, Fomekong-Lontchi J, Kakam S, Aymélé-Choungmo SR, Kenfack-Fogang P, Massussi JA, Niba AS, Djiéto-Lordon C. Leaf litter-dwelling ant (Formicidae) diversity in a tropical rainforest and agro-forestry system, South Region of Cameroon: Implications for conservation management. International Journal of Zoology Studies. 2020;5:1-9.