Original Research Article

BIOEFFICACY OF NEWER MOLECULES INSECTICIDES AGAINST TEA MOSQUITO BUG, Helopeltis theivora WATERHOUSE UNDER LABORATORY CONDITION

ABSTRACT

Aims: Bio-efficacy of newer insecticides against the Tea mosquito bug (TMB) in Tea.
Study design: CRD
Place and Duration of Study: R&D center, Parry Agro Industries Limited, Murugali Tea Estate, Valparai, Coimbatore, Tamil Nadu between September 2019 and September 2021.
Methodology: Field populations of *H. theivora* were collected and Bouquet bioassay method was used to assess the efficacy. Eleven insecticides with three replications (15 shoots/ replication) and Completely Randomized Design (CRD) was followed. The treatments includes *viz.,*T1- Chlorantraniliprole 18.5 SC @ 0.3ml/lit., T2- Spirotetramate +Imidacoprid 11.01 SC @ 2ml/litre., T3 - Thiacloprid 21.7 SC @ 1ml/lit., T4 - Thiamethoxam 25 WG @ 0.5gm/lit., T5- Spinosad 45 SC @ 0.5ml/lit., T6- Dinotefuran 20 SG @ 0.5g/lit., T7- Emamectin benzoate 5 SG @ 0.5g/lit., T8- Buprofezin 25 SC @ 3ml/lit., T9- Sulfaxaflor 21.8 SC @ 1.8ml/lit., T10- Tolfenpyrad 15% EC @ 2ml/lit., and T11- Control (Water). The shoots were sprayed with hand atomizer and observations on the % adult mortality and Feeding puncture/ shoots were recorded at 24, 48 and 72 hours after treatment (HAT). Moribund insects were consider as dead and taken for the count and data were analyzed statistically.
Results: Among all the treatments tested, tolfenpyrad 15% EC after 72 HAT treated tea shoots having less no of feeding punctures (85.33 Nos) and maximum 100 percent adult mortality followed by dinotefuran 20 SG (100.00%), sulfaxaflor 21.8 SC (93.33%), emamectin benzoate 5 SG (90.00%), thiacloprid 21.7 SC (88.33%), spirotetramate + imidacoprid 11.01 SC (81.67%), buprofezin 25 SC (75.00%), thiamethoxam 25 WG (71.67%), chlorantraniliprole 18.5 SC(68.33%), spinosad 45 SC (61.67 %). The feeding punctures were maximum in untreated control (167.22 Nos).
Conclusion: The present study revealed the application of Tolfenpyrad 15% EC @ 2ml/lit. is the optimum dose for the effective control of *Helopeltis theivora* under laboratory conditions.

Key Words: Bio-efficacy, Insecticides, Tea, Tea mosquito bug, Sucking pests and Hemiptera

1. INTRODUCTION

Tea, *Camellia sinensis* (L.) O Kuntze is one of India's most important economic crops and is mainly grown for its leaf. Tea, the most popular non-alcoholic beverage consumed worldwide, is produced by processing the young leaves of the tea plant. Tea belongs to the family Theaceae, originated from the high regions of South and northwest India. The tea plant is predominantly grown in Asia, followed by Africa and to a minimal extent in Europe, South America, Australia, and New Zealand. India ranks second in production and area as compared to china. However, Asia-Pacific dominates the global market and accounts for 40% of the total demand in the tea market [19]. In 2021 tea production was 1.28 billion kg in India, and Tea production in West Bengal was approximately 25 million kilograms in March 2021, the highest of any other region in the country [11].

Several species *viz.,* Tea mosquito bug, red, pink, and purple mites, thrips, termites, red slug caterpillar, looper, caterpillar, green leafhopper, Aphid, and Shot hole borer to attack tea plants [8]. Tea mosquito bug, *Helopeltis theivora* Waterhouse (Hemiptera: Miridae) is considered one of the most notorious pests is causing considerable economic loss up to 25% to 50% [14; 3; 24]. Out of a total 4.36 lakh hectares in India, 3.49 lakh hectares (80%) of tea plantations suffer from *Helopeltis theivora* [4]. During the last few decades, TMB, *Helopeltis* sp. Waterhouse, (Hemiptera: Miridae) has become a serious pest and cause severe threats to most tea growing areas in India. During a severe infestation, tea leaves curl up, become badly deformed, remain small, gradually these shoots dry up, and sometimes crop loss is near total [18]. This insect was considered the most severe pests in Kerala, Vandiperiyar, Peermadu, Mundagayam (Idukki Dist) and entered some regions of Anamalais. It mainly attacks young tea leaves, which are essential for tea manufacturing. Adults and nymphs suck the sap from buds, young leaves and petioles, and tender tea shoots. Among them, the tea mosquito bug, *Helopeltis theivora* Waterhouse is an important one causing considerable economic loss [20].

The distribution and abundance of problems significantly arthropods are greatly influenced by weather, altitude, crop variety, harvesting, pruning, manuring, regulation of shade, use of pesticides. In beginning several different insecticide used to control TMB, but in present, only the safer insecticides having low MRL values such as thiomethoxam, thiacloprid deltamethrin, profenofos, bifenthrin and quinalphos were used for the management of insect pests in tea. The insecticides lamdacyhalothrin, Profenofos and fenpropathrin have ovicidal action against the eggs of TMB [13]. Large-scale and sometimes indiscriminate pesticides have upset the natural ecosystem by enhancing secondary pest outbreaks and often created pesticide residue problems in made teas. It has become a significant concern to the tea industry in recent years. The importing countries impose stringent restrictions for the acceptability of the made tea due to pesticide residues. An essential problem in controlling *H. theivora* is its capability to develop resistance quickly to frequently used insecticides. Keeping in view of all above statements, the present study was designed the newer molecules were tested against the tea mosquito bug the break the resistance chain.

2. MATERIAL AND METHODS

2.1 Mass culturing of Tea mosquito bug (*H. theivora)*:

Field populations of *H. theivora* were collected from Parry Agro Industries Limited, Murugali Tea Estate in Valparai area, (10°19'36.88" N 76°57'4.18" E) District of Coimbatore, Tamil Nadu. The collected insect was kept as a mother culture and cultured in separate cages (47.5 x 47.5 x 47.5 cm) on young tea foliage (variety – UPASAI - 9) shoots were directly collected from estate nursery and maintained in a BOD at 27 ± 2°C, 80 % RH and a photoperiod of 16 h light: 8 h dark. These insects were taken for conducting bioassay studies under laboratory conditions.

2.2 Bioassay

Two to five days old adult male and female *H. theivora* was collected from laboratory at Parry Agro Industries Limited, Murugali Tea Estate in Valparai, (10°19'36.88" N 76°57'4.18" E) District of Coimbatore, Tamil Nadu. These insects were taken for conducting bioassay studies under laboratory conditions. Eleven treatments with three replication (15 shoots/ replication) in Completely Randomized Design (CRD). The treatments *viz.,* T1- Chlorantraniliprole 18.5 SC @ 0.3ml/l, T2- Spirotetramate +Imidacoprid 11.01 SC @ 2ml/l, T3 - Thiacloprid 21.7 SC @ 1ml/l, T4 - Thiamethoxam 25 WG @ 0.5gm/l, T5-

Spinosad 45 SC @ 0.5ml/l, T6- Dinotefuran 20 SG @ 0.5g/l, T7- Emamectin benzoate 5 SG @ 0.5g/l, T8- Buprofezin 25 SC @ 3ml/l, T9- Sulfaxaflor 21.8 SC @ 1.8ml/l, T10- Tolfenpyrad 15 EC @ 2ml/l, and T11- Control (Water). Before the bioassay, the tea mosquito bugs adults was released in an empty cage for 30 minutes as starvation. Field recommended dosage of insecticides was diluted in water. Toxicity assays were conducted using the standard 'Bouquet method' recommended by the Insecticide Resistance Action Committee (IRAC). Healthy shoots (three leaves and a bud) of UPASI - 9 clones were collected from an experimental plot, washed thoroughly with distilled water and air-dried. Fifteen tea shoots for each treatment were sprayed with each chosen insecticide separately at the respective dilutions using a hand sprayer (27.3 x 5.5 x 3.5 cm). Then they were kept in a glass tube (8.2 x 13.2 cm) containing water and wrapped with cotton. The sprayed tea shoots were kept under ceiling fans for 15 min to evaporate the emulsion. The glass tubes containing tea shoots were placed in a glass cage (20 x 15 cm). The tubes were kept at 27 ± 2°C in culture room. Thirty adults of *H. theivora* were released separately into each cage containing tea shoots. Observations on the % adult mortality and Feeding puncture/ shoots were recorded as 24, 48 and 72 hours after treatment (HAT). Test TBM adults were collected from laboratory for LC_{50} bioassay. Collected adults were exposed to different dosage of Tolfenpyrad 15 EC and Dinotefuran 20 SG for 24h. Absorbed mortality was substituted in SPSS software based on Finney probit analysis method [6] to find out the LC_{50} values of the selected insecticides. Moribund insects were considered dead and taken for the count, and collected data were analyzed using statistical software OPSTAT. The mortality data were converted to corrected per cent mortality using Abbott's formula [2].

3. RESULTS AND DISCUSSION

Bioefficacy of newer insecticide molecules against Tea Mosquito Bug revealed that among all the treatments, Tolfenpyrad 15% EC treated tea shoots at 72 HAT had 100 percent adult mortality followed by Dinotefuran 20% SG (100.00%), Sulfaxaflor 21.8 SC (93.33%), Emamectin benzoate 5% SG (90.00%), Thiacloprid 21.7% SC (88.33%), Spirotetramate +Imidacoprid 11.01 SC% (81.67%), Buprofezin 25% SC (75.00%), Thiamethoxam 25% WG (71.67%), Chlorantraniliprole 18.55 SC (68.33%), Spinosad 45% SC (61.67 %) and Water (Nil), respectively (Table 1). Bioefficacy of newer insecticide molecules against Tea Mosquito Bug revealed that among all the treatments, Tolfenpyrad 15% EC treated tea shoots having less no of feeding punctures (85.33 Nos) followed by Dinotefuran 20% SG (89.11), Sulfaxaflor 21.8% SC (91.11), Thiacloprid 21.7 % SC (102.78), Emamectin benzoate 5% SG (103.89), Spirotetramate +Imidacoprid 11.01 SC% (103.89), Thiamethoxam 25% WG (111.44), Buprofezin 25% SC (111.56), Chlorantraniliprole 18.5 SC% (11.56), Spinosad 45% SC (116.67) and the feeding punctures was maximum in control (167.22 Nos) (Table 2). In LC_{50} bioassay, Dinotefuran 20 SG showed the lowest LC_{50} value (90.75 ppm) followed by Tolfenpyrad 15% EC (305.80 ppm) (Table 3, Figure 1& 2).
The present results are in agreement with Qu et al. (15), who reported that dinotefuran was the most toxic among six tested insecticides against two invasive whiteflies *Bemisia tabaci* (Gennadius), Middle East-Asia Minor1 (MEAM1 or biotype B), and Mediterranean (MED or biotype Q).The spray application of

imidacloprid, thiamethoxam, and diafenthiuron effectively reduced the sucking pests population on chilli, brinjal and arecanut were reported by [19], [10], [22] and [23]. According to Venkateshalu and Mahesh [26], dinotefuran 20 % SG @ 30 g a.i./ha was found highly effective against sucking pests of Okra. Similarly, the dinotefuran 20 % SG @ 30 g a.i./ha was found superior against leafhoppers, aphids, thrips, and whiteflies in the cotton ecosystem were reported by [24], [9] and [1]. [5] was reported that thiamethoxam reduced 85.90%of the TMB population in the Bi-lashcherra Experimental Farm of Bangladesh Tea Research Institute (BTRI). The present finding was also strengthened by the previous results by [12], [5] and [16]. A comparison of the expected effective dose of thirteen insecticides against tea mosquito bug based on their LC_{50} values with recommended dose revealed a pronounced shift in the level of susceptibility of *H. theivora* to all the chosen insecticides except acephate was reported by [7]. The LC_{95} values suggest medium to high resistance for endosulfan and low to medium resistance for cypermethrin, lambda-cyhalothrin, imidacloprid, and quinalphos. However, there was not much chance for the other registered insecticides, and they were found to be still effective at their recommended doses was reported by [17].

Table 1. Mortality percentage of *H. theivora* adults exposed to tea shoots treated with different insecticides under laboratory conditions

S.No.	Treatment details	Dose (ml or g/l)	Adult mortality % 24 HAT	48 HAT	72 HAT	Mean % Mortality	% reduction over control
1.	Chlorantraniliprole 18.5 SC	0.3	21.67^{b}±0.10	38.33^{cd}±0.16	68.33^{de}±0.06	42.78	88.31
2.	Spirotetramat 11.01 +Imidacloprid 11.01 SC	2.0	28.33^{b}±0.22	51.67^{bc}±0.07	81.67^{bcd}±0.11	53.89	90.72
3.	Thiacloprid 21.7 SC	1.0	28.33^{b}±0.08	55.00^{b}±0.11	88.33^{abc}±0.14	57.22	91.26
4.	Thiamethoxam 25 WG	0.5	21.67^{b}±0.18	38.33^{cd}±0.16	71.67^{cde}±0.16	43.89	88.61
5.	Spinosad 45 SC	0.5	18.33^{b}±0.10	28.33^{d}±0.08	61.67^{c}±0.06	36.11	86.15
6.	Dinotefuran 20 SG	0.5	48.33^{a}±0.07	75.00^{ab}±0.10	100.00^{a}±0.00	74.44	93.28
7.	Emamectin benzoate 5 SG	0.5	25.00^{b}±0.16	51.67^{bc}±0.07	90.00^{ab}±0.10	55.56	91.00
8.	Buprofezin 25 SC	3.0	21.67^{b}±0.10	48.33^{b}c±0.07	75.00^{bcde}±0.10	48.33	89.66
9.	Sulfaxaflor 21.8 SC	1.8	45.00^{ab}±0.00	71.67^{ab}±0.06	93.33^{ab}±0.09	70.00	92.86
10.	Tolfenpyrad 15 EC	2	51.67^{a}±0.07	81.67^{a}±0.06	100.00^{a}±0.00	77.78	93.57
11.	Control (Water)	-	5.00^{c}±0.00	5.00^{e}±0.00	5.00^{f}±0.00	5.00	-
	CD (P=0.05)	-	0.35	0.28	0.27	-	-
	SE(d)	-	0.18	0.14	0.13	-	-

Means ± SE within a column followed by the same letter are not significantly different from each other at 5% level of significance (LSD test)

HAT- Hours After Treatment

Table 2. Feeding damage of *H. theivora* adults exposed to tea shoots treated with different insecticides under laboratory conditions

S.No.	Treatment details	Dose (ml or g/l)	Feeding punctures 24 HAT	Feeding punctures 48 HAT	Feeding punctures 72 HAT	Cumulative Feeding puncture	% reduction over control
1.	Chlorantraniliprole 18.5 SC	0.3	$76.33^{bc}\pm0.38$	$109.67^{b}\pm0.13$	$131.00^{bc}\pm0.12$	112.56	32.69
2.	Spirotetramat 11.01 +Imidacloprid 11.01 SC	2.0	$65.67^{c}\pm0.34$	$102.00^{bc}\pm0.25$	$120.33^{c}\pm0.13$	103.89	37.87
3.	Thiacloprid 21.7 SC	1.0	$64.00^{cd}\pm0.33$	$99.67^{bc}\pm0.41$	$121.33^{c}\pm0.09$	102.78	38.54
4.	Thiamethoxam 25 WG	0.5	$73.67^{bc}\pm0.15$	$110.33^{b}\pm0.39$	$131.67^{b}\pm0.21$	111.44	33.36
5.	Spinosad 45 SC	0.5	$81.00^{ab}\pm0.23$	$115.33^{b}\pm0.24$	$135.00^{bc}\pm0.22$	116.67	30.23
6.	Dinotefuran 20 SG	0.5	$52.33^{d}\pm0.20$	$88.33^{c}\pm0.10$	$101.00^{d}\pm0.09$	89.11	46.71
7.	Emamectin benzoate 5 SG	0.5	$67.67^{bc}\pm0.25$	$102.67^{bc}\pm0.23$	$122.00^{bc}\pm0.21$	103.89	37.87
8.	Buprofezin 25 SC	3.0	$69.67^{bc}\pm0.28$	$111.00^{b}\pm0.32$	$129.33^{bc}\pm0.20$	111.56	33.29
9.	Sulfaxaflor 21.8 SC	1.8	$54.67^{d}\pm0.16$	$91.33^{c}\pm0.20$	$104.00^{c}\pm0.15$	91.11	45.51
10.	Tolfenpyrad 15% EC	2	$53.00^{d}\pm0.17$	$86.33^{c}\pm0.13$	$98.33^{c}\pm0.06$	85.33	48.97
11.	Control (Water)	-	$96.00^{a}\pm0.21$	$154.00^{a}\pm0.13$	$233.33^{a}\pm0.34$	167.22	-
	CD (P=0.05)	-	0.76	0.74	0.54	-	-
	SE(d)	-	0.36	0.35	0.26	-	-

Means ± SE within a column followed by the same letter are not significantly different from each other at 5% level of significance (LSD test)

HAT- Hours After Treatment

Table 3. The LC_{50} values of Tolfenpyrad and Dinotefuran on *H. theivora* adults after 24 h of exposure

Insecticide	Regression equation	LC_{50} (ppm)	Fiducial limit	Table χ2	Calculated χ2
Tolfenpyrad 15% EC	y = 4.62x - 6.48	305.80	289.14 - 323.43	9.49	2.79
Dinotefuran 20% SG	y = 2.31x + 0.49	90.76	81.11 - 101.56	9.49	7.25

Figure 1. The LC50 value of Tolfenpyrad on *Helopeltis theivora* adults after 24h of exposure

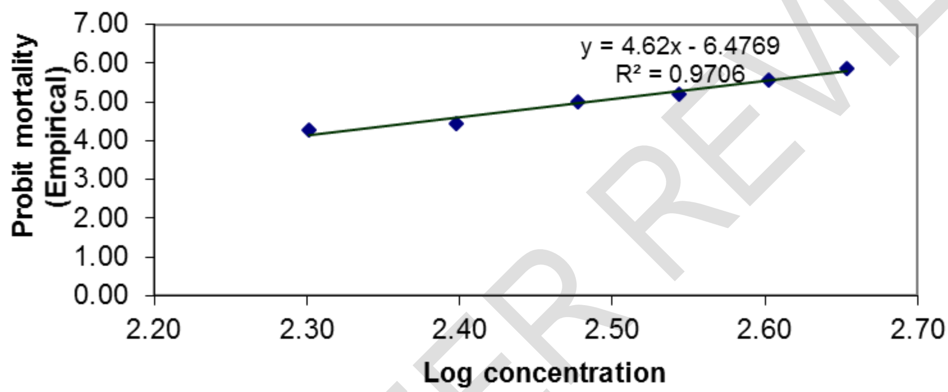
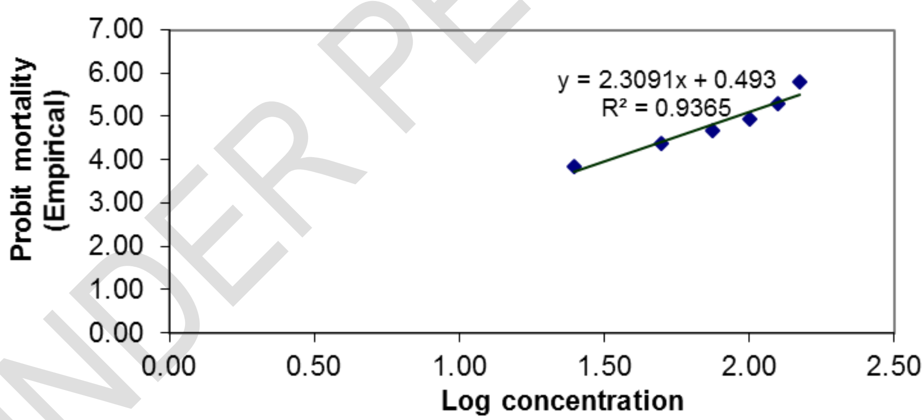


Figure 2. The LC50 value of Dinotefuran on *Helopeltis theivora* adults after 24h of exposure



4. CONCLUSION

The present investigation revealed the application of Tolfenpyrad 15% EC @ 2ml/lit. is the optimum dose for the effective control of *Helopeltis theivora* under laboratory conditions. Thus, Tolfenpyrad 15% EC @ 2ml/lit. it can be recommended for widespread application to manage *Helopeltis theivora* successfully. However, field trials in the future must be carried out before recommendations.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

REFERENCE

1. Abbas Q, Arif MJ, Gogi MD, Abbas SK, Karar H. Performance of imidacloprid, thiomethoxam, acetamaprid and a biocontrol agent (*Chrysoperla carnea*) against whitefly, jassid and thrips on different cotton cultivars. W J Zool. 2012; 7: 141-46.
2. Abbott WS. A method of computing the effectiveness of an insecticide. J Econ Entomol. 1925; 18: 265-267.
3. Barbora BC, Singh K. All about *Helopeltis theivora:* a serious pest of tea. Two and a bud. 1994; 41(2): 19-21.
4. Bora S, Sarmah M, Rahaman A, Gurusubramanian G. Relative toxicity of pyrethroid and non-pyrethroid insecticides against male and female tea mosquito bug, *Helopeltis theivora* Waterhouse (Darjeeling strain). J Entomol Res. 2007; 31:37-41.
5. Chowdhury RS, Ahmed M, Mamun MSA and Paul SK. Relative efficacy of some insecticides for the control of tea mosquito bug, *Helopeltis theivora* (Waterhouse) in Bangladesh. J Pl Prot Sci. 2013; 5(1): 50-54.
6. Finney DT. Probit analysis. The Cambridge University press London. 1971. p. 333. (*In press*)
7. Gurusubramanian G, Bora S. Insecticidal resistance to tea mosquito bug, *Helopeltis theivora* Waterhouse (Miridae: Heteroptera) in North East India. J Environ Res Dev. 2008a; 2(4): 560-567.
8. Gurusubramanian G, Sarmah M, Rahman A, Roy S, Bora S. Pesticide usage pattern in tea ecosystem, their retrospects and alternative measures: A review. J Environ Biol. 2008b; 29(6): 813-826.

9. Halappa B, Patil RK. Bioefficacy of different insecticides against cotton leafhopper, *Amarasca biguttula biguttula* (Ishada) under field condition. Trends Biosci. 2014; *7*(10): 908-914.
10. Kumar R, Mahla MK, Singh B, Ahir KC, Rathor NC. Relative efficacy of newer insecticides against sucking insect pests of brinjal (*Solanum melongena*). J Entom Zool Stud. 2017; *5*(4): 914-917.
11. Langford NJ. From Global to Local Tea Markets: The Changing Political Economy of Tea Production within India's Domestic Value Chain. Dev Change. 2021; 52(6): 1445-1472. **https://doi.org/10.1111/dech.12652**
12. Maity L, Sarkar PK. Bio-effectiveness of Dinotefuran against Tea mosquito bug, *Helopeltis theivora* waterhouse, in Tea Plantations of West Bengal, India. The Bios. 2016; 11(4): 2209-2213.
13. Muraleedharan N. Bioecology and Management of tea pest in South India. J Plantn Crops. 1992; 20(1): 1-21.
14. Prasad S. Infestation of Helopeltis. Bombay: Tea times, Sandoz (India) Ltd. 1992. P. 243.
15. Qu C, Zhang W, Li F, Tetreau G, Luo C Wang R. Lethal and sub lethal effects of dinotefuran on two invasive whiteflies, *Bemisia tabaci* (Hemiptera: Aleyrodidae). J Asia Pac Entomol. 2017; 20: 325-330.
16. Roy S, Mukhopadhyay A, Gurusubramanian G. Population dynamics of tea mosquito bug (*Helopeltis theivora* Waterhouse, Heteroptera: Miridae) in the sub-Himalayan Dooars tea plantation and possible suggestion of their management strategies. Curr Biotica. 2009a; 2(4**)**: 414-428.
17. Roy S, Mukhopadhyay A, Gurusubramanian G. Sensitivity of the tea mosquito bug (*Helopeltis theivora* Waterhouse), to commonly used insecticides in 2007 in Dooars tea plantations, India and implication for control. American- Eurasian J Agric Environ Sci. 2009b; 6:244_251.
18. Saha D, Roy S, Mukhopadhyay A. Insecticide susceptibility and activity of major detoxifying enzymes in female *Helopeltis theivora* (Heteroptera: Miridae) from sub-Himalayan tea plantations of North Bengal, India. Int J Trop Insect Sci. 2012; 32:85-93.
19. Sangle PM, Pawar SR, Antu M and Korat DM. Bio-efficacy studies of newer insecticides against sucking insects pests on chilli. J Entom Zool Stud. 2017; 5(6):476-480.
20. Sannigrahi, S, Talukdar T. Pesticide use patterns in Dooars tea industry. Two and a Bud*.* 2003; 50(1): 35-38.
21. Shrabanti M, Maumita G. India's tea export in the scenario of trade openness: an analysis of trend and structural shift. American-Eurasian J Sci Res. 2015; 10(1):1-1.
22. Shaikh AA, Bhut JB Variya MV. Effectiveness of different insecticides against sucking pests in brinjal. Int J Pl Protec. 2014; 7: 339- 344.
23. Shivanna, BK, Naik BG, Nagaraja R, Gayathridevi S, Naik RK, Shruthi H. Evaluation of new molecules against scarlet mite, *Raoiella indica* Hirst in arecanut. J Entomol Nematol*.* 2012; 4(1): 4-6.
24. Sreenivas AG, Nadagoud S, Hanchinal SG, Bheemanna M, Naganagoud A, Patil NB. Management of sucking insect pest complex of Bt cotton by using dinotefuran–a 3rd generation neonicotinoid molecule. J Cotton Res Dev. 2015; 29 (1): 90-93.
25. Subramaniam, B. Tea in India. P.I.D. and Wiley Eastern Ltd. 1995. p. 38-40.
26. Venkateshalu, Mahesh M. Bio-efficacy of Dinotefuran 20 per cent SG against sucking insect pests of Okra. Asian J Bio Sci. 2017; 12: 8-14.