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Relative Toxicity of Different Insecticides to Asian Citrus Psylla (*Diaphorina citri* Kuwayama)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Asian citrus psyllids *Diaphorina citri* (Kuwayama) act as vector of the devastating citrus disease, Huanglongbing (HLB) also known as citrus greening which is widely spread in citrus growing regions. The use of insecticides for management of citrus phylla is one of the prominent and effective method to overcome their menace. However, recently very few insecticides have been found under label claim for this pest. The present investigation was conducted in order to know the toxicity of some new chemistry insecticides against *D.citri*. Bioassay experiments were conducted during 2022-23. The toxicity was assessed through uptake bioassay technique for systemic insecticides by using fresh citrus twigs. The results showed that, among the five tested insecticides imidacloprid 17.8 % SL was the most effective insecticide with lowest LC_{50} values for both nymph and adult psyllid i. e. 0.028 and 0.032, respectively. However, except spirotetramat 15.3 % OD, the LC_{50} values of thiamethoxam 25 % WG, abamectin 1.9 % EC, fenpropathrin 30 % EC were placed within the fiducial limit of most toxic insecticide i.e. imidacloprid 17.8% SL. They are

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considered as at par and equally toxic to *D. citri.* The relative toxicity trend against the adult psylla was imidacloprid > abamectin > thiamethoxam > fenpropathrin > spirotetramat and for the nymph, the trend was imidacloprid > thiamethoxam> abamectin > fenpropathrin > spirotetramat.

Keywords: Huanglongbing disease; bioassay; abamectin; imidacloprid; insecticides; thiamethoxam.

1. INTRODUCTION

The Asian citrus psyllid, (*Diaphorina citri* Kuwayama) (Homoptera: Psyllidae), is widely distributed in southern Asia. It is an important pest of citrus in several countries and acts as a vector of the causal agent, "*Candidatus* liberibacter asiaticus" for the most devastating disease called greening disease or Huanglongbing (HLB) which causes heavy losses to citrus orchards and has resulted in destruction of several citrus industries in Asia and Africa [1]. Both nymphs and adults of citrus psylla suck the plant cell sap with the help of their sharp piercing mouth parts, resulted curling, leaves and flowers defoliation and die back of branches from tip to downward and premature dropping of fruits [2]. The fifth instar nymphs of citrus psyllid acting as the main vector of greening bacterium are accounted for about 83 to 95 per cent yield losses [3]. HLB acts to disrupt the phloem of the citrus tree by limiting its ability to uptake nutrients. Initially this leads to yellowing of leaves, infested trees with stunted growth, sparsely foliated branches, unseasonal bloom, promotion of premature leaf and fruit drop, twig dieback, production of small and misshapen fruits that contain bitter juice with no economic value [4]. Earlier Capoor et al. [5] also reported that the young leaves were chlorotic with green banding along the major veins, matured leaves with yellowish-green patches between veins, fruits were small size, generally lopsided, underdeveloped, unevenly colored, hard and poor in juice. Population of citrus psylla has two peaks in a year during spring and summer and these peaks coincided with the availability of new flush [6]. Insecticides are best strategic measure to manage psyllid populations. Imidacloprid and aldicarb were suggested as effective in the period of November and April [7,8]. Similarly, broad spectrum insecticides were used in winter, spring and summer season as foliar sprays [8,9,10] but they gave short term protection against immatured psyllids [11,12]. Also cultural, mechanical and biological management practices for this citrus psyllids are not easily applicable, labourious and not greatly effective during their severe attack in citrus trees. Hence the use of chemical insecticides for management of citrus psylla is one of the prominent, effective and rapid methods to overcome their menace. However, recently a very few insecticides have been found under label claim for this pest. Therefore, is an important need to test some novel chemical insecticides against *D.citri*, as an alternate option for label claim insecticides in view to reduce the development of resistances and residual effect. With these views facts, the present investigation was carried out to determine the toxicity of some new chemistry insecticide against *D.citri.*

2. METHODOLOGY

The bioassay experiments were conducted against *D.citri* during 2022-23 in the Toxicology Laboratory, Department of Entomology by Dr. PDKV., Akola (M.S.). The toxicity was assessed through uptake bioassay technique for systemic insecticides as described by Prabhaker et al. [13] and Molina *et al.* 2022 [14], for five insecticides *viz.* Thiamethoxam 25 % WG, Abamectin 1.9 % EC, Imidacloprid 17.8 % SL, Spirotetramat 15.3 % OD and Fenpropathrin 30 % EC. Bioassays were conducted against nymphs and adults stages of *D.citri* in laboratory with four replicates per insecticide.

The nymphs of psylla were collected in the zipped plastic bags and adults were carefully captured in glass vials or polythene bags tied with rubber band to avoid the escape. The collected psyllids were brought to the laboratory and reared. They were provided with fresh and moisten leaves till the start of bioassays. Citrus shoots (about 15 cm in length and with at least two-three terminal leaves) infested with psyllid nymphs were placed in glass tubes (50 ml) containing an insecticide solution for 24 h. Distilled water was used for control treatment. Each shoot was protected with a paper cone with glycerin in the corners to prevent the nymphs from escaping. After that, the shoots were transferred to a glass tubes with water, where nymphal mortality was checked after 24, 48, 72 and 96 hours. For the bioassay experiment for adults, citrus shoots were placed in each insecticide solution for 24 h. After that, shoots were transferred to a clean 50 ml tubes with

water. Each tube was placed inside a plastic container (1 litre) capacity with a filter paper disc at the bottom and a 2 ml water vial as a humidity source. Ten adults were released in each container covered with muslin cloth and on the numbers of dead and live psyllids adults, observations were recorded at 6, 12, 24 and 48 hours after the treatment [14]. The corrected per cent mortalities were determined as per Abbott's formula (Abbott, 1925) and the LC_{50} values were determined by running probit analysis (Finney, 1952).

3. RESULTS AND DISCUSSION

The nymph and adult mortality of *D.citri* were studied by exposed to different concentrations of insecticides. LC_{50} and LC_{90} values were calculated to compare the toxicity of various insecticides [15]. The bioassay results showed that, amongst the five insecticides tested imidacloprid 17.8 % SL was the most effective insecticide with lowest LC_{50} values. In nymphal bioassay at the LC_{50} levels, the imidacloprid was 3.61 times more toxic than spirotetramat 15.3 % OD. Abamectin 1.9 % EC, thiamethoxam 25 % WG and fenpropathrin 30 % EC recorded 2.97, 3.48 and 2.73 fold higher toxic than spirotetramat (Table 1). In adult, the relative toxicity of imidacloprid was found 3.13 fold more toxic than that of spirotetramat. The next better insecticides were abamectin, thiamethoxam and fenpropathrin which recorded relative toxicity values of 2.94, 2.70 and 2.44 fold more toxic than spirotetramat (Unity), which was found least toxic to *D. citri* (Table 2).

A similar trend of toxicity at LC_{90} level was observed against nymphs and adults for the all the tested insecticides. However, except spirotetramat, the LC_{50} values of thiamethoxam, abamectin, fenpropathrin were lying within the fiducial limit of most toxic insecticide i.e. imidacloprid and hence considered as on par and equally toxic to *D. citri.*

The above results, on relative toxicity of different insecticides were in agreement with the findings of previous workers Chauhan and Srivastava [16] tested the field efficacy of different insecticide against *D.citri* and revealed that, imidacloprid was most effective in reduction of nymph and adult population of psylla, followed by thiamethoxam and novaluron. The results of the present study was also supported by Powell et al. [17] who reported that, the biannual or more frequent applications of Admire (imidacloprid) significantly reduced psyllid population, percentage of trees infestations and percentage of flushes infestations.

Similar results were reported by Childers and Rogers [18] in which foliar applications with thiamethoxam and imidacloprid was found to reduce psylla population of 86.9-96.4 % and 91.5-98.0 % over control up to 12 DAT [19]. Foliar application with abamectin @ 0.3 ml/l resulted 90.2-92.5% reduction in psylla population [20]. Sarada et al. [21] also reported that foliar application of abamectin @ 0.0007 % reduced psylla population more than 80 % after 3 and 7 DAT. The present findings are in line with the findings of Boina et al. [22] who reported that feeding by psylla adults on daily treated plants with a sublethal concentration (0.1µ/L) of imidacloprid significantly reduced the population of citrus psylla. Khan et al. [23] reported that, bioassay with methomyl and imidacloprid inflicted 97-100% mortality to *D. citri.* They also observed gradually decline in mortality in case of methomyl but it was very quick in imidachloprid and lambda cyhalothrin.

According to Wankhade et al. [24] the treatment with abamectin 1.9 EC @ 0.4 ml/l (0.0007%) was found most effective in recording the least nymphal population under field conditions followed by imidacloprid 17.8 SL which proved effective against citrus psylla. The present studies are also on par with the results of Molina et al. [14] who reported that thiamethoxam and imidacloprid were the equally effective on African citrus psylla (*Trioza erytreae)* nymphs and were persistent over time. Spirotetramat and abamectin were the least effective on *T. erytreae* nymph control, which collaborates with the results in the present studies. Khan et al. [25] reported a cumulative mortality of adult *D. citri* with Confidor® (imidacloprid), Movento® (spirotetramat) and Radiant® (spinetoram) with more than 95% at commercially recommended doses. Qasim and Hussian [26] reported that, imidacloprid was better than Bifenthrin against *D. citri.* The results of present studies are in congruent with Dalvaniya et al. [27] who reported that foliar applications of imidacloprid and thiamethoxam significantly reduced *D. citri.* population in lime plants. In accordance with the present findings, Rao et al. [28] revealed that, module with foliar application of thiamethoxam, abamectin and imidacloprid at 20 days interval before, during and after flushing periods was found to be superior in protecting new flush against *D. citri*.

Table 1. Median lethal concentration (LC 50) of different insecticides on citrus psylla (nymph) under laboratory conditions

Sr. no.	Insecticide	Slope	Regression equation (y)	Chi-Square	LC50 %	Fiducial Limit		LC90 %	Fiducial Limit		Relative Toxicity at LC50	Relative Toxicity Rank
						Lower	Upper		Lower	Upper		
1	Thiamethoxam 25 % WG	2.72	Y=4.19+2.72x	0.566	0.029	0.018	0.045	0.086	0.055	0.134	3.48	2
2	Abamectin 1.9 % EC	17.28	Y=25.35+17.28x	0.622	0.034	0.032	0.037	0.040	0.038	0.044	2.97	3
3	Imidacloprid 17.8 % SL	4.33	Y=6.70+4.33x	0.754	0.028	0.021	0.038	0.056	0.041	0.076	3.61	1
4	Spirotetramat 15.3 % OD	4.46	Y=4.44+4.46x	0.737	0.101	0.077	0.133	0.196	0.149	0.257	1.00	5
5	Fenpropenthrin 30 % EC	20.04	Y=28.73+20.04x	0.755	0.037	0.035	0.039	0.043	0.040	0.045	2.73	4

Table 2. Median lethal concentration (LC 50) of different insecticides on citrus psylla (adult) under laboratory conditions

Sr. no.	Insecticide	Slope	Regression equation (y)	Chi-Square	LC_{50} (%)	Fiducial Limit		LC_{90} (%)	Fiducial Limit		Relative Toxicity at LC_{50}	Relative Toxicity Rank
						Lower	Upper		Lower	Upper		
1	Thiamethoxam 25 % WG	2.56	Y=3.67+2.56x	0.020	0.037	0.023	0.060	0.117	0.072	0.191	2.70	3
2	Abamectin 1.9 % EC	16.94	Y=24.97+16.94x	0.952	0.034	0.031	0.036	0.040	0.037	0.043	2.94	2
3	Imidacloprid 17.8 % SL	3.30	Y=4.92+3.30x	0.283	0.032	0.022	0.047	0.079	0.054	0.114	3.13	1
4	Spirotetramat 15.3 % OD	4.54	Y=4.54+4.54x	0.811	0.100	0.076	0.131	0.192	0.146	0.251	1.00	5
5	Fenpropenthrin 30 % EC	16.35	Y=22.73+16.35x	0.837	0.041	0.037	0.044	0.049	0.045	0.053	2.44	4

Fig. 1. Adult *Psylla* bioassay

Fig. 2. Nymph *psylla* bioassay

4. CONCLUSION

Based on the relative toxicity values obtained in the present studies various insecticide tested could be arranged in sequence of better toxicity as imidacloprid > abamectin > thiamethoxam > fenpropathrin > spirotetramat against adult psyllids and imidacloprid > thiamethoxam> abamectin > fenpropathrin > spirotetramat against psyllids nymph.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Manjunath KL, Halbert SE, Ramadugu C, Webb S, Lee RF. Detection of *Candidatus* liberibacter asiaticus in *Diaphorina citri* and its importance in the management of citrus Huanglongbing in Florida. Phytopathology; 2008.
2. Shah HA, Saleem MA. Applied Entomology. 2nd Ed. Izhar sons Printers, Lahore; 2000.
3. Dawane PN, Barkhade UP, Wadaskar RM. Studies on the population dynamics of citrus psylla (*Diaphorina citri* Kuwayama) in Nagpur Mandarin International Journal of Chemical Studies. 2014;2(1):69-74.
4. Salifu A, Grogan AK, Thomas H, Roka FM. Spreen economic analysis of strategies to combat HLB in Florida Citrus. The Southern Agricultural Economics Association Annual Meeting, Birmingham, AL. 2012;4-7.
5. Capoor SP, Rao DG, Viswanath SM. Greening disease of citrus in the Deccan. Trap Country and its relationship with the vector, *Diaphorina citri* Kuwayama. Proceedings of the 6th Conference of the International Citrus Virology, University of California; 1974.
6. Beloti VH, Rugno GR, Felippe MR, Carmo-Uehara AD, Garbim LF, Godoy WA, Yamamoto PT. Population dynamics of *Diaphorina citri* Kuwayama (*Hemiptera*: Liviidae) in Orchards of 'Valencia' Orange, 'Ponkan' Mandarin and 'Murcott' Tangor Trees. Fla. Entomol. 2013;96:173-179.
7. Qureshi JA, Stansly PA. Rate, placement and timing of aldicarb applications to control Asian citrus psyllid, *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae), in oranges. Pest Manag. Sci. 2008;64:1159-1169.
8. Rogers M, Stansly P, Stelinski L. Florida citrus pest management guide: Asian citrus psyllid and citrus leafminer. Entomol. Nematol. Dept., Fla. Coop. Ext.Serv., Inst. Food Agri. Sci., Univer. Fla., ENY. 2008; 734
9. Rogers ME, General pest management considerations. Citrus Ind. 2008;89;12-17.
10. Stansly P, Qureshi J. Arevalo H, Why, when and how to monitor and manage Asian citrus psyllid. Citrus Ind. 2009;90:24-26.
11. Qureshi JA, Stansly PA. Integrated approaches for managing the Asian citrus psyllid *Diaphorina citri* (Homoptera: Psyllidae) in Florida. Proc. Fla. State Horti. Soci. 2007;110-115.
12. Qureshi JA, Stansly PA. Exclusion techniques reveal significant biotic mortality suffered by Asian citrus psyllid *Diaphorina citri* (Hemiptera: Psyllidae) populations in Florida citrus. Biol. Cont. 2009;50:129- 136.
13. Prabhaker N, Castle S, Byrne F, Henneberry T, Toscano NC. Establishment of baseline susceptibility data to various insecticides for Homalodisca coagulata (Homoptera: Cicadellidae) by comparative bioassay techniques. J. Econ. Entomol. 2006;99:141–154.
14. Molina P., Hernández-Suárez E., Rizza R. Efficacy of Selected Insecticides for Chemical Control of the African Citrus Psyllid, *Trioza erytreae* (Psylloidea: Triozidae) Agronomy. 2022; 12: 441:1-13.
15. Pandi GGP, Paul B., Shah V, Shankarganesh K. Relative toxicity of insecticides against coccinellid beetle. Ann. Pl. Protect. Sci. 2003;21:17-20.
16. Chauhan D., Srivastava P. Evaluation of effectiveness of various insecticides for the management of citrus Psylla, *Diaphorina citri* Kuwayama. International Journal of Chemical Studies. 2018;6(2):1043-1051.
17. Powell CA, Burton MS, Pelosi R, Ritenour MA, Bullock RC. Effects of insecticides on Asian citrus psyllid (Hemiptera: Psyllidae) populations in a Florida citrus grove. Online Plant Health Progress; 2007.
18. Childers CC, Rogers ME. Chemical control and management approaches of the Asian citrus psyllid, *Diaphorina citri* Kuwayama (Homoptera: Psyllidae) in Florida citrus. Proceedings of the Florida State Horticultural Society. 2005;118:49–53.

19. Sharma DR. Population dynamics in relation to abiotic factor and management of citrus psylla in Punjab. Indian Journal of Horticulture. 2008;65(4):417–22.
20. Rao CN, Shivankar VJ. Relative efficacy of certain bio-rational insecticides to citrus psylla (*Diaphorina citri*). Indian Journal of Agricultural Sciences. 2011;81(7):91–4.
21. Sarada G, Gopal K, Nagalakshmi T, Venkatramana KT, Mukundalashmi L, Gouri Sanker T, Gopi V. Management of citrus psylla (*Diaphorina citri* Kuwayama) using biorational insecticides. Research and Reviews: Journal of Ecology and Environmental Sciences. 2014;9–11.
22. Boina DR, Salyani M, Stelinski LL. Chemical control of the Asian citrus psyllid, *Diaphorina citri* Kuwayama. Proc. Fla. State Hort. Soc. 2009;122:176-180.
23. Khan I, Zahid M. Khan GZ. Toxicity of botanic and synthetic pesticide to citrus psyllid *Diaphorina citri* Kuwayama and *Chrysoperla carnea* (Stephens). Pakistan J. Zool. 2012;44(1):197-201.
24. Wankhade SM, Kadam UK, Patil SK, Bansode GM. Studies on the seasonal incidence and management of citrus psylla (*Diaphorina citri* Kuwayama) in sweet orange. Indian J. Agric. Res. 2015;49(4): 321-326.
25. Khan AA, Afzal M, Raza MA. Toxicity of botanicals and selective insecticides to Asian citrus psylla, *Diaphorina citri* K. (Homoptera: Psyllidae) in laboratory conditions. Jokull Joural. 2013;63(8):52-72.
26. Qasim M, Hussian D. Efficacy of insecticides against Citrus Psylla (*Diaphorina Citri* Kuwayama) in Field and Laboratory Conditions. Cercetări Agronomiceîn Moldova, Vol. XLVIII. 2015; 2(162):91-97.
27. Dalvaniya DG, Patel PS, Parikh A, Panickar B. Efficacy of some insecticides against citrus psylla, *Diaphorina citri* Kuwayama on kagzi lime. Journal of Entomological Research Society. 2015; 39(2):141–144.
28. Rao CN, Rahangdale SY, George A, Dhengre VN. Evaluation of chemical control schedules against Asian citrus psyllid (*Diaphorina citri*) (Hemiptera: Liviidae), Indian Journal of Agricultural Sciences. 2018;87(5):690–693.

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