Archives of Agriculture and Environmental Science 7(4): 601-605 (2022)
https://doi.org/10.26832/24566632.2022.0704019

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes

ORIGINAL RESEARCH ARTICLE

Evaluation of insecticidal efficacy against maize leaf aphid [*Rhopalosiphum maidis* (Fitch)] under inner terai condition of Nepal

Saraswati Neupane[1*] and Subash Subedi[2]

[1]Nepal Agricultural Research Council (NARC), National Maize Research Program, Rampur, Chitwan, NEPAL
[2]Nepal Agricultural Research Council (NARC), Oilseed Research Program, Nawalpur, Sarlahi, NEPAL
[*]Corresponding author's E-mail: sarusanu2017@gmail.com

ARTICLE HISTORY

Received: 19 November 2022
Revised received: 20 December 2022
Accepted: 23 December 2022

Keywords

Aphid
Insecticide
Management
Maize

ABSTRACT

Field experiments were carried out at the National Maize Research Program in Rampur, Chitwan, with the objective of comparing the effectiveness of insecticides in the field for controlling maize leaf aphid (*Rhopalosiphum maidis* Fitch) during the winter season of 2019 and 2020. The design of the experiment was randomized complete block with four replications. The plot size was 6 rows of 5 m long with the spacing of 60cm × 25cm. Maize hybrid Rampur Hybrid-14 (RML-86/RML-96) was used as experimental variety. The efficacies of five insecticides viz., thiomethoxam 25% w/w 0.2g/L (T1), acetamiprid 20%WP 2g/L (T2), flonicamid 50% WG 0.5g/L (T3), neemix 3ml/L(T4), imidacloprid 0.5ml/L(T5) and untreated control (T6) were used as experimental treatments. The recommended dose of fertilizer was 180: 60: 40 N: P_2O_5: K_2O kg/ ha with farm yard manure 10 t/ha and seed rate was 20kg/ha. Data on aphid incidence, severity, yield and yield components were recorded. All the tested insecticides significantly (P≤0.05) reduced the plant infestation caused by maize aphid, and thereafter increased the grain yield of maize compared to control. However, newer insecticide flonicamid 50% WG 0.5g/L was found as the most effective insecticide with lower aphid colony per plant (2.85), aphid score (2.63), aphid infested plant (7.33%) and higher crop yield (7904.79kg/ha). The application of insecticides prior to their severe infestations is necessary for the efficient control of the maize leaf aphid. The research findings will assist maize farmers in choosing and applying the best insecticide to ensure efficient management of maize leaf aphid with high yield.

©2022 Agriculture and Environmental Science Academy

Citation of this article: Neupane, S., & Subedi, S. (2022). Evaluation of insecticidal efficacy against maize leaf aphid [*Rhopalosiphum maidis* (Fitch)] under inner terai condition of Nepal. *Archives of Agriculture and Environmental Science*, *7*(4), 601-605, https://dx.doi.org/10.26832/24566632.2022.0704019

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important commodities for agricultural transformation, grows mainly in inner terai and mid hill belt mostly by small scale farmers in Nepal. Maize contributed 26.96% in total edible cereal grain production and accounting 1.64% of total GDP and 6.83% of Agriculture GDP in Nepal (MoALD, 2022). The total area under maize production is 979,776 ha, out of which mid hill occupies more than 70% of total cultivated area (MoALD, 2022). The national average yield of maize is 3.06 t/ha which is quite low compared to potential attainable yield of about 5.7 t/ha (on farm yield with improved varieties) reported by NMRP (2021). A number of biotic and abiotic stresses during different crop stages are the factors that impede maize production (Neupane and Subedi, 2019). The maize aphid, *Rhopalosiphum maidis* (Fitch), has been more severe between the last week of January and the third week of March as a major pest of maize cultivation over the last three to four years (Neupane *et al*., 2022). This phloem sap-sucking polyphagous aphid pest may cause a yield loss as high as 40% (Alam *et al*., 2019). In addition to maize this pest can infect over 182 plant species (Alam *et al*., 2020). Aphid infestation in maize

affects pollination, causes direct plant damage by sucking phloem nutrients, hinders photosynthesis due to sooty mould, and even introduces various disease-causing microorganisms as a vector, resulting in a yield loss of about 10–20% each year in maize crops in Nepal (Subedi, 2015). Most of the maize farmers in Nepal faced the problem of the aphid infestation prior to tasseling, leads to ears without grain or kernels and result the yield loss (NMRP, 2019). Most maize plants have colonies of maize aphids on or near the tassels or whorl leaves. Some farmers' fields in the mid-hill and terai region of Nepal, especially during the winter season, may have up to 50% maize plant infested by aphid (NMRP, 2020). Aphid infestation in maize tassel affects pollination and introduces multiple bacteria, viruses, and fungi on leaf, cob, and other plant parts (Alam *et al*., 2020).

Aphid infestation can be addressed with different management strategies, including cultural, physical, mechanical, biological, chemical, and host plant resistance. It is important to identify cost-efficient, eco-friendly pest management strategies. To manage various kinds of pest in crop several new insecticides have been recommended. There are many insecticides available for the chemical control of aphids, but information on the effectiveness of new insecticides available in the market against aphids attacking maize is very limited. The application of the right insecticide at the right time with right dose is likely the most effective method for fending off economical pests. Therefore, in present study we evaluated the effectiveness of newly arrived insecticides in the market against maize aphid at field conditions.

MATERIALS AND METHODS

The experiments were organized following randomized complete block design with four replications during winter season of 2019 and 2020 under natural infestation at field condition of National Maize Research Program (NMRP), Rampur, Chitwan. The geographical location of NMRP, Rampur, Chitwan is in 27˚40' N latitude, 84˚19' E longitude at an altitude of 228 meter above sea level. It has humid and subtropical climate with cool winter and hot summer. The soil is generally acidic (pH 4.6-5.7), light textured and sandy loam. The average total annual rainfall was 2215.30 mm with a distinct monsoon period (>75% of annual rainfall) from mid June to mid-September. Recently released maize hybrid Rampur Hybrid-14 (RML-86/RML-96) was shown on September 30 of 2019 and 2020 in six rows of five meter long with the spacing of 60cm×25cm. The recommended dose of fertilizer 180:60:40 N: P_2O_5: K_2O kg/ha with farm yard manure 10t/haand seed rate 20kg/ha was used in the experiment. Beside these most of recommended maize farming practices were followed. There were altogether five treatments representing different insecticides (thiomethoxam 25% w/w 0.2g/L, acetamiprid 20%WP 2g/L, flonicamid 50% WG 0.5g/L, neemix 3mL/L and imidacloprid 0.5mL/L) and one control (water spray). The insecticide was applied twice during before tasseling stage of the plant at 10 days interval. Data on aphid incidence (aphid colony per plant and aphid infested plant per plot in%), severity (0-5 scale) where 0 for no aphid infestation and 5 for severe infestation (Neupane *et al*., 2022), yield components (rotten ear and thousand kernel weight in g) and yield (kg/ha) were recorded. All data were analyzed statistically using Microsoft Excel 2010 and GENSTAT 18th edition computer package programs.

RESULTS AND DISCUSSION

All insecticides used in the experiment had significant effect (P<0.05) on aphid colony per plant, aphid score (0-5), aphid infested plant (%), rotten ear and grain yield (kg/ha) than in the control (water spray) plot. The lower aphid colony per plant, aphid score and aphid infested plant were 2,59, 2,65 and 8.86%, respectively was observed in the plot sprayed with flonicamid 50% WG 0.5g/L of water with highest crop yield (7880.16kg/ha). The next second highest yield of 7450.63kg/ha was occurred in the plot sprayed with thiomethoxam 10% EC at 0.2 g/L of water. The highest aphid colony per plant (6.87), aphid score (4.95) and aphid infested plant (27.29%) was observed in the control plot having the yield of 6534.29kg/ha (Table 1).

Table 1. Effect of insecticides and control Aphid infected maize at NMRP, Rampur in the experiment performed in 2019.

Treatments	AC/P	AS (0-5)	AIP %	RE	GY (kg/ha)	TGW (g)
Thiomethoxam 25% w/w 0.2g/L	3.35^{b†}	2.75^{b}	11.00^{bc}	5.50^{b}	7450.63^{a}	417.50
Acetamiprid20%WP 2g/L	5.43^{a}	3.08^{b}	19.03^{ab}	5.75^{b}	7201.24^{ab}	412.50
Flonicamid 50% WG 0.5g/L	2.59^{b}	2.65^{b}	8.86^{c}	3.00^{b}	7880.16^{a}	420.00
Neemix 3mL/L	6.50^{a}	2.93^{b}	22.86^{a}	3.75^{b}	7168.33^{ab}	413.00
Imidacloprid 0.5mL/L	3.28^{b}	2.78^{b}	11.75^{bc}	6.50^{b}	7630.83^{a}	410.00
Control (water spray)	6.87^{a}	4.95^{a}	27.29^{a}	10.25^{a}	6534.29^{b}	387.50
Grand mean	4.67	3.19	16.80	5.79	7310.92	410.08
P-value	<.001	<.001	0.003	0.006	0.036	0.138
LSD (0.05)	1.52	0.6995	8.95	3.403	782.90	24.85
CV%	21.60	14.60	35.30	39.00	7.10	4.00

†Means of 4 replications. Means in column with same superscript is not significantly different by DMRT (P<0.05). AC/P-Aphid Colony per plant, AS-Aphid Score, AIP- Aphid Infested Plant, R.E- Number of Rotten Ear, GY-Grain Yield, TGW-Thousand Grain Weight, kg/ha- kilogram per hectare, g-gram, TSW-Thousand Seed Weight.

Table 2. Effect of different insecticides to control maize aphid at NMRP, Rampur, during 2020.

Treatments	AC/P	AS (0-5)	AIP %	RE	GY (kg/ha)	TGW (g)
Thiomethoxam 25% w/w 0.2g/L	3.12^{b†}	2.60^{c}	11.11^{b}	8.75^{abc}	7397.43^{b}	416.25^{ab}
Acetamiprid20%WP 2g/L	5.23^{a}	3.18^{abc}	14.44^{b}	5.00^{bc}	7076.24^{b}	417.25^{ab}
Flonicamid 50% WG 0.5g/L	3.12^{b}	2.50^{c}	5.80^{c}	3.75^{c}	7929.41^{a}	421.50^{a}
Neemix 3mL/L	5.75^{a}	4.00^{a}	20.38^{a}	11.25^{a}	7368.33^{b}	416.75^{ab}
Imidacloprid 0.5mL/L	3.32^{b}	2.98^{bc}	12.83^{b}	9.75^{ab}	7330.83^{b}	401.75^{b}
Control (water spray)	6.06^{a}	4.25^{a}	21.19^{a}	14.25^{a}	6059.29^{c}	379.75^{c}
Grand mean	4.44	3.25	14.29	8.79	7193.59	408.88
P-value	<.001	0.019	<.001	0.009	<.001	<.001
LSD (0.05)	1.463	1.11	4.343	5.42	369.6	16.23
CV %	21.9	22.7	20.2	40.9	3.40	2.6

†Means of 4 replications. Means in column with same superscript is not significantly different by DMRT (P<0.05). AC/P-Aphid colony per plant, AS-Aphid Score, AIP- Aphid infested Plant, R.E- Number of Rotten Ear, GY-Grain yield, TGW-thousand grain weigh, kg/ha- kilogram per hectare, g-gram, TSW-Thousand seed weight.

Almost similar trend of aphid infestation along with yield data were observed in the experiment conducted in subsequent year 2020. The observations regarding the incidence and severity of aphid (aphid colony per plant, aphid infested plant % and aphid score (0-5)), yield attributing traits (rotten ear, thousand grain weight) and grain yield (kg/ha) differed significantly (P<0.05) with the application of different insecticides (Table 2). The lower aphid colony per plant (3.12), aphid score (2.50) and aphid infested plant (5.80%) was observed in the plot sprayed with flonicamid 50% WG 0.5g/L of water with higher crop yield (7929.41 kg/ha) followed by the plot sprayed with thiomethoxam 25% w/w at 0.2 g/L of water with lower aphid colony per plant (3.12) and yield (7397.43kg/ha). The highest aphid colony per plant (6.06), aphid score (4.25), aphid infested plant (21.19%) was observed in the control plot having yield (6059.29kg/ha) (Table 2).

The combined performance of different insecticidal application to the aphid damage parameters, yield and yield components during 2019-2020 shown in Table 3. Statistically significant differences were observed for the parameter's aphid colony/plant, aphid score, aphid infested plant %, no of rotten ear, grain yield (kg/ha) and thousand grain weight (g) among the tested insecticides in combined analysis for two consecutive years. The lower aphid colony per plant (2.85), aphid score (2.63) and aphid infested plant (7.33%) was observed in the plot sprayed with flonicamid 50% WG 0.5g/L of water with higher crop yield (7904.79kg/ha) followed by the plot sprayed with thiomethoxam 25% w/w at 0.2g/L of water with lower aphid colony per plant (3.24) and yield (7480.83kg/ha). The highest aphid colony per plant (6.13), aphid score (4.48), aphid infested plant (21.62%) was observed in the control plot having yield (6296.79kg/ha) (Table 3).

Aphids are one of the important insect pests that can damage maize, and as a result of climate change, their infestation is increasing worse in areas of the country where maize is grown. Pest management has historically involved the use of various pesticides. In order to effectively control the target organisms, pesticides must be toxic, while being safe for the environment and unintended organisms. The newly developed insecticides have lower dosage requirements and shorter residual activity durations as advantages (Hazra *et al*., 2017). The present study revealed that newer insecticide flonicamid 50% WG 0.5g/L and thiomethoxam 25% w/w at 0.2g/Lof water were found as the most effective insecticides resulted lower aphid colony per plant, aphid infested plant and higher crop yield. Flonicamid (IK1220; N-cyanomethyl-4-trifluoromethyl-nicotinamide) is belongs to the pyridinecarboxamide group, a novel class of chemical pesticides for controlling aphids that are resistant to other insecticides (Morita *et al*., 2014).

The main insecticidal mechanism of flonicamid is starvation due to the inhibition of stylet penetration into plant tissues (Morita *et al*., 2014). Thiamethoxam [(EZ)-3-(2-chloro-1,3-thiazol-5-yl-methyl)-5-methyl-1,3,5-oxadiazinan-4-ylidene(nitro)amine] is classified according to the pharmacophore as N-nitroguanidineneonicotinoid (Cui *et al*., 2018). Thiamethoxam is presently one of the most effective chemicals for the control of sucking pests such as aphids (Zhang *et al*., 2021), whiteflies (Kumar *et al*., 2019), thrips, some microlepidoptera, and a number of coleopteran species. The result is in line with the findings of Aston *et al*. (2022) who reported that sublethal concentrations of flonicamid and thiamethoxam increase fecundity and phloem-feeding behavior on *Myzus persicae*. Similar results of effectiveness of flonicamid and thiamethoxam have been earlier reported against wheat aphid (Cui *et al*., 2018), cowpea aphid (Bora *et al*., 2019), okra aphid (Kodandaram *et al*., 2017) and aphids in other crops (Morita *et al*., 2014). The findings are in line with the findings of Zhang *et al*. (2021), who reported that the neonicotinoids, viz. imidacloprid, thiamethoxam and flonicamid were quite effective in reducing aphid population in soybean crop. Ullah *et al*. (2020) also reported that insecticides belonging to neonicotinoid group of insecticides are very effective against sucking pests. Suthar *et al*. (2018) also reported that flonicamid 50 WG 0.015%, clothianidin 50 WDG 0.02%, carbosulfan 25 EC 0.04% and thiacloprid 24 SC 0.024% emerged out as the best treatments on the basis of efficacy against aphid, yield and economics.

Table 3. Combined analysis of effect of different insecticides to control maize aphid at NMRP, Rampur, during 2019-2020.

Treatments	AC/P	AS (0-5)	AIP %	RE	GY (kg/ha)	TGW (g)
Insecticides						
Thiomethoxam 25% w/w 0.2g/L (T1)	3.24^{b†}	2.63^{b}	11.05^{bc}	7.13^{bc}	7480.83^{b}	416.88^{a}
Acetamiprid20%WP 2g/L (T2)	6.07^{a}	3.13^{bc}	20.86^{a}	4.75^{bc}	7138.74^{b}	417.00^{a}
Flonicamid 50% WG 0.5g/L (T3)	2.85^{b}	2.63^{b}	7.33^{c}	4.38^{c}	7904.79^{a}	418.63^{a}
Neemix 3mL/L (T4)	5.74^{a}	3.59^{b}	20.11^{a}	7.13^{bc}	7268.33^{b}	414.88^{a}
Imidacloprid 0.5mL/L (T5)	3.30^{b}	2.88^{b}	12.29^{b}	8.13^{b}	7424.03^{b}	405.88^{a}
Control (water spray) (T6)	6.13^{a}	4.48^{a}	21.62^{a}	12.25^{a}	6296.79^{c}	383.63^{b}
Grand mean	4.56	3.22	15.54	7.29	7252.25	409.48
P-value	<.001	<.001	<.001	<.001	<.001	<.001
LSD (0.05)	0.967	0.61	4.547	3.32	395.5	14.13
Year						
Year 1 (2019)	4.67	3.18	16.80	5.79	7311.00	410.1
Year 2 (2020)	4.44	3.25	14.29	8.79	7194.00	408.9
P-value	0.41	0.72	0.06	0.003	0.303	0.765
LSD (0.05)	0.559	0.35	2.625	1.917	228.4	8.16
Insecticide × Year						
T1× Year 2019	3.35	2.75	11.00	5.50	7451.0	417.5
T2× Year 2019	5.43	3.08	19.03	3.75	7201.0	412.5
T3× Year 2019	3.12	2.65	8.86	3.00	7880.0	420.0
T4× Year 2019	6.50	2.93	22.86	5.75	7168.0	413.0
T5× Year 2019	3.28	2.78	11.75	6.50	7631.0	410.0
T6× Year 2019	6.87	4.95	27.29	10.25	6534.0	387.5
T1× Year 2020	3.12	2.50	11.11	8.75	7397.0	416.2
T2× Year 2020	5.27	3.18	14.44	5.00	7076.0	417.2
T3 × Year 2020	2.58	2.60	5.80	3.75	7929.0	421.5
T4× Year 2020	5.75	4.25	20.38	11.25	7368.0	416.8
T5× Year 2020	3.32	2.98	12.83	9.75	7331.0	401.8
T6× Year 2020	6.06	4.00	21.19	14.25	6059.0	379.8
P-value	0.199	0.629	0.025	0.086	0.573	0.800
LSD (0.05)	1.368	0.86	6.431	4.696	559.4	19.98
CV%	20.9	18.6	28.8	44.8	5.4	3.4

†Means of 4 replications. Means in column with same superscript is not significantly different by DMRT (P<0.05). AC/P-Aphid colony per plant, AS- Aphid Score, AIP- Aphid infested Plant, R.E- Number of Rotten Ear, GY-Grain yield, TGW-thousand grain weigh, T1: Thiomethoxam 25% w/w 0.2 g/L, T2: Acetamiprid 20%WP 2 g/L, T3: Flonicamid 50% WG 0.5 g/L, T4: Neemix 3 mL/L, T5: Imidacloprid 0.5 mL/L, T6: Control (water spray), kg /ha- kilogram per hectare, g-gram, TSW-Thousand seed weight.

Conclusion

The application of flonicamid 50% WG @ 0.5g/Land thiomethoxam 25% w/w @ 0.2g/Lwere found effective for the management of maize leaf aphid and produced higher grain yield. The findings from the study will be beneficial to the farmers, as with emerging climate change, aphid problem is becoming more serious in maize growing regions of the country. Therefore, these newer insecticides that have been evaluated can lower the chemical load in maize crops and also work well with IPM programs.

ACKNOWLEDGEMENTS

The fund for this research was received from Nepal Agricultural Research Council. The authors are grateful to technical team of National Maize Research Program (NMRP) Rampur, Chitwan for conducting experiments and technical supports.

Conflict of interest

All the authors would like to declare that there is no conflict of interest among them that could possibly arise in future.

Open Access: This is an open access article distributed under the terms of the Creative Commons Attribution NonCommercial 4.0 International License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) or sources are credited.

REFERENCES

Alam, M. J., Ahmed, K. S., Hoque, M., Mansura, A., Rony, M. N. H., & Haque, M. S. (2019). Bio-efficacy of some bio-pesticides against maize aphid, *Rhopalosiphum maidis*; a threatening pest of maize. *Journal of Science, Technology and Environment Informatics*, *8*(1), 563-573.

Alam, M. J., Mukta, L. N., Nahar, N., Haque, M. S., & Razib, S. M. H. (2020). Management practices of aphid (*Rhopalosiphum maidis*) in infested maize field. *Bangladesh Journal of Environmental Science*, *38*, 23-28.

Aston, L., Lisa Kirkland, A., Chirgwin, E., Rooyen, A., & Umina, P.A. (2022). Baseline susceptibility of Australian Myzus persicae (Hemiptera: Aphididae) to novel insecticides flonicamid and afidopyropen. *Crop Protection*, 158,e105992. https://doi.org/10.1016/j.cropro.2022.105992

Bora, A., Suzuki, T., & Funar-Timofei, S. (2019). Neonicotinoid insecticide design: molecular docking, multiple chemometric approaches, and toxicity relationship with Cowpea aphids. *Environ Science and Pollution Research, 26*, 14547–14561, https://doi.org/10.1007/s11356-019-04662-9

Cui, L., Wang, G., Yang, D., Nahiyoon, S. A., Yan, X., & Yuan, H. (2018). Biocidal radiuses of abamectin, thiamethoxam and sulfoxaflor droplets controlling against wheat aphid (*Sitobion avenae*). *PLoS ONE*, 13(11), e0205598. https://doi.org/10.1371/journal.pone.0205598

Hazra, D., Karmakar, R., Poi, R., Bhattacharya, S., & Mondal, S. (2017). Recent advances in pesticide formulations for eco-friendly and sustainable vegetable pest management: A review. *Archives of Agriculture and Environmental Science*, *2*, 232-237.

Kodandaram, M. H., Kumar, Y. B., Banerjee, K., Hingmire, S., Rai, A. B., & Singh, B. (2017). Field bioefficacy, phytotoxicity and residue dynamics of the insecticide flonicamid (50 WG) in okra [*Abelmoschus esculenta* (L) Moench]. *Crop Protection*, *94*, 13–19.

Kumar, V., Jindal, V., Kataria, S. K., & Pathania, M. (2019). Activity of novel insecticides against different life stages of whitefly (*Bemisia tabaci*). *Indian Journal of Agricultural Sciences*, *89*(10), 1599-1603

Morita, M., Yoneda, T., & Akiyoshi, N. (2014). Research and development of a novel insecticide, flonicamid. *Journal of Pesticide Sciences*, *39*(3), 179–180.

MOALD. (2022). Statistical Information on Nepalese Agriculture 2078/79 (2021/22). Government of Nepal, Ministry of agriculture and livestock development, Planning and development cooperation coordination division, Statistics and analysis section, Singhdurbar, Kathmandu, Nepal.

Neupane, S., & Subedi, S. (2019). Life cycle study of maize stem borer (*Chilopartellus Swinhoe*) under laboratory condition at National Maize Research Program, Rampur, Chitwan, Nepal. *Journal of Agriculture and Natural Resources*, *2*(1), 338-346, https://doi.org/10.3126/janr.v2i1.26099

Neupane, S., Subedi, S., Neupane, P., & Shrestha, R.K. (2022). Screening of maize genotypes against maize leaf aphid [*Rhopalosiphum maidis* (Fitch)] under field condition at Chitwan, Nepal. *Journal of Nepal Agricultural Research Council*, *8*,1-6, https://doi.org/10.3126/jnarc.v8i.44806

NMRP. (2019). Annual Report 2075/76 (2018/19). National Maize Research Program, NARC, Rampur, Chitwan, Nepal.

NMRP. (2020). Annual Report 2076/77 (2019/20). National Maize Research Program, NARC, Rampur, Chitwan, Nepal.

NMRP. (2021). Annual Report 2077/78 (2020/21). National Maize Research Program, NARC, Rampur, Chitwan, Nepal.

Subedi, S. (2015). A review on important maize diseases and their management in Nepal. *Journal of Maize Research and Development*, *1*(1), 28-52, https://doi.org/10.3126/jmrd. v1i1.14242

Suthar, D. M., Borad, P. K., & Bharpoda, T. M. (2018). Efficacy of different insecticides against aphid in cumin. *Journal of Entomology and Zoology Studies*, *6* (4), 1767-1769.

Ullah, F., Gul, H., Tariq, K., Desneux, N., Gao, X., & Song, D. (2020).Thiamethoxam induces transgenerational hormesis effects and alteration of genes expression in *Aphis gossypii*. *Pesticide Biochemistry and Physiology*, 165, e104557. https://doi.org/10.1016/j.pestbp.2020.104557

Zhang, A., Zhu, L., Shi, Z., Liu, T., Han, L., & Zhao, K. (2021). Effects of imidacloprid and thiamethoxam on the development and reproduction of the soybean aphid *Aphis glycines*. *PLoS ONE*, 16(9), e0250311. https://doi.org/10.1371/journal.pone.0250311