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# TOXICITY OF THIAMETHOXAM 25WG AND SULFOXAFLOR 21.8SC TO RICE WHITE BACKED PLANTHOPPER *SOGATELLA FURCIFERA* (HORVATH)

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## ABSTRACT

**Baseline toxicity of neonicotinoid insecticides viz., thiamethoxam 25WG and sulfoxaflor 21.8SC was assessed in the field collected populations of the rice white backed planthopper *Sogatella furcifera* (Horvath). The major rice growing regions of Tamil Nadu when studied revealed that the field populations vary in their susceptibility. Coimbatore and Bhavani populations were more susceptible compared to the Nagapattinam one. Baseline toxicity of thiamethoxam 25WG was relatively high with narrow variation ($LC_{50}$- 0.3130 to 1.7882 ppm; $LC_{95}$- 1.0993 to 6.3840 ppm); $LC_{50}$ of sulfoxaflor 21.8SC ranged from 1.3121 to 3.8392 ppm, while the $LC_{95}$ values were 3.1507 to 5.2754 ppm. The resistance ratios varied among the populations viz., thiamethoxam 25WG (2.5 to 5.6 folds) and sulfoxaflor 21.8SC (1.8 to 2.9 folds). Thus, the population from Nagapattinam exhibited maximum resistance.**

**Key words:** Rice, *Sogatella furcifera*, field populations, baseline toxicity, lethal concentration, neonicotinoids, susceptibility, resistance, thiamethoxam, sulfoxaflor, resistance ratios

Rice is the staple food in India (Prasad et al., 2017) and it is attacked by >800 insect pests, of which planthoppers are serious causing significant economic loss. Planthoppers constitute a large group of phytophagous insects (Catindig et al., 2009). Brown planthopper (BPH) *Nilaparvata lugens* (Stal) and white backed planthopper (WBPH) *Sogatella furcifera* (Horvath) are the major pests considered as green revolution induced pests (Gunathilagaraj and Ganesh Kumar, 1997). Besides, the direct damage caused by the feeding, planthoppers serve as a vector for virus disease such as southern rice black streak dwarf virus (SRBSDV) (Zhang et al., 2008; Zhou et al., 2008). Chemical control remains the most efficient means to manage planthoppers. However, due to the large scale and intensive use of these, resistance to insecticides has been reported in rice planthoppers. Neonicotinoid and phenyl pyrazole insecticides were used in mid-1990's in many East Asian countries. At present neonicotinoid insecticides including imidacloprid, thiamethoxam, and nitenpyram are most frequently used in China (Su et al., 2013b; Zhang et al., 2014). Currently, *S. furcifera* has developed resistance to 12 compounds as reported in the Arthropod Pesticide Resistance Database (APRD), and this involve various detoxification enzymes (Denholm and Rowland, 1992; Whalon et al., 2008). Systemic neonicotinoids like imidacloprid, thiamethoxam and their analogues sulfoxaflor, triflumezopyrim and flupyradifurone have similar mode of action (Casida, 2018; Taillebois et al., 2018). Imidacloprid and thiamethoxam exhibit more resistance in planthoppers. Resistance monitoring is necessary to understand the current status of susceptibility of field populations of *S. furcifera*. Early detection of changes can prompt adoption of alternative measures. The use of insecticides alternatively with same mode of action helps the farmer overcome resistance (Liao et al., 2019). For newer molecules, baseline susceptibility helps in determining the resistance level and enables location specific management practices. Hence, the present study to assess the current status of resistance levels of field populations of *S. furcifera* to thiamethoxam 25WG and sulfoxaflor 21.8SC in different locations of Tamil Nadu.

## MATERIALS AND METHODS

The laboratory reared TNAU susceptible *S. furcifera* population and populations collected from major rice growing locations of Tamil Nadu viz., Coimbatore ($11^{0}$0'11"N; $76^{0}$55'26"E), Bhavani ($11^{0}$36'15"N, $77^{0}$43'8"E) and Nagapattinam ($10^{0}$47'43"N, $79^{0}$44'5"E) during December 2019 were mass cultured separately and maintained as stock culture in glasshouse (25± 1ºC, 70-80% RH). Susceptible variety TN1 was used for rearing *S. furcifera.* in aluminium cages (45x 45x 60 cm) on 10 days old seedlings transplanted in plastic pots (10 cm dia). The potted plants maintained in the glass house were covered with the mylar film cages. Different aged rice seedlings were maintained separately for nymphs and adult rearing. Initially five pairs of *S. furcifera* were released on 35 days old seedlings and allowed for oviposition (Heinrichs, 1985). The seedlings with eggs were placed in separate cages for the nymphal emergence and further emerged nymphs were released on 7-10 days old seedlings. These were maintained without exposure of insecticides up to $F_2$ generation and used for the bioassay studies. For baseline susceptibility studies, standard insects (1 to 2 days old female adult) were collected from the rearing cages daily. Dried and wilted plants together with *S. furcifera* were removed from the cages and plants were tapped gently to dislodge the hoppers and the insects were transferred to fresh rice seedlings (Heong et al., 2011).

Technical grade thiamethoxam 25WG and sulfoxaflor 21.8SC were purchased from UPL India Private Ltd., Mumbai for the bioassay; and the TNAU susceptible *S. furcifera* population (maintained for more than 20 generation without the exposure of insecticide) was taken as a baseline and preliminary range test was conducted to fix dose that gives 50% mortality ($LC_{50}$). Initially the dose was fixed from wider to narrow range. The range which gave 20 to 80% mortality was taken finally for the study. Mortality data was taken at 24 hr interval, with each concentration replicated thrice by releasing 15 adult female insects/ mylar film cage. $F_1$ generation of the susceptible population was taken for the preliminary range test and the x dose from the preliminary range test was selected. Dose for the other field populations (resistant population) were fixed at different levels and baseline susceptibility test was undertaken. For the resistant population, $F_2$ generation insects were taken for the baseline susceptibility study. Dose response bioassay for the selected insecticides was performed using seedling dip method (IRAC, 2012; Tsujimoto et al., 2016; Murtiati et al., 2021).

Initially, series of insecticide concentrations were prepared and the seedlings were dipped in these for about 10-30 sec and allowed to dry for 15 min. Suitable hoppers were collected from the rearing cage using a suction device. It was ensured that, only one target life stage was used, with care to ensure that life stages of short/ long winged forms do not get mixed in one test (Zhuang et al., 2000). Forty-five adult female insects were used against one insecticide concentration with three replications. Number of live and dead insects at 24 hr interval was counted and recorded. Moribund insect was counted as dead. Mortality in the control treatment was also recorded. Results were expressed as % mortality and corrected using Abbott's formula (Abbott, 1925). Concentration mortality results were subjected to probit analysis (Finney, 1971). Regression equation for dosage-mortality responses were computed to determine the $LC_{50}$ value. Log-concentration-probit mortality lines were computed by Finney's probit analysis (Regupathy and Dhamu, 1990). The resistance ratio (RR) was calculated by dividing the $LC_{50}$ value of field population by susceptible one. Resistance levels were classified on the basis of the standard (Su et al., 2013a; Zhang et al., 2014) as susceptible (RR < 3-folds), minor resistance (RR = 3-5 folds), low resistance (RR = 5-10 fold), medium resistance (RR = 10-40 folds) and high resistance (RR = 40-160 folds).

## RESULTS AND DISCUSSION

Baseline toxicity to thiamethoxam 25WG of *S. furcifera* from different regions was relatively high with narrow variation in $LC_{50}$ (0.3523 to 1.9861 ppm) and $LC_{95}$ values (1.0993 to 6.3840 ppm). Among the resistant ones, Nagapattinam population showed 5.6 folds resistance followed by the one from Bhavani (3.7 folds) and Coimbatore (2.5 folds) (Figs. 1, 2; Table 1); the Coimbatore population was susceptible to thiamethoxam while Nagapattinam one was found comparatively more resistant. Application of insecticides at frequent intervals to manage rice planthoppers lead to development of resistance in rice growing areas of Nagapattinam. The results on lower resistance level to thiamethoxam 25WG (2.5- 5.6 folds) are in conformity with those of Su et al. (2013b) where 1.5 to 8.0 folds resistance was seen. The present findings agree with Zhang et al. (2014) that *S. furcifera* is showing less resistance of 0.6 to 3.1 folds with $LC_{50}$ ranging from 0.06 to 0.28 ppm. Zhang et al. (2017) reported that the field population of *S. furcifera* from China is exhibiting lower to moderate resistance (0.8 to 14.9 folds) to thiamethoxam with $LC_{50}$ value of 0.1 to 1.4 ppm. These results are in agreement with present ones. Nagapattinam population showed more resistance (6.2 folds) to imidacloprid 17.8SL followed by Bhavani (4.1 folds) and Coimbatore populations (2.8 folds) with $LC_{50}$ values ranging from 0.4 to 2.5 ppm (Surya Raj et al., 2020).

The $LC_{50}$ of sulfoxaflor 21.8SC to field populations of *S. furcifera* ranged from 1.3121 to 3.8392 ppm Nagapattinam population recorded higher $LC_{50}$ (3.8392 ppm) followed by Bhavani (3.2116 ppm) and Coimbatore populations (2.3782 ppm). $LC_{95}$ values

Table 1. Toxicity of thiamethoxam 25WG and sulfoxaflor 21.8SC to *S. furcifera*

| Insecticide | Locations | Regression equation | $X^2$ | $LC_{50}$ (ppm) | Fiducial limits Lower | Fiducial limits Upper | $LC_{95}$ (ppm) | Fiducial limits Lower | Fiducial limits Upper | RR |
|---|---|---|---|---|---|---|---|---|---|---|
| Thiamethoxam 25 % WG | TNAU susceptible | y = 3.351x + 3.166 | 0.1557 | 0.3523 | 0.3130 | 0.3965 | 1.0993 | 0.8182 | 1.4770 | - |
| | Coimbatore | y = 5.351x - 0.095 | 0.1192 | 0.8947 | 0.8401 | 0.9530 | 1.8201 | 1.4667 | 2.2586 | 2.5 |
| | Bhavani | y = 4.318x + 0.163 | 0.0520 | 1.3180 | 1.2188 | 1.4252 | 3.1648 | 2.4804 | 4.0382 | 3.7 |
| | Nagapattinam | y = 3.229x + 0.810 | 0.0708 | 1.9861 | 1.7882 | 2.2059 | 6.3840 | 4.6022 | 8.8557 | 5.6 |
| Sulfoxaflor 21.8% SC | TNAU susceptible | y = 4.357x + 0.120 | 0.4450 | 1.3121 | 1.2158 | 1.4225 | 3.1507 | 2.4690 | 4.0205 | - |
| | Coimbatore | y = 7.308x - 5.060 | 0.2573 | 2.3782 | 2.2701 | 2.4913 | 4.0059 | 3.4227 | 4.6885 | 1.8 |
| | Bhavani | y = 9.649x - 9.545 | 0.3111 | 3.2116 | 3.1018 | 3.3254 | 4.7538 | 4.2516 | 5.3154 | 2.4 |
| | Nagapattinam | y = 11.98x - 13.98 | 0.4255 | 3.8392 | 3.7316 | 3.9499 | 5.2754 | 4.7908 | 5.8090 | 2.9 |

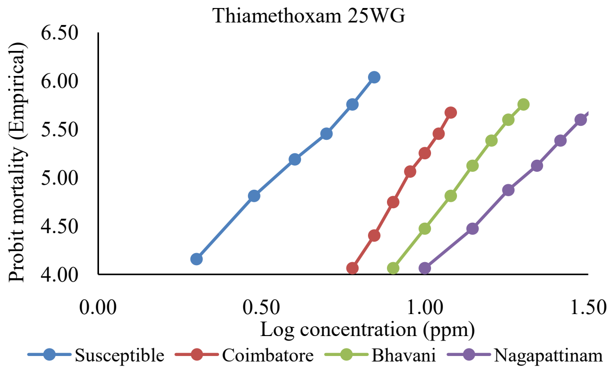

Fig. 1. LCPM regression lines for populations of *S. furcifera* to thiamethoxam 25WG

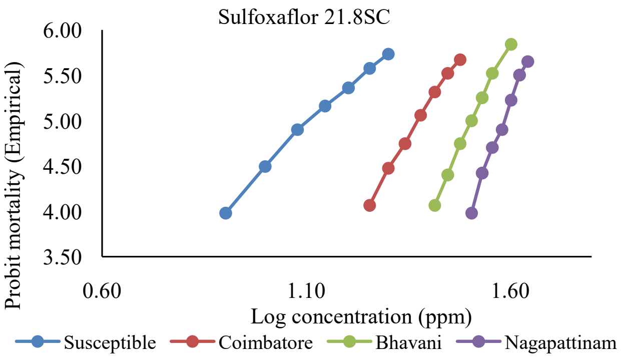

Fig. 2. LCPM regression lines for populations of *S. furcifera* to sulfoxaflor 21.8SC

followed similar trend and varied from 3.1507 to 5.2754 ppm. The resistant ratio was 2.9, 2.4 and 1.8 folds as compared to the susceptible one (1.3121 ppm) (Table 1). These findings derive support from Kapasi et al. (2017) from northeastern Karnataka. Priyadharshini et al. (2020) observed that *N. lugens* sulfoxaflor 21.8SC shows resistance of 1.9 to 3.35 folds. The present results contradict with those of Ghosh et al. (2013) showing comparatively lower $LC_{50}$ values for sulfoxaflor (0.382 to 2.986 ppm) to selected *N. lugens* populations of West Bengal.

Thus, *S. furcifera* populations from different regions of Tamil Nadu differed significantly in their response to sulfoxaflor. The regional variation in susceptibility of different *S. furcifera* populations had been already reported in India (Basanth et al., 2013). Elevated activity of glutathione-S-transferase, peroxidase and mixed function oxidase (MFO) might be responsible for this (Vontas et al., 2002). The planthoppers showing resistance to imidacloprid was due to the increased P450 monooxygenase activity (Nakao, 2017).

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## REFERENCES

Abbott, Walter S. 1925. A method of computing the effectiveness of an insecticide. Journal of Economic Entomology 18(2): 265-267.

Basanth Y S, Sannaveerappanavar V T, Sidde Gowda D K. 2013. Susceptibility of different population of *Nilaparvata lugens* from major rice growing areas of Karnataka, India to different groups of insecticides. Rice Science 20(5): 371-378.

Casida J E. 2018. Neonicotinoids and other insect nicotinic receptor competitive modulators: progress and prospects. Annual Review of Entomology 63: 125-144.

Catindig J L A, Arida G S, Baehaki S E, Bentur J S, Cuong L Q, Norowi M, Rattanakarn W, Sriratanasak W, Xia J, Lu Z. 2009. Situation of planthoppers in Asia. Planthoppers: new threats to the sustainability of intensive rice production systems in Asia pp. 191-220.

Denholm I, Rowland M W. 1992. Tactics for managing pesticide resistance in arthropods theory and practice. Annual Review of Entomology 37(1): 91-112.

Finney D J. 1971. Quantal responses to mixtures. Probit analysis. Third Edition. Cambridge University Press, United Kingdom. pp. 230-268.

Ghosh, Amalendu, Amrita D, Samanta A, Chatterjee M L, Roy A. 2013. Sulfoximine: A novel insecticide for management of rice brown planthopper in India. African Journal of Agricultural Research 8(38): 4798-4803.

Gunathilagaraj K, Ganesh K M. 1997. Rice insect outbreaks: an analysis. Madras Agricultural Journal 84: 298-310.

Heinrichs E A, Medrano E G, Rapusas H R. 1985. Genetic evaluation for insect resistance in rice. International Rice Research Institute, Philippines. 356 pp

Heong, Kong L. 2011. Research methods in toxicology and insecticide resistance monitoring of rice planthoppers. International Rice Research Institute, Philippines. 101 pp

IRAC. 2012. IRAC susceptibility test methods series. www.iraconline.org.

Kapasi, Mahantesh, Bheemanna M, Guruprasad G S, Vijaykumar G. 2017. Baseline susceptibility of sulfoxaflor 24 SC insecticide on paddy brown planthopper, (*Nilaparvata lugens*, Stal) population of Northeastern Karnataka. Journal of Entomology and Zoology Studies 5(5): 1445-1449.

Liao X, Jin R, Zhang X, Ali E, Mao K, Wan H. 2019. Characterization of sulfoxaflor resistance in the brown planthopper, *Nilaparvata lugens* (Stål). Pest Management Science 75(6): 1646-1654.

Murtiati S, Tarwotjo U, Rahadian R. 2021. Resistance monitoring of *Nilaparvata lugens* (Stal) against pymetrozine insecticide with determination of diagnostic concentrations. Biosaintifika: Journal of Biology and Biology Education 13(1): 58-64.

Nakao T. 2017. Insecticide resistance in rice planthoppers. Advances in agrochemicals: ion channels and G protein-coupled receptors (GPCRs) as targets for pest control 2: 23-39.

Prasad R, Yashbir S S, Dinesh K. 2017. Current status, challenges, and opportunities in rice production. Rice Production Worldwide. 4: 1-32.

Priyadharshini E, Muthukrishnan N, Sathiah N, Prabakar K. 2020. Baseline toxicity study of sulfoxaflor against rice brown planthopper, *Nilaparvata lugens* (Stål) populations of Tamil Nadu. Journal of Entomology and Zoology Studies 8 (5): 2176-2180.

Regupathy A, Dhamu K P. 1990. Statistics work book for insecticide toxicology. Suriya Desktop Publishers, Coimbatore. 177 pp.

Su, Jianya, Zhiwei W, Kai Z, Xiangrui T, Yanqiong Y, Xueqing Z, Aidong S, and Cong F G. 2013a. Status of insecticide resistance of the whitebacked planthopper, *Sogatella furcifera* (Hemiptera: Delphacidae). Florida Entomologist: 948-956.

Su, Jianya, Zhiwei W, Kai Z, Xiangrui T, Yanqiong Y, Xueqing Z, Aidong S, Cong F. 2013b. Status of insecticide resistance of the whitebacked planthopper, *Sogatella furcifera* (Hemiptera: Delphacidae). Florida Entomologist: 948-956.

Surya raj R, Muthukrishnan N, Sathiah N, Prabakar K. 2020. Baseline susceptibility of different population of whitebacked planthopper, *Sogatella furcifera* from rice growing areas of Tamil Nadu, India to imidacloprid 17.8% SL. Journal of Entomology and Zoology Studies 8(5): 1894 - 1898.

Taillebois, Emiliane, Alison C, Andrew K J, and Steeve H T. 2018. Neonicotinoid insecticides mode of action on insect nicotinic acetylcholine receptors using binding studies. Pesticide Biochemistry and Physiology 151: 59-66.

Tsujimoto K, Sugii S, Sanada-Morimura S, Matsumura M. 2016. A new method for monitoring the susceptibility of the brown planthopper, *Nilaparvata lugens* (Hemiptera: Delphacidae), to pymetrozine by combining topical application and measurement of offspring number. Applied Entomology and Zoology 51(1): 155-160.

Vontas, John G, Dimitra C, Nikou, Hilary R, Janet H. 2002. Purification, molecular cloning and heterologous expression of a glutathione S-transferase involved in insecticide resistance from the rice brown planthopper, *Nilaparvata lugens*. Biochemical Journal 362(2): 329-337.

Whalon, Mark E, David M, Robert H. 2008. Analysis of global pesticide resistance in arthropods. Global Pesticide Resistance in Arthropods 5: 31.

Zhang, Heng-Mu, Jian Y, Jian-Ping C, Adams M J. 2008. A black-streaked dwarf disease on rice in China is caused by a novel fijivirus. Archives of Virology 153(10): 1893-1898.

Zhang, Kai, Wei Z, Shuai Z, Shun-Fan W, Lan-Feng B, Jian-Ya S, Cong-Fen G. 2014. Susceptibility of *Sogatella furcifera* and *Laodelphax striatellus* (Hemiptera: Delphacidae) to six insecticides in China. Journal of Economic Entomology 107(5): 1916-1922.

Zhang, Xiaolei, Xun L, Kaikai M, Peng Y, Dongyang L, Ehsan A, Hu W, Jianhong L. 2017. Neonicotinoid insecticide resistance in the field populations of *Sogatella furcifera* (Horváth) in Central China from 2011 to 2015. Journal of Asia-Pacific Entomology 20(3): 955-958.

Zhou, Guo H, Jing W, DeJiang C, Peng L, Dong L X, Shu G Z. 2008. Southern rice black-streaked dwarf virus: a new proposed Fijivirus species in the family Reoviridae. Chinese Science Bulletin 53(23): 3677-3685.

Zhuang, Yong L, Jin L S. 2000. A method for monitoring of resistance to buprofezin in brown planthopper. Journal of Nanjing Agricultural University 23(3): 114-117.

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