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Baseline susceptibility of different population of Whitebacked planthopper, *Sogatella furcifera* from rice growing areas of Tamil Nadu, India to imidacloprid 17.8% SL

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Abstract
Baseline susceptibility of neonicotinoid insecticide *viz.*, imidacloprid 17.8% SL was carried out in rice whitebacked planthopper during 2019-20 at Tamil Nadu Agricultural university, Coimbatore. F3 generation of TNAU susceptible WBPH population was taken as base population and preliminary range tests were conducted to determine 50% mortality (LC_{50}). Initially doses were fixed from wider to narrow range. Different concentrations of insecticides giving the mortality range from 20-80% were taken for the study. Each concentration of insecticides was replicated thrice by releasing 15 adult female insects per mylar cages. After fixing the X dose for susceptible population, dose for the other population were fixed at different concentration. Laboratory cultured TNAU susceptible population and populations from Coimbatore, Bhavani and Nagapattinam regions were treated. The results revealed that Nagapattinam populations showed higher LC_{50} and higher resistance level followed by Bhavani and Coimbatore population against the imidacloprid 17.8 SL. The resistance ratio varied from 2.8 - 6.2 fold among the populations against imidacloprid 17.8% SL.

Keywords: Baseline susceptibility, neonicotinoid, resistance, rice, white backed planthopper

Introduction
In India rice is the staple food and grown in large areas. The whitebacked planthopper is the serious migratory pest in many parts of Asia [1]. Rice is attacked by more than 100 insect species which cause significant economic loss in various regions [2]. Planthoppers are common rice insect pests in Asian rice production regions. The white-backed planthopper (WBPH) *Sogatella furcifera* (Horvath) belonging to the Family Delphacidae (Homoptera) is the main species infesting rice in subtropical and temperate areas. Unlike other leafhoppers and planthoppers it does not transmit any virus or mycoplasma and damage is by direct feeding, leading to hopper burn and ovipostional injury [3]. It feeds on the phloem and causes decrease in leaf area, plant height, dry weight, leaf and stem nitrogen concentration, chlorophyll contents and photosynthetic rate [4, 5] which subsequently results in yield losses. In addition, both adults and nymphs while sucking the sap inject their toxic saliva into the plant which produces "hopper burn" resulting in drying of leaves. High fecundity, exponential population growth and the spread of some of the rice virus diseases are the main causes for the occurrence of this serious pest that causes rice damage [6]. In last three decades damage due to the whitebacked planthopper is progressively increased. In India, this insect causes extensive damage to the rice crop in Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Andhra Pradesh, Orissa, Kerala, Tamil Nadu, Puducherry and Assam [7].
To control this planthopper, neonicotinoid and phenypyrzole insecticides are used in mid 1990's in many East asian countries. At present, neonicotinoid insecticides including imidacloprid, thiamethoxam, nitenpyram are most frequently used insecticides for managing rice planthopper in china for more than 10 years [8]. Currently, *S. furcifera* has developed different degrees of resistance to 12 compounds in the Arthropod Pesticide Resistance Database (APRD). The mechanism underlying insecticide resistance may involve variations in target sites over expression or alteration of detoxification enzymes and enhancement of drug elimination [9, 10, 11]. Systemic neonicotinoid insecticide imidacloprid 17.8 SL has been used as insect neurotoxin against WBPH under IRAC category of the inhibitors of nicotinic acetycholine receptor competitive modulators [12].

In the present study, baseline toxicity of imidacloprid 17.8 SL to WBPH population of three locations and their resistance ratio were estimated.

Materials and methods

Collection of WBPH from various regions of Tamil Nadu

The laboratory reared TNAU susceptible WBPH population and field WBPH population from insecticides unexposed field were collected from Coimbatore (Latitude - $11^0$0'11"N, Longitude 76055'26"E, 17.11.2019), Bhavani (Latitude - $11^0$36'15"N, Longitude - $77^0$43'8"E, 12.12.2019) and Nagapattinam (Latitude – $10^0$47'43"N, Longitude $79^0$44'5"E, 17.12.2019) during December 2020. The TNAU susceptible WBPH population obtained from Paddy Breeding Station, TNAU, Coimbatore in November 2019. More than 50 healthy female adults and 500 nymphs was collected from each regions was taken in separate mylar cage with khada cloth on both sides for better aeration. The field collected populations were released in the separate insect cages in glasshouse condition at 25± 1ºC and 70-80% humidity.

Mass culturing of Whitebacked planthopper

Susceptible variety (cv TN1) seedlings were used for the mass culturing of WBPH. Initially for the mass rearing five pairs of the WBPH were released into 35 days old seedlings and allowed for oviposition [13]. The seedlings with eggs were placed in the separate cages for the nymphal emergence. Emerged nymphs were released into 7-10 days old seedlings. Seedlings with different ages were maintained for the adult and nymphal feeding. Water in rearing cages was replaced once in two days to avoid fungal attack. Seedlings were replaced once in a week. The populations were maintained without the exposure of insecticides upto F3 generation and then taken for the bioassay studies. The rearing cages were examined periodically for the presence of predators and other insect species. Whenever the predators and other insect species were observed they were removed promptly for facilitating the normal development of WBPH population.

For Baseline susceptibility study, TNAU susceptible WBPH population was taken as a base population and preliminary range test was conducted to fix doses which gave the 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 24hrs interval. Each concentration of insecticides was replicated thrice by releasing 15 adult female insects per mylar cages. F3 generation of TNAU susceptible WBPH population were taken for the preliminary range test. After fixing the X dose from the preliminary range test, doses for the resistant population were fixed at different doses and baseline susceptibility test was carried. In this case, F3 generation insects were taken for the baseline susceptibility studies.

Bioassay

The bioassay method followed for Whitebacked planthopper was seedling dip method (IRAC method No. 5) developed and recommended by insecticide resistance action committee [14]. Seeds of TN 1 were directly sown in the plastic containers and after 10-12 days used for the baseline susceptibility studies instead of transplanting 10-12 days old seedlings. Intially, different concentration of insecticide solutions were prepared. 15g of agar boiled in the 1lit of water for about 15 mins and allowed to cool down to 40-45^{0}C. Then the agar was poured into the plastic container with 10 days old seedlings and it is allowed to solidify for about 15-20 mins, which helps to prevent falling of soil, when the plants were dipped into the insecticide solution and also makes it easier to find dead or affected hoppers during assessment.

Different concentration of insecticide solutions was prepared and the seedlings were dipped into the chemical solutions of different concentrations for about 10-30 seconds and allowed to dry for 15 min. Suitable hoppers were collected from the rearing cage using a suction device. We also ensured that only one target life stage was used per test, did not mix life stages or short winged and long winged forms in one test [15]. Fourty five adult female insects were collected and used against one insecticide concentration and three replications were maintained. Number of live and dead insects at 24 hr interval was counted and recorded. Insects that fell onto their backs and could not recover a normal posture was counted as dead. Untreated mortality was also recorded. Results were expressed as percentage mortality and corrected against untreated mortality using Abbott's formula.

Assesment of resistance

Concentration mortality results were subjected to probit analysis [16] after converting the observed mortality into corrected mortality by using Abbott's formula [17] for developing regression equation for dosage-mortality responses and to determine the LC_{50} value. The Resistance ratio (RR) was calculated by dividing the LC_{50} of resistant population by the LC_{50} of the susceptible population.

$$\text{Resistance ratio (RR)} = \frac{\text{LC}_{50}\text{ of resistant population}}{\text{LC}_{50}\text{ of susceptible population}}$$

Resistance levels were classified on the basis of the standard described [8] as susceptible (RR < 3-fold), minor resistance (RR = 3-5 fold), low resistance (RR = 5-10 fold), medium resistance (RR = 10-40 fold) and high resistance (RR = 40-160 fold).

Results and Discussion

The lethal concentration (LC_{50}) of TNAU susceptible WBPH populations against the Imidacloprid 17.8% SL was about 0.4043 ppm. Among the susceptibility of the WBPH population of Coimbatore, Bhavani and Nagapattinam against the imidacloprid, field collected Nagapattinam population (Table 1) showed higher LC_{50} and LC_{95} (2.4994 ppm, 7.2642 ppm) followed by Bhavani (1.6462 ppm, 5.3473 ppm), Coimbatore (1.1138 ppm, 3.3026 ppm). This shows that the Nagapattinam population has developed highest resistant level (6.2 fold) followed by Bhavani (4.1 fold), Coimbatore (2.8 fold) and the population from this region had been frequently sprayed by the imidacloprid 17.8% SL.

The results of our study is on par with [18] *S. furcifera* from five regions of Guizhou province recorded low resistance against thiamethoxam (RR = 0.27 – 9.69) and susceptibility to moderate resistance against imidacloprid (RR = 0.71 – 26.06) The imidacloprid resistant strains of WBPH were obtained through laboratory selections for cross resistance profiling showed resistance fold of 10.4 [19]. The population from Yunnan, Jiangsu and Zhejiang provinces resulted in moderate resistance to the imidacloprid with LC_{50} value ranging from 0.2 ppm to 1.091 ppm. The results of our study, imidacloprid (0.40 – 2.49 ppm) are strengthened by comparing with [20] field population of WBPH from central China showed

moderate level of resistance to imidacloprid (RR = 1.1 – 16.4) with LC_{50} value (0.1 – 1.5 ppm) and thiamethoxam showed the resistance (RR = 0.8 – 14.9) with LC_{50} (0.1 – 1.4 ppm). Our susceptibility results for imidacloprid (0.40 – 2.49 ppm) is similar with the susceptibility study of the eight population of WBPH from China against imidacloprid and thiamethoxam, which showed the moderate resistance (RR = 4.05 – 31.81) with LC_{50} (0.4 – 3.98 ppm) and thiamethoxam (RR = 2.88 – 19.95) with LC_{50} (0.5 – 3.49 ppm) [21]. In china, BPH field population was collected and continuously exposed to imidacloprid for 25 generations and the results revealed the development of resistance of 11.35 fold when compared with the susceptible strain [22]. The Asian population of BPH showed the LD_{50} values of 0.18 – 24.2 µg/g against the imidacloprid and 0.27 – 2.10 µg/g against Thiamethoxam. Both Imidacloprid and Thiamethoxam exhibited cross resistance [23].

Conclusion

Our studies clearly inferred that field populations of *S. furcifera* collected from different rice growing areas of Tamil Nadu *viz.* Coimbatore, Bhavani and Nagapattinam differed in their susceptibility to imidacloprid. Among them, Nagapattinam population exhibited higher resistance to imidacloprid 17.8% SL, when compared with Coimbatore and Bhavani population.

Table 1: Probit analysis of dosage-mortality responses of field population of *S. frucifera* to imidacloprid 17.8% SL

Locations	LC_{50} (ppm)	Fiducial limits		LC_{95} (ppm)	Fiducial limits		slope	X^2	RR
		Lower	Upper		Lower	Upper			
Susceptible	0.4043	0.3612	0.4526	1.2950	0.9280	1.8071	3.1184	0.2512	-
Coimbatore	1.1138	1.0116	1.2264	3.3026	2.4221	4.5033	3.4410	0.1061	2.8
Bhavani	1.6462	1.4758	1.8362	5.3473	4.0342	7.0879	3.0930	0.4610	4.1
Nagapattinam	2.4994	2.2753	2.7457	7.2642	5.2189	10.1113	3.5157	0.1417	6.2

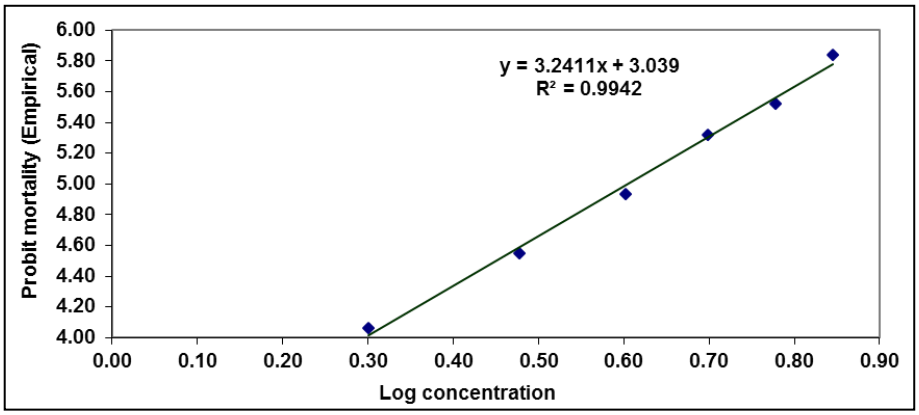

Fig 1: Relationship between log concentration and probit mortality of WBPH from TNAU susceptible population region against imidacloprid 17.8% SL

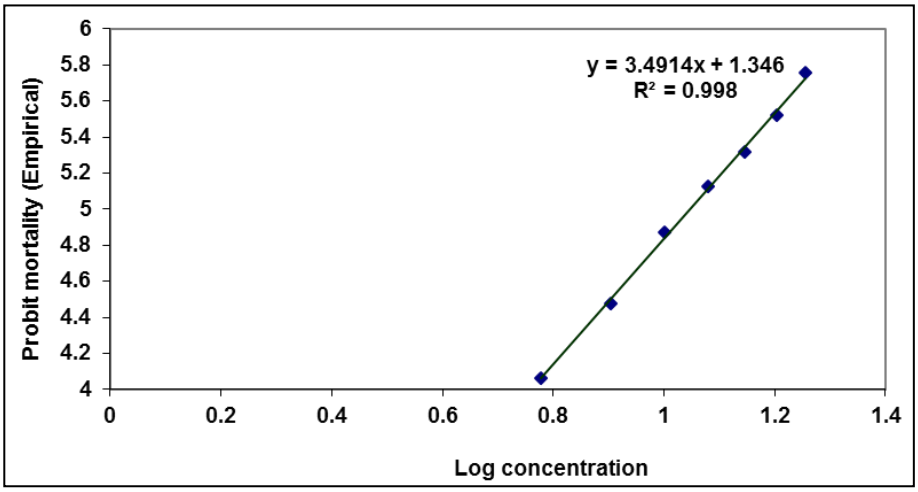

Fig 2: Relationship between log concentration and probit mortality of WBPH from Coimbatore population region against imidacloprid 17.8% SL

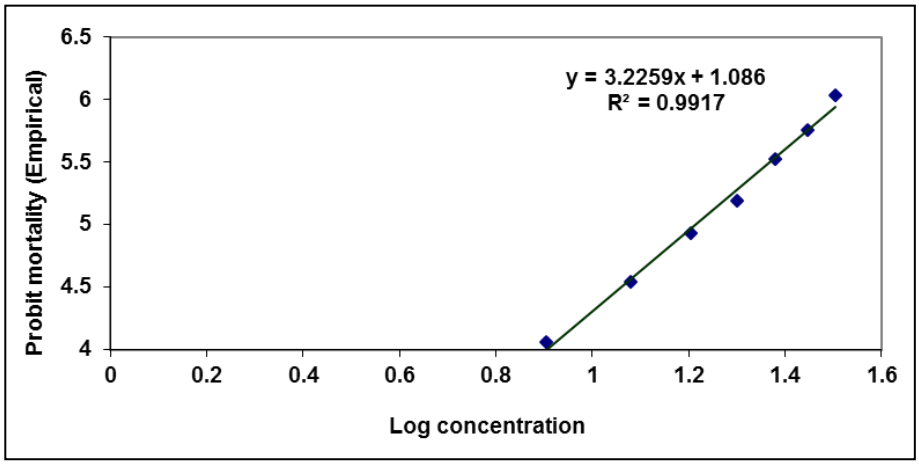

Fig 3: Relationship between log concentration and probit mortality of WBPH from Bhavani region against imidacloprid 17.8% SL

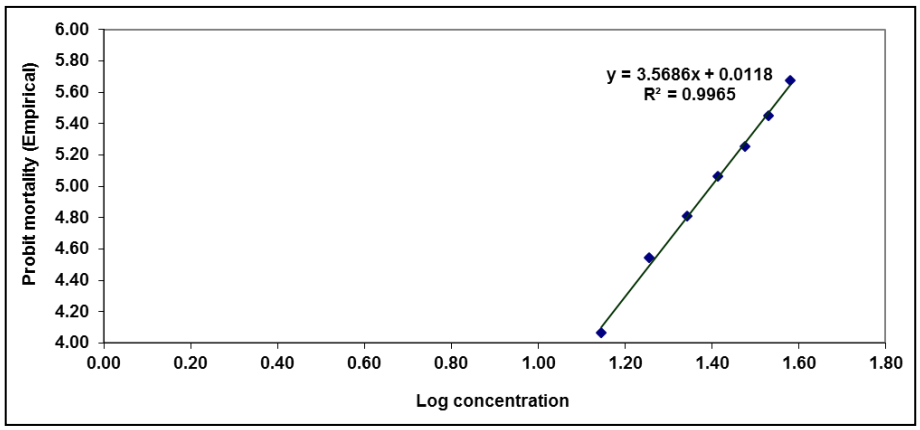

Fig 4: Relationship between log concentration and probit mortality of WBPH from Nagapattinam region against imidacloprid 17.8% SL

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