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Baseline susceptibility studies of sulfoxaflor 24 SC against cotton leafhopper, *Amrasca biguttula biguttula* (Ishida) population of Karnataka

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Abstract
Laboratory experiments were carried out during 2014-15 and 2015-16 to study the baseline susceptibility of sulfoxaflor against the leafhopper population of major cotton growing districts of Karnataka, India. Among different districts studied, Yadgir and Raichur districts leafhopper population recorded higher LC_{50} values of 23.84 and 22.79 ppm respectively, followed by Belagavi (19.66 ppm), Dharwad (18.48 ppm), Koppal (16.32 ppm), Haveri (16.03 ppm) and Mysore (14.18 ppm) districts during 2014-15. The similar trend was noticed during 2015-16 season. The comparison studies were made with Flonicamid 50 WG and Imidacloprid 17.8 SL for a population collected from Raichur district.

Keywords: *Amrasca biguttula biguttula*, insecticide resistance, baseline susceptibility and sulfoxaflor

Introduction

Cotton (*Gossypium* spp.) popularly known as “White Gold” is a major commercial crop unanimously designated as “King of Fibres” and contributes significantly to Indian agriculture and Indian economy. The insect pests are the major limiting factors of cotton production worldwide. Among the major insect pests studied, the cotton leafhopper, *Amrasca biguttula biguttula* (Ishida) (Homoptera: Cicadellidae) is an alarming pest causing both quantitative and qualitative losses. The losses in yield due to this pest have been reported to be 1.19 q per ha[1 & 2]. The leafhopper feed continuously on plant juices with a damage to phloem tubes resulting in a diseases with symptoms called “hopper burn” [3]. Diseased plant leaves curl and develops brown dead spots with a yellow halo at the edges. Severely infested leaves may desiccate and fall off.

Among the various tactics used by farmers to manage the cotton leafhopper, insecticides form the first line of defence in spite of their drawbacks. Several potent insecticides have been recommended for managing the sucking pests, but the arbitrary use of insecticides has resulted in the development of resistance in insects to insecticides, resurgence, secondary pest outbreaks, disruption of the natural enemy complex, loss in biodiversity and environmental pollution [4]. Cotton leafhoppers found to have developed resistance to the recommended organophosphate and organochlorine insecticides [5 & 6]. However, in the recent past field level failure of neonicotinoids and carbamates were also noticed in this pest [7]. Under such circumstances new molecules selective to target pests are required to be evaluated for the justification of chemical control as the first line of defence. Sulfoxaflor is a new and safer insecticide from a novel, new class of chemistry known as sulfoximines.

Sulfoxaflor is a systemic insecticide which acts as an insect neurotoxin and is the only member a class of chemicals called the sulfoximines. Sulfoxaflor acts on the central nervous system of the insects as a agonist at nicotinic acetylcholine receptors (nAChRs) with much lower toxicity to mammals very similarly to neonicotinoids. The sulfoximines are very effective against a wide range of sap-feeding insect pests that are resistant to other classes of insecticides, including many that are resistant to the neonicotinoids. The symptoms of insects intoxicated by sulfoxaflor are initially excitatory and include tremors, antennal waving and leg extension or curling, followed by partial or complete paralysis and death. In recognition of these facts, the IRAC has placed sulfoxaflor in a mode of action subgroup (Group 4C) that is separate from the neonicotinoids (Group 4A) [8].

As new molecules are developed for use in managing insect pests, it is necessary to develop baseline susceptibility data which would not only help in fixing the dosages for effective management but also in understanding the level of resistance developed by the pest and any possible cross resistance there in, could be assessed in advance. As the information available on the baseline susceptibility of sulfoxaflor molecules against cotton leafhopper being limited. Thus, the present study was taken up to assess the susceptibility of leafhopper populations from different cotton growing districts of karnataka, India to sulfoxaflor 24 SC insecticide.

Material and methods

The present investigations were undertaken during 2014-15 and 2015-16 in the Department of Agricultural Entomology, Main Agricultural Research Station, UAS, Raichur to study the baseline susceptibility of sulfoxaflor 24 SC against cotton leafhopper population of major cotton growing areas of Karnataka.

Test insects

The test insect *A. biguttula biguttula* nymphs were collected from major cotton growing districts of Karnataka viz., Raichur, Yadgir, Koppal, Haveri, Belagavi, Dharwad and Mysuru. The districts selected in the present study were based on the intensity of pesticide usage on cotton such as, high pesticide usage, medium pesticide usage and low pesticide usage areas. For bioassay, each district collection of test insect constituted the composite collection of 3 - 4 cotton fields. Insects were collected at 5 - 7 days after insecticide application in farmer fields or insecticide free cotton fields looking into the availability of test insect in the field.

Test insecticides for bioassay

The test insecticide, sulfoxaflor 24 SC was used for baseline susceptibility studies on cotton leafhopper population of different districts. However, for comparison imidacloprid 17.8 SL and flonicamid 50 WG insecticides were used on leafhopper population collected from Raichur district. The insecticide sulfoxaflor 24 SC was supplied by Dow Agro Sciences, PVT. Ltd, Mumbai. Whereas, imidacloprid 17.8 SL (Confidor) and flonicamid 50 WG (Ulala) were procured from local market. Insecticide solutions were prepared from the formulated products using distilled water. At initial stage, bracketing or preliminary range-finding tests was done to arrive required concentrations of insecticides.

Bioassay

The uniform sized (3rd instar) leafhopper nymphs collected from each location were exposed to graded concentrations of test insecticides. The bioassay method followed for the leafhopper was leaf dip bioassay developed and recommended by the Insecticide Resistance Action Committee (IRAC) method No. 8 [9].

The experimental set-up was consisted of two plastic cups, one serving as the inner test chamber and the other as the outer water reservoir. A small hole was made in the center of the inner cup bottom to insert the petiole of the leaf. The fresh uncontaminated cotton leaves selected and the petiole was cut to a length of approximately four centimeters. The leaves were dipped in the respective insecticidal concentrations for five seconds by holding the petiole end using forceps, and then the leaves were shade-dried thoroughly in the open air by hanging them vertically. The petiole of the treated leaf was passed through the hole in the inner test container and placed inside the outer cup containing water so as to keep it in an upright position and to prevent drying. The collected leafhopper nymphs were then released into the each test cup at the rate of 20 per cup using fine camel hair brush (0 size) and the cup was covered with muslin cloth and secured using a rubber band. Each treatment was replicated thrice with twenty insects per replication. A control treatment was maintained by dipping the leaf in distilled water alone. At 72 hours after treatment the treated leaf was carefully taken out from the plastic cup and the mortality of leafhopper was recorded in all treatments. Moribund leafhopper nymphs which did not respond to probing were considered as dead.

Analysis

Percentage of mortality for each concentration of test insecticide and control were computed and corrected per cent mortality was calculated by using Abbott's formula [10]. Whenever the mortality in control exceeded 20 per cent, the experiment was repeated once again. The corrected mortality data of each test insecticide of each location was subjected to probit analysis using EPA probit analysis program version 1.5 for calculation of LC_{50} and LC_{90} values. The bioassay studies were conducted in two cropping seasons *i.e.*, 2014-15 and 2015-16 for all seven district populations against the test insecticides.

Results and Discussion

The results are presented insecticide wise for the year 2014-15 and 2015-16.

Susceptibility of cotton leafhopper populations to sulfoxaflor 24 SC insecticides

The data on the LC_{50} values of sulfoxaflor to seven different geographic populations of *A. biguttula biguttula* for two years are presented in the Tables 1 and 2. The results indicated that there has been marked difference in LC_{50} values among the different location populations.

During 2014-15, the median lethal concentrations of sulfoxaflor to seven field populations of cotton leafhopper ranged from 14.18 to 23.84 ppm. Yadgir population recorded a maximum LC_{50} value (23.84 ppm) with correspondence fiducial limits of lower (19.92) and upper (28.53) values, followed by the population collected from Raichur (22.79), Belagavi (19.66), Dharwad (18.48), Koppal (16.32) and Haveri (16.03). Lowest LC_{50} value was observed in population collected from Mysuru (14.18 ppm) with correspondence fiducial limits of lower (11.66) and upper (17.25) values. The LC_{90} values followed the similar trend as that of LC_{50} values obtained during 2014-15 (Table 1).

During 2015-16, the median lethal concentrations of sulfoxaflor to seven field populations of cotton leafhopper ranged from 15.97 to 26.02 ppm. Yadgir population recorded a maximum LC_{50} value (26.02 ppm) with correspondence fiducial limits of lower (21.68) and upper (31.22) values, followed by the population collected from Raichur (24.05), Belagavi (21.94), Dharwad (19.94), Haveri (18.68) and Koppal (17.91). Lowest LC_{50} value was observed in population collected from Mysuru (15.97 ppm) with correspondence fiducial limits of lower (12.97) and upper (19.66) values. The LC_{90} values followed the similar trend as that of LC_{50} values obtained during 2015-16 (Table 2). The literature pertaining to the susceptibility of cotton leafhopper against sulfoxaflor insecticide are not available, so this is the first study of its kind. However, the studies on the susceptibility of the cotton aphid, *Aphis gossypii* Glover against sulfoxaflor has been conducted by Gore *et al.* [11] who reported that, the LC_{50} values for sulfoxaflor ranged from 1.01 to 5.85 ppm and 0.92 to 4.13 ppm at 48 and 72 hrs on cotton aphid.

The present results of higher LC_{50} values in Yadgir and Raichur districts are in line with the findings of Sagar *et al.* [12] (2013) who reported the higher LC_{50} values of acetamiprid, monocrotophos, acephate, oxydemeton methyl and fipronil in a cotton leafhopper population of Yadgir and Raichur districts. While, lower LC_{50} values in Haveri, Dharwad and Mysuru districts. The increased LC_{50} values for sulfoxaflor in leafhopper population of Yadgir and Raichur might be due to extensive usage of insecticides in Yadgir and Raichur districts as compared to other major cotton growing districts of Karnataka. The leafhopper population of these two areas might have developed a cross resistance. Kranthi [13] opined that overuse of neonicotinoids with less importance to the principles of insecticide resistance management can lead to the development of pest resistance to the insecticides.

Susceptibility of cotton leafhopper population to imidacloprid 17.8 SL and flonicamid 50 WG insecticides

LC_{50} value of imidacloprid against population collected from Raichur was 161.31 ppm and 174.48 ppm during 2014-15 and 2015-16 respectively. Whereas, the LC_{50} value of flonicamid against population collected from Raichur was 53.41 ppm and 61.33 ppm during 2014-15 and 2015-16 respectively. (Table 3). The literature pertaining to the susceptibility of leafhopper population to flonicamid is not available. Present findings of LC_{50} values of imidacloprid are in contradictory with the results of Shreevani *et al.* [14] who reported lower LC_{50} value of imidacloprid (0.022 ppm) on leafhopper and Sagar *et al.* [15] who also reported lower LC_{50} (75.21 ppm) and LC_{90} (280.14 ppm) values during 2011 -12, Whereas, LC_{50} (85.75 ppm) and LC_{90} (313.90 ppm) values during 2012-13. The continuous increase in number of sprays and repeated use of insecticides year by year in cotton crop might be resulted in increased LC_{50} and LC_{90} values in the present studies.

All the field populations of cotton leafhopper shown considerable variation in their susceptibility to sulfoxaflor (Figure 1 & 2). In general leafhopper population of Yadgiri and Raichur recorded a comparatively higher LC_{50} values. While, leafhopper populations of Koppal, Haveri, Dharwad, Belagavi and Mysuru recorded lower LC_{50} values to sulfoxaflor. The present study clearly indicated that sulfoxaflor insecticide had a higher sensitivity and good performance on studied sucking insect pest as compared to other insecticides used in investigations. Hence, sulfoxaflor can be used as a component in integrated resistance management (IRM) approach for the management of cotton leafhopper insect pest.

Table 1: Log dose probit analysis of sulfoxaflor 24 SC on cotton leafhopper (*Amrasca biguttula biguttula*) during 2014-15

Location	LC_{50} (ppm)	Fiducial limits		LC_{90} (ppm)	Fiducial limits		Slope	χ2
		Lower	Upper		Lower	Upper		
Raichur	22.79	19.23	27.02	63.42	43.81	76.08	3.37	1.89
Yadgir	23.84	19.92	28.53	68.23	54.76	82.14	3.18	2.93
Belagavi	19.66	16.33	23.67	58.45	49.09	77.23	2.96	1.94
Dharwad	18.48	15.21	22.45	56.83	47.71	74.18	2.79	0.72
Koppal	16.32	13.27	20.00	53.12	38.24	73.46	2.80	2.05
Haveri	16.03	13.06	19.67	51.08	42.16	71.81	2.64	0.74
Mysuru	14.18	11.66	17.25	45.31	38.80	58.20	2.90	1.17

Table 2: Log dose probit analysis of sulfoxaflor 24 SC on cotton leafhopper (*Amrasca biguttula biguttula*) during 2015-16

Location	LC_{50} (ppm)	Fiducial limits		LC_{90} (ppm)	Fiducial limits		Slope	χ2
		Lower	Upper		Lower	Upper		
Raichur	24.05	19.96	28.99	75.13	54.02	98.24	2.96	2.20
Yadgir	26.02	21.68	31.22	78.41	57.80	106.20	2.99	1.24
Belagavi	21.94	17.75	27.11	71.30	52.51	93.36	2.68	2.30
Dharwad	19.94	16.46	24.16	64.18	47.36	85.91	2.77	0.73
Koppal	17.91	14.68	21.84	51.61	43.08	72.33	2.96	1.68
Haveri	18.68	15.21	22.94	56.03	45.54	80.61	2.62	1.67
Mysuru	15.97	12.97	19.66	40.38	30.60	60.71	2.88	0.96

Table 3: Log dose probit analysis of flonicamid 50 WG and imidacloprid 17.8 SL on cotton leafhopper (Raichur)

2014-15 season								
Insecticide	LC_{50} (ppm)	Fiducial limits		LC_{90} (ppm)	Fiducial limits		Slope	χ2
		Lower	Upper		Lower	Upper		
Flonicamid 50 WG	53.41	49.20	57.99	108.18	93.36	124.14	4.69	2.66
Imidacloprid 17.8 SL	161.31	142.14	183.07	431.21	366.50	530.21	3.10	1.84
2015-16 season								
Insecticide	LC_{50} (ppm)	Fiducial limits		LC_{90} (ppm)	Fiducial limits		Slope	χ2
		Lower	Upper		Lower	Upper		
Flonicamid 50 WG	61.33	55.77	68.44	123.14	115.32	147.08	3.86	3.46
Imidacloprid 17.8 SL	174.48	149.66	203.40	496.31	405.88	610.73	2.91	1.12

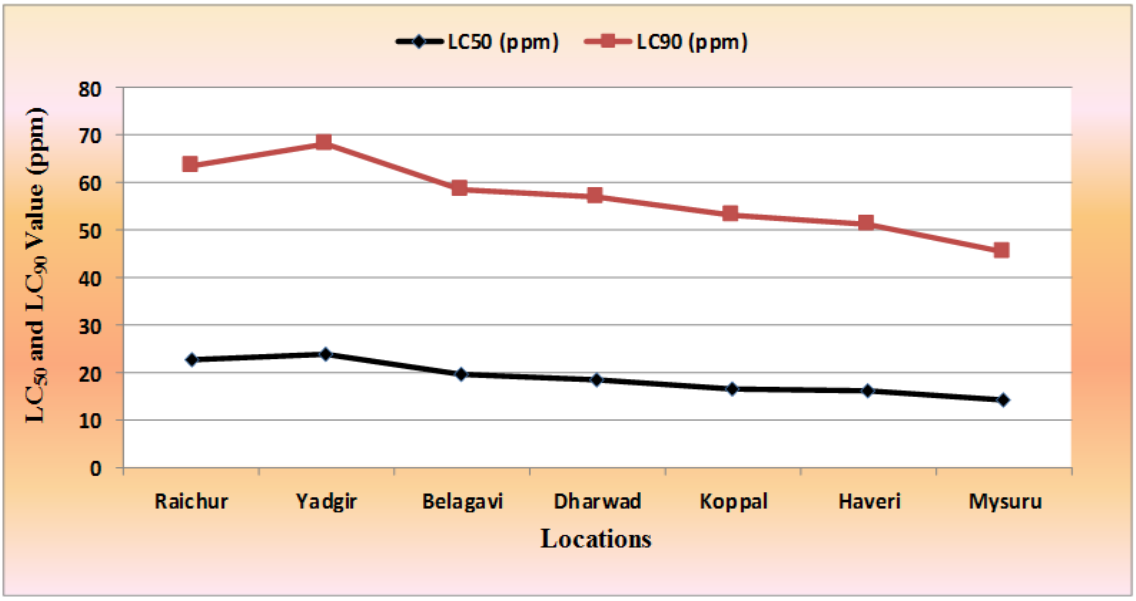

Fig 1: Susceptibility of cotton leafhopper (*A. biguttula biguttula*) populations to sulfoxaflor 24 SC insecticide during 2014-15

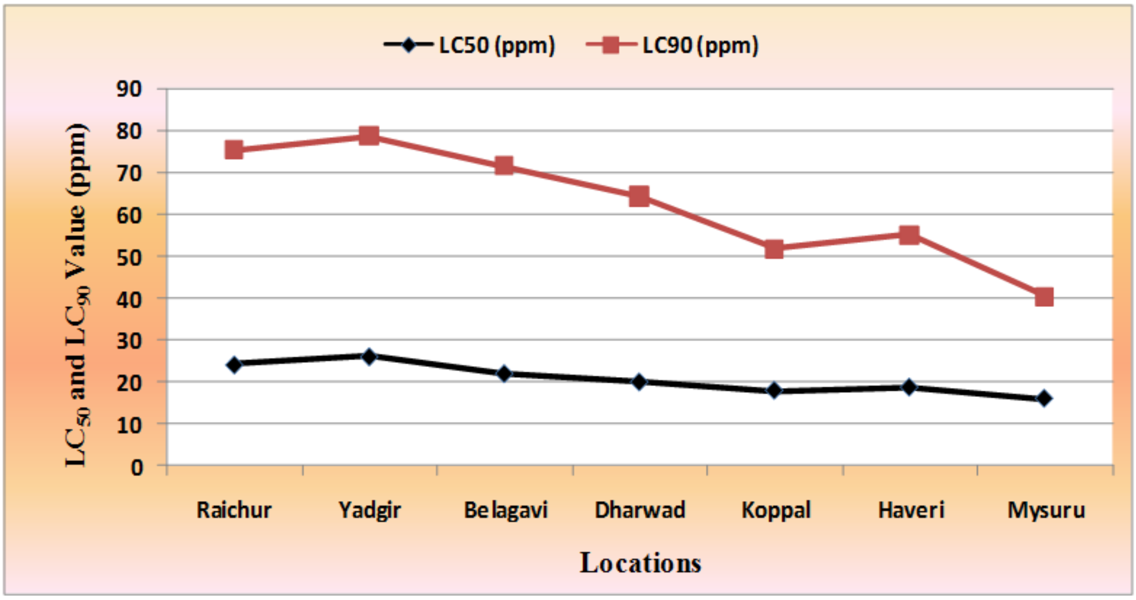

Fig 2: Susceptibility of cotton leafhopper (*A. biguttula biguttula*) populations to sulfoxaflor 24 SC insecticide during 2015-16

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