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Efficacy of insecticides against jassid, *Amrasca biguttula biguttula* (Ishida) infesting okra

RC Barot and SD Patel

Abstract
A field experiment was conducted during summer 2021 to evaluate the efficacy of insecticides against jassid, *Amrasca biguttula biguttula* (Ishida) (Hemiptera: Cicadellidae) infesting okra at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. All evaluated insecticides were effective against jassid. Flonicamid 0.015 percent, tolfenpyrad 0.030 percent and afidopyropen 0.010 percent were most effective against jassid in okra. These insecticides also recorded significantly higher fruit yield of okra as compared to other insecticides.

Keywords: Okra, jassid, *Amrasca biguttula biguttula*, insecticide, efficacy

Introduction
Okra [*Abelmoschus esculentus* (L.) Moench], also known as Lady's finger, belongs to the family Malvaceae. It is one of the most important vegetable crops grown in India. It is probably originated around Ethiopia and widely cultivated throughout North Africa and the Middle East. Okra is mostly cultivated in tropical and sub-tropical regions of the world. The tender leaves, shoots, flower buds and calyxes of a smooth variety of okra are consumed as a vegetable in western Africa and southeastern Asia (Lamont, 1999) [3]. Okra fruits contain 6.4 g carbohydrates, 2.2 g protein, 0.2 g fat, 66 mg calcium, 500 mg phosphorus, 15 mg iron and 13 mg vitamin C per 100 g of an edible portion (Chauhan, 1972) [2]. During the year 2019-20, the total area under okra cultivation in India was 5.19 lakh hectares with a production of 63.71 lakh tonnes (Anonymous, 2020) [1]. As many as 72 insect species have been recorded on okra (Pal *et al*., 2013) [5]. Among various pests, jassid, *Amrasca biguttula biguttula* (Ishida) (Hemiptera: Cicadellidae) causes 54-66 percent reduction in vegetative growth and yield, if the okra crop remains unprotected (Singh *et al.*, 2013) [9]. The information regarding the management of jassid with chemical insecticides was scanty. Therefore, a field experiment was conducted to evaluate the efficacy of insecticides against jassid infesting okra.

Materials and Methods
The experiment was conducted during summer 2021 at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. Okra variety GAO 5 was raised at the spacing of 45 X 30 cm. All recommended agronomical practices, except plant protection measures, were followed to okra crop. The experiment was laid out in Randomized Block Design (RBD) with three replications. Nine insecticides *viz.*, flupyradifurone 17.09 SL 0.043 percent, afidopyropen 5 DC 0.010 percent, tolfenpyrad 15 EC 0.030 percent, diafenthiuron 50 WP 0.050 percent, flonicamid 50 WG 0.015 percent, imidacloprid 17.8 SL 0.009 percent, thiamethoxam 25 WG 0.010 percent, buprofezin 15% + acephate 35% WP 0.075 percent, acephate 50% + imidacloprid 1.8% SP 0.104 percent, along with control, were evaluated for their efficacy against jassid.

The first spray of respective insecticides was applied on the appearance of jassid in the experimental plot and the second spray was applied after 15 days of the first spray. Knapsack sprayer, fitted with a hollow cone nozzle, was used to apply insecticide. Approximately, 500 litres of spray solution was used to spray one hectare area. To record the observations on jassid population, five plants were randomly selected from each net plot area. From each selected plant, one leaf from the top, middle and lower canopy was observed and the number of jassids (nymph + adult) was counted before the first spray as well as 3, 7, 10 and 14 days after each spray.

Statistical analysis

The data on jassid population were subjected to square root ($\sqrt{x}$+0.5) transformation and were analyzed by analysis of variance (ANOVA) technique. The treatment means were compared using Duncan's New Multiple Range Test (Steel & Torrie, 1980) [10].

Results

First spray

The data on jassid population are presented in Table 1. Before the first spray, the differences among the treatments for jassid population were non significantly, indicating that there was a uniform distribution of jassid infestation.

Table 1: Bio-efficacy of insecticides against jassid infesting okra (First spray)

Tr. No.	Treatments	No. of jassid /leaf before spray	No. of jassid /leaf at indicated days after spray				
			3	7	10	14	Pooled
T_1	Flupyradifurone 0.043%	1.99 (3.47)	1.23^{cd} (1.01)	1.36^{b} (1.35)	1.44^{bcde} (1.57)	1.46^{b} (1.64)	1.37^{b} (1.38)
T_2	Afidopyropen 0.010%	1.97 (3.40)	0.96^{ab} (0.41)	1.09^{a} (0.70)	1.17^{a} (0.88)	1.19^{a} (0.92)	1.10^{a} (0.72)
T_3	Tolfenpyrad 0.030%	1.97 (3.39)	0.95^{a} (0.40)	1.08^{a} (0.66)	1.16^{a} (0.84)	1.17^{a} (0.86)	1.09^{a} (0.68)
T_4	Diafenthiuron 0.050%	2.00 (3.51)	1.48^{de} (1.69)	1.61^{c} (2.10)	1.65^{cde} (2.22)	1.70^{c} (2.39)	1.61^{c} (2.09)
T_5	Flonicamid 0.015%	1.98 (3.43)	0.92^{a} (0.35)	1.05^{a} (0.61)	1.14^{a} (0.79)	1.16^{a} (0.84)	1.07^{a} (0.64)
T_6	Imidacloprid 0.009%	2.02 (3.58)	1.50^{e} (1.75)	1.63^{c} (2.16)	1.67^{e} (2.30)	1.73^{c} (2.49)	1.63^{c} (2.17)
T_7	Thiamethoxam 0.010%	2.00 (3.51)	1.50^{e} (1.76)	1.62^{c} (2.13)	1.65^{cde} (2.22)	1.72^{c} (2.46)	1.62^{c} (2.14)
T_8	Buprofezin + acephate 0.075%	1.98 (3.44)	1.22^{cd} (0.99)	1.35^{b} (1.33)	1.42^{bcd} (1.53)	1.45^{b} (1.59)	1.36^{b} (1.35)
T_9	Acephate + imidacloprid 0.104%	1.98 (3.43)	1.21^{bc} (0.96)	1.34^{b} (1.30)	1.42^{b} (1.50)	1.44^{b} (1.57)	1.35^{b} (1.33)
T_{10}	Control	2.05 (3.69)	1.99^{f} (3.46)	2.01^{d} (3.55)	2.02^{f} (3.60)	2.04^{d} (3.67)	2.02^{d} (3.57)
S. Em. ± T		0.10	0.08	0.07	0.07	0.07	0.036
P		-	-	-	-	-	0.023
T x P		-	-	-	-	-	0.072
F test (T)		NS	Sig.	Sig.	Sig.	Sig.	Sig.
C.V. (%)		8.68	10.43	8.78	8.34	8.46	8.74

Note: (1) Figures outside the parentheses are $\sqrt{x+0.5}$ transformed values and those inside the parentheses are retransformed values
(2) Treatment means followed by the same letter(s) within the column are not significantly different by DNMRT at 5% level of significance

Three days after the first spray, there were significant differences among the treatments. Significantly lower population of jassid (0.35 /leaf) was noticed in the treatment of flonicamid 0.015 percent which was at par with tolfenpyrad 0.030 percent (0.40 /leaf) and afidopyropen 0.010 percent (0.41 /leaf). The treatment thiamethoxam 0.010 percent (1.76 /leaf) recorded significantly higher jassid population among evaluated insecticides and it was at par with imidacloprid 0.009 percent (1.75 /leaf) and diafenthiuron 0.050 percent (1.69 /leaf). The control plot registered the population of 3.46 jassids /leaf.

After seven days of the first spray, significantly lower population of jassid (0.61 /leaf) was recorded in the plots treated with flonicamid 0.015 percent which was at par with tolfenpyrad 0.030 percent (0.66 /leaf) and afidopyropen 0.010 percent (0.70 /leaf). Treatments of acephate + imidacloprid 0.104 percent (1.30 /leaf), buprofezin + acephate 0.075 percent (1.33 /leaf) and flupyradifurone 0.043 percent (1.35 /leaf) were mediocre in bio-efficacy against jassid and they were also at par with one another. Among evaluated insecticides, significantly higher population (2.16 /leaf) was recorded in plots treated with imidacloprid 0.009 percent which was at par with thiamethoxam 0.010 percent (2.13 /leaf) and diafenthiuron 0.050 percent (2.10 /leaf). The jassid population in control plot was 3.55 /leaf.

After 10 days of the first spray, differences among treatments were significant and all insecticidal treatments were significantly superior to control. Among evaluated insecticides, flonicamid 0.015 percent recorded significantly lower jassid population (0.79 /leaf), however, it did not differ significantly from tolfenpyrad 0.030 percent (0.84 /leaf) and afidopyropen 0.010 percent (0.88 /leaf). The next effective treatment was acephate + imidacloprid 0.104 percent (1.50 /leaf) which was at par with buprofezin + acephate 0.075 percent (1.53 /leaf) and flupyradifurone 0.043 percent (1.57 /leaf). Imidacloprid 0.009 percent (2.30 /leaf) was significantly least effective among evaluated insecticides against jassid in okra.

After 14 days of the first spray, flonicamid 0.015 percent (0.84 /leaf) had significantly lower jassid population and it was at par with tolfenpyrad 0.030 percent (0.86 /leaf) and afidopyropen 0.010 percent (0.92 /leaf). Acephate + imidacloprid 0.104 percent (1.57 /leaf), buprofezin + acephate 0.075 percent (1.59 /leaf) and flupyradifurone 0.043 percent (1.64 /leaf) were moderately effective against jassid. They were also at par with one another. Among evaluated insecticides, imidacloprid 0.009 percent recorded the highest population of jassid (2.49 /leaf) and it was at par with thiamethoxam 0.010 percent (2.46 /leaf) and diafenthiuron 0.050 percent (2.39 /leaf).

Data on jassid population were pooled over periods, which indicated that the significantly lower jassid population (0.64 /leaf) was observed in the plots treated with flonicamid 0.015 percent which was at par with tolfenpyrad 0.030 percent (0.68 /leaf) and afidopyropen 0.010 percent (0.72 /leaf). All of above three treatments differed significantly from the rest of

the treatments. Acephate + imidacloprid 0.104 percent (1.33 /leaf), buprofezin + acephate 0.075 percent (1.35 /leaf) and flupyradifurone 0.043 percent (1.38 /leaf) were moderately effective and they remained at par with one another. Among evaluated insecticides, imidacloprid 0.009 percent recorded the highest population (2.17 /leaf) which was at par with thiamethoxam 0.010 percent (2.14 /leaf) and diafenthiuron 0.050 percent (2.09 /leaf).

Second Spray

Based on population of jassid, recorded three days after the second spray (Table 2), flonicamid 0.015 percent and tolfenpyrad 0.030 percent emerged as the most effective insecticide and both of them recorded the population of 0.26 jassid /leaf. Both insecticides were at par with afidopyropen 0.010 percent (0.30 /leaf). Acephate + imidacloprid 0.104 percent (0.88 /leaf), buprofezin + acephate 0.075 percent (0.92 /leaf) and flupyradifurone 0.043 percent (0.94 /leaf) were found to be mediocre in effectiveness. Among evaluated insecticides, imidacloprid 0.009 percent had significantly higher population of jassid (1.68 /leaf) and it was at par with diafenthiuron 0.050 percent (1.61 /leaf) and thiamethoxam 0.010 percent (1.64 /leaf). Among all treatments, significantly highest population of jassid (3.42 /leaf) was observed in control plots.

After seven days of the second spray, the lowest jassid population (0.42 /leaf) was noticed in the treatment of flonicamid 0.015 percent which was at par with tolfenpyrad 0.030 percent (0.47 /leaf) and afidopyropen 0.010 percent (0.54 /leaf). Acephate + imidacloprid 0.104 percent (1.14 /leaf), buprofezin + acephate 0.075 percent (1.17 /leaf) and flupyradifurone 0.043 percent (1.19 /leaf) were moderately effective against jassid and they were at par with one another. Among evaluated insecticides, imidacloprid 0.009 percent (1.98 /leaf), thiamethoxam 0.010 percent (1.94 /leaf) and diafenthiuron 0.050 percent (1.91 /leaf) were found to be least effective. Significantly highest jassid population (3.27 /leaf) was recorded in control plots.

After ten days of second spray, jassid population was significantly different in different treatments (Table 2). Treatments of flonicamid 0.015 percent and tolfenpyrad 0.030 percent had a significantly lower jassid population 0.53 jassid /leaf, however they did not differ significantly from afidopyropen 0.010 percent (0.58 /leaf). The next best treatment was acephate + imidacloprid 0.104 percent (1.21 /leaf) which was at par with buprofezin + acephate 0.075 percent (1.27 /leaf) and flupyradifurone 0.043 percent (1.30 /leaf). Control plots had a significantly highest jassid population (3.24 /leaf).

Table 2: Bio-efficacy of insecticides against jassid infesting okra (Second spray)

Tr. No.	Treatments	No. of jassid /leaf at indicated days after spray				
		3	7	10	14	Pooled
T_1	Flupyradifurone 0.043%	1.20^{bc} (0.94)	1.30^{bc} (1.19)	1.34^{b} (1.30)	1.35^{b} (1.32)	1.30^{b} (1.18)
T_2	Afidopyropen 0.010%	0.89^{a} (0.30)	1.02^{a} (0.54)	1.04^{a} (0.58)	1.07^{a} (0.65)	1.01^{a} (0.51)
T_3	Tolfenpyrad 0.030%	0.87^{a} (0.26)	0.98^{a} (0.47)	1.01^{a} (0.53)	1.05^{a} (0.61)	0.98^{a} (0.46)
T_4	Diafenthiuron 0.050%	1.45^{cd} (1.61)	1.55^{cd} (1.91)	1.58^{c} (2.01)	1.60^{c} (2.06)	1.55^{c} (1.89)
T_5	Flonicamid 0.015%	0.87^{a} (0.26)	0.96^{a} (0.42)	1.01^{a} (0.53)	1.03^{a} (0.55)	0.97^{a} (0.44)
T_6	Imidacloprid 0.009%	1.48^{d} (1.68)	1.57^{d} (1.98)	1.62^{c} (2.14)	1.64^{c} (2.19)	1.58^{c} (1.99)
T_7	Thiamethoxam 0.010%	1.46^{cd} (1.64)	1.56^{cd} (1.94)	1.61^{c} (2.09)	1.63^{c} (2.16)	1.57^{c} (1.95)
T_8	Buprofezin + acephate 0.075%	1.19^{bc} (0.92)	1.29^{bc} (1.17)	1.33^{b} (1.27)	1.33^{b} (1.26)	1.29^{b} (1.15)
T_9	Acephate + imidacloprid 0.104%	1.17^{b} (0.88)	1.28^{b} (1.14)	1.31^{b} (1.21)	1.30^{b} (1.19)	1.27^{b} (1.10)
T_{10}	Control	1.98^{e} (3.42)	1.94^{e} (3.27)	1.93^{d} (3.24)	1.90^{d} (3.11)	1.94^{d} (3.26)
S. Em. ± T		0.08	0.08	0.07	0.07	0.036
P		-	-	-	-	0.023
T x P		-	-	-	-	0.072
F test (T)		Sig.	Sig.	Sig.	Sig.	Sig.
C.V. (%)		10.62	10.23	9.37	8.38	9.35

Note:

(1) Figures outside the parentheses are $\sqrt{x + 0.5}$ transformed values and those inside the parentheses are retransformed values

(2) Treatment means followed by the same letter(s) within the column are not significantly different by DNMRT at 5% level of significance

Data presented in Table 2 indicated that after 14 days of the second spray, significantly lower population of jassid (0.55 /leaf) was observed in flonicamid 0.015 percent treated plots which were at par with tolfenpyrad 0.030 percent (0.61 /leaf) and afidopyropen 0.010 percent (0.65 /leaf). The insecticidal treatments of acephate + imidacloprid 0.104 percent (1.19 /leaf), buprofezin + acephate 0.075 percent (1.26 /leaf) and flupyradifurone 0.043 percent (1.32 /leaf) were moderately effective against jassid and they were at par with one another. Among evaluated insecticides, significantly highest population of jassid (2.19 /leaf) was recorded in imidacloprid 0.009 percent which was at par with thiamethoxam 0.010 percent (2.16 /leaf) and diafenthiuron 0.050 percent (2.06 /leaf).

The data on jassid population were pooled over periods, which indicated that differences among the treatments were significant. Among evaluated insecticides, flonicamid 0.015 percent with the population of 0.44 jassid /leaf was significantly superior, except tolfenpyrad 0.030 percent (0.46 /leaf) and afidopyropen 0.010 percent (0.51 /leaf) with whom it was at par. Treatments of acephate + imidacloprid 0.104 percent (1.10 /leaf), buprofezin + acephate 0.075 percent (1.15 /leaf) and flupyradifurone 0.043 percent (1.18 /leaf) were moderately effective against jassid and they were at par with one another. Among evaluated insecticides, imidacloprid 0.009 percent recorded significantly highest population of jassid (1.99 /leaf) and it was at par with thiamethoxam 0.010 percent (1.95 /leaf) and diafenthiuron 0.050 percent (1.89 /leaf). Among all treatments, control plots had a significantly highest jassid population (3.26 /leaf).

The jassid population data were also pooled over periods and sprays, which indicated that the all the treatments differed significantly (Table 3) Flonicamid 0.015 percent with the jassid population of 0.53 jassid /leaf emerged as the most

effective treatment, however, it was at par with tolfenpyrad 0.030 percent (0.57 /leaf) and afidopyropen 0.010 percent (0.61 /leaf). Treatments of acephate + imidacloprid 0.104 percent (1.21 /leaf), buprofezin + acephate 0.075 percent (1.25 /leaf) and flupyradifurone 0.043 percent (1.28 /leaf) were moderately effective against jassid, *A. biguttula biguttula* and they were at par with one another. While, the treatment of imidacloprid 0.009 percent (2.08 /leaf) found to be less effective against jassid and it was at par with thiamethoxam 0.010 percent (2.04 /leaf) and diafenthiuron 0.050 percent (1.99 /leaf).

Fruit Yield of Okra

Data on the fruit yield of okra are presented in Table 4. Differences among the treatments were significant. All insecticidal treatments yielded significantly higher than control plots. The highest yield (82.29 q/ha) was recorded in plots treated with flonicamid 0.015 percent which was at par with tolfenpyrad 0.030 percent (81.15 q/ha), afidopyropen 0.010 percent (80.05 q/ha), buprofezin + acephate 0.075 percent (77.05 q/ha), acephate + imidacloprid 0.104 percent (77.13 q/ha) and flupyradifurone 0.043 percent (70.92 q/ha). Among evaluated insecticides, the lowest yield was recorded in imidacloprid 0.009 percent (67.14 q/ha) which was at par with thiamethoxam 0.010 percent (67.63 q/ha) diafenthiuron 0.050 percent (67.67 q/ha), flupyradifurone 0.043 percent, buprofezin + acephate 0.075 percent and acephate + imidacloprid 0.104 percent. Control plots recorded the yield of 54.20 q/ha which was significantly lowest among all treatments.

Table 3: Bio-efficacy of insecticides against jassid infesting okra (Pooled over periods) and their impact on fruit yield of okra

Tr. No.	Treatments	No. of jassid /leaf at indicated spray			Fruit yield (q/ha)
		First	Second	Pooled over periods and sprays	
T_1	Flupyradifurone 0.043%	1.37^{b} (1.38)	1.30^{b} (1.18)	1.34^{b} (1.28)	70.92^{abc}
T_2	Afidopyropen 0.010%	1.10^{a} (0.72)	1.01^{a} (0.51)	1.05^{a} (0.61)	80.05^{ab}
T_3	Tolfenpyrad 0.030%	1.09^{a} (0.68)	0.98^{a} (0.46)	1.03^{a} (0.57)	81.15^{a}
T_4	Diafenthiuron 0.050%	1.61^{c} (2.09)	1.55^{c} (1.89)	1.58^{c} (1.99)	67.67^{bc}
T_5	Flonicamid 0.015%	1.07^{a} (0.64)	0.97^{a} (0.44)	1.02^{a} (0.53)	82.29^{a}
T_6	Imidacloprid 0.009%	1.63^{c} (2.17)	1.58^{c} (1.99)	1.61^{c} (2.08)	67.14^{c}
T_7	Thiamethoxam 0.010%	1.62^{c} (2.14)	1.57^{c} (1.95)	1.59^{c} (2.04)	67.63^{bc}
T_8	Buprofezin + acephate 0.075%	1.36^{b} (1.35)	1.29^{b} (1.15)	1.32^{b} (1.25)	77.05^{abc}
T_9	Acephate + imidacloprid 0.104%	1.35^{b} (1.33)	1.27^{b} (1.10)	1.31^{b} (1.21)	77.13^{abc}
T_{10}	Control	2.02^{d} (3.57)	1.94^{d} (3.26)	1.98^{d} (3.41)	54.20^{d}
S. Em. ± T		0.036	0.036	0.026	3.76
P		0.023	0.023	0.016	-
S		-	-	0.011	-
T x P		0.072	0.072	0.051	-
T x S		-	-	0.036	-
P x S		-	-	0.023	-
T x P x S		-	-	0.072	-
F test (T)		Sig.	Sig.	Sig.	Sig.
C.V. (%)		8.74	9.35	9.07	8.98

Note: (1) Figures outside the parentheses are $\sqrt{x+0.5}$ transformed values and those inside the parentheses are retransformed values
(2) Treatment means followed by same letter(s) within the column are not significantly different by DNMRT at 5% level of significance

Discussion

The above results on the efficacy of insecticides are in agreement with Mallick *et al.* (2016) [4], who reported that tolfenpyrad 15 EC @ 150 g a.i./ha had better efficacy against sucking pest complex of okra. Pathan *et al.* (2017) [6] also reported that flonicamid 0.015 percent was most effective insecticide. Saha *et al.* (2019) [7] observed that flonicamid 50 WG @ 0.4 ml/L was the most effective against leafhopper population in okra and it was followed by flonicamid 50 WG @ 0.3 ml/L. According to Singh *et al.* (2020) [8], flonicamid 50 WG @ 0.4 g/L and flupyradifurone 200 SL @ 2.5 ml/L provided satisfactory control of sucking pest in okra.

Mallick *et al.* (2016) [4] reported that the significantly highest okra fruit yield was recorded in treatments of tolfenpyrad 15 EC @ 125 and 150 g a.i/ha. Pathan *et al.* (2017) [6] also reported that flonicamid 0.015 percent yielded the highest quantity of okra fruit. Similarly, Singh *et al.* (2020) [8] reported the highest okra fruit yield was observed in the treatment of flonicamid 50 WG @ 0.4 g/L. Thus, the above reports are in conformity with the present findings.

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