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RESPONSE OF BENEFICIAL ARTHROPODS TO INSECTICIDES; USED FOR THE IPM MODULE AGAINST COTTON JASSID (*AMRASCA BIGUTTULA BIGUTTULA* ISHIDA)

Md. Salahuddin[1*], Masum Ahmad[1], Mohammad Mahir Uddin[1], Md. Abdul Wahab[2], Md. Mahfujur Rahman[1] and Mohd. Muntasir Rahman[3]

[1]Department of Entomology, Bangladesh Agricultural University, Mymensingh, Bangladesh. [2]Cotton Research Farm, Gazipur, Bangladesh. [3]Department of Agronomy, Sylhet Agricultural University, Sylhet, Bangladesh.

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ABSTRACT

A field experiment was conducted during the August 2024 to February 2025 cotton seasons at the Cotton Research, Training, and Seed Multiplication Farm, Sreepur, Gazipur, to evaluate five insecticides, viz., Imidacloprid (Tido 20 SL) @ 0.5 ml L^{-1}, Thiamethoxam (Spike 25 WG) @ 0.3 g L^{-1}, Diafenthiuron (Pannel 50 SC) @ 0.5 ml L^{-1}, Acetamiprid (Tundra 20 SP) @ 0.5 g L^{-1}, and Acephate (Asataf 75 SP) @ 1.5 g L^{-1}. Significant differences were observed among treatments in suppressing jassid population, conserving beneficial arthropods, and improving productivity. Diafenthiuron recorded the lowest mean jassid population (0.53 $leaf^{-1}$) with 84.77% reduction over untreated control. Acetamiprid and Acephate showed moderate efficacy, while Imidacloprid provided comparatively lower control. Thiamethoxam performed poorly and sometimes increased jassid incidence. After five sprays, Acetamiprid conserved the highest populations of spiders (0.33 $plant^{-1}$) and ladybird beetles (0.32 $plant^{-1}$), while Diafenthiuron produced the highest seed cotton yield (2713.99 kg ha^{-1}), net return (Tk. 124,979 ha^{-1}), and benefit-cost ratio (1.85).

Keywords: Cotton, jassid, insecticide, beneficial arthropods, IPM module

INTRODUCTION

Cotton is the "King of Fiber" and one of the most important cash crops in Bangladesh. For its importance as a main raw material in the textile and garment industry, major contribution to national GDP and foreign earnings, it's also called

*Corresponding author: *salahuddin.231203901@bau.edu.bd*

"White Gold". Bangladesh ranks as the world's second-largest cotton importer and the fourth-largest consumer. During 2024-2025, cotton was cultivated on 46,760 hectares, producing 99,798 metric tons of seed cotton and 219,338 bales of lint (CDB 2025). In spite of high demand, there are many constraints for cultivating cotton in Bangladesh, including erratic rainfall during sowing time, infestation by serious pests and diseases, heavy weed infestations, long crop duration, lower yields, and fluctuation of the seed cotton price. Among these, infestation of major insect pests is one of the main constraints from sowing to harvesting. However, cotton is vulnerable to various insect pests, which cause serious damage to the crop, leading to severe yield losses. In recent years, the incidence of the sucking pest, *Amrasca biguttula biguttula* (jassid or leafhopper), also called *Amrasca devastans* (Dist.), has become serious in Bangladesh, India, Pakistan, Thailand, and other South East Asian countries (Roy *et al*. 2009). Cotton jassid damage alone may reduce yield by 50 %, and damage by jassids and bollworms together may reduce yield as much as by 70 % (Wadud and Moniruzzaman 2001).

To control the insect pests of cotton, sustainable management strategies are preferable for an eco-friendly approach. However, farmers prefer chemical pesticides over other management techniques because of their effectiveness, availability, and cost-effectiveness (Siddique and Azad 2010). Despite of all the positive and negative impacts of insecticides, cases of natural enemies showing resistance to insecticides have also been recorded in some studies (Barbosa *et al*. 2016). It is recommended that selective insecticides be encouraged to control cotton pests, maintaining the natural enemies' population (Machado *et al*. 2019). Besides, chemical control is the most effective tactic for the management of cotton insect pests, but should only be used as last option, judiciously in combination with proper spray technology and only when economic threshold levels approaches to reduce pesticide loads (Asrar *et al.* 2013). The uses of neonicotinoids are supposed to be less toxic to the non-target insects like predators and parasitoid than other conventional insecticides. These chemicals are selective and specific, with no side as well as after effects on non-target insects and environment (Hafeez *et al.* 2020). Integration of chemical and biological control strategies remain a viable option in an IPM programme for the control of cotton pests (Malinga and Laing 2022). So it is imperative to find out an eco-friendly and need based use of chemical pesticides as a component of Integrated

Pest Management (Murugesan *et al*. 2002). From the above circumstances an experiment was conducted in the cotton field to evaluate the efficacy of different synthetic insecticides against jassid infestation and to observe their effect on the abundance of natural enemies.

MATERIALS AND METHODS

Experimental design and crop management: The trial was established using a randomized complete block design (RCBD) with three replications. Each plot consisted of four rows, each 4.5 m long, with 90 cm spacing between rows and 35 cm between individual plants. Standard agronomic practices for cotton were applied uniformly across all plots. Fertilizer application followed recommended rates, while irrigation, weeding, and other crop management operations were performed consistently for all treatments.

Data Collection: Treatments were applied to the experimental plots immediately after pest infestation and repeated at 10-day intervals for a total of five applications. At 3 and 7 days after treatment (DAT), nymphs and adults were sampled from three leaves (top, middle, and bottom) of three randomly selected plants per plot. Beneficial arthropods (spiders and ladybird beetles) were similarly recorded from five randomly selected plants per plot at the same intervals. Yield was assessed from two separate pickings. Jassid density (nymphs + adults) per leaf and the abundance of natural enemies were calculated for each replicate of every treatment at 3 and 10 DAT. The percent reduction of jassid population over farmers practice was calculated by using the following formula:

$$\text{\% reduction of jassid population over control}$$
$$= \frac{\text{Jassid number in control - Jassid number in treatment}}{\text{Jassid number in control}} \times 100$$

Seed Cotton Yield and BCR: Seed cotton from each treated and control plot was harvested, sun-dried, weighed, and converted to yield per hectare based on plot size. Total production cost for each treatment was determined by accounting insecticide prices and application expenses. The monetary value of seed cotton yield was then estimated, and the BCR was calculated as the ratio of net profit to total cost.

Statistical Analysis: All experimental data were encoded, organized, and processed using Microsoft Excel 2010. Treatment effects were assessed through analysis of variance (ANOVA) under a Randomized Complete Block Design (RCBD) using R software (version 4.5.1). Mean separation was performed using Duncan's Multiple Range Test (DMRT) following Gomez and Gomez (1984). Graphs were generated in Microsoft Excel 2010.

RESULTS

In the present study, the effectiveness of different chemical insecticides against jassid (*Amrasca biguttula biguttula* Ishida) was evaluated, where five sprays were applied and the number of jassid population per leaf, number of natural enemies (spider and ladybird beetle) per plant, and yield data were collected from pre-treatment and three and seven days after treatment (DAT).

Effect of insecticidal treatments on jassid and associated natural enemies after the application of first spray: Pre-treatment observations showed no significant differences in jassid (3.02-3.66 leaf^{-1}), spider (0.80-0.93 plant^{-1}), or ladybird beetle populations (0.40-0.53 plant^{-1}), indicating uniform initial conditions (Table 1).

Table 1. Effect of different insecticidal treatments on jassid (per leaf) and associated natural enemies (spiders and ladybird beetles per plant) after first spray.

Treatments	Jassid/leaf			Natural enemies/plant					
				Spider			Ladybird beetles		
	Pre-Treatment	3 DAT	7 DAT	Pre-Treatment	3 DAT	7 DAT	Pre-Treatment	3 DAT	7 DAT
Imidacloprid	3.02a	1.01c	1.69d	0.80a	0.47b	0.40b	0.53a	0.20c	0.40b
Thiamethoxam	3.45a	1.66b	2.55b	0.93a	0.20c	0.27b	0.60a	0.20c	0.27c
Diafenthiuron	3.41a	0.63d	0.99f	0.80a	0.20c	0.40b	0.40a	0.20c	0.33b
Acetamiprid	3.56a	0.66d	1.32e	0.80a	0.47b	0.40b	0.47a	0.33b	0.40b
Acephate	3.59a	0.86c	1.99c	0.87a	0.27bc	0.20b	0.53a	0.20c	0.20c
Control	3.66a	3.82a	3.15a	0.80a	0.73a	0.73a	0.53a	0.47a	0.60a
Sig. Level	NS	***	***	NS	**	*	NS	***	***
SEM (±)	0.34	0.11	0.11	0.20	0.13	0.15	0.12	0.06	0.05
CV %	9.85	7.81	5.63	31.28	68.31	77.33	23.35	22.61	12.95
LSD (0.05)	0.61	0.20	0.20	0.59	0.39	0.46	0.21	0.11	0.08

DAT-Days After Treatment; Means within a column followed by the same letter(s) do not differ significantly according to the LSD test at $p \leq 0.05$. *** = Significant at 0.1% level of probability; ** = Significant at 1% level of probability; * = Significant at 5% level of probability; NS = Non-significance, SEM = Standard error of the mean.

After the first spray, all insecticides significantly reduced jassid density at 3 DAT compared to untreated control (3.82 $leaf^{-1}$), with Diafenthiuron (0.63 $leaf^{-1}$) and Acetamiprid (0.66 $leaf^{-1}$) providing the greatest suppression, followed by Acephate, Imidacloprid, and Thiamethoxam ($p < 0.001$). This trend persisted at 7 DAT, where Diafenthiuron (0.99 $leaf^{-1}$) and Acetamiprid (1.32 $leaf^{-1}$) remained most effective, while the control recorded the highest population (3.15 $leaf^{-1}$). Spider abundance was not significantly affected by treatments at either observation, whereas ladybird beetle populations were significantly reduced by all insecticides, with Thiamethoxam and Acephate causing the greatest declines and the control maintaining the highest density ($p < 0.001$).

Effect of insecticidal treatments on jassid and associated natural enemies after the application of second spray: All insecticides significantly reduced jassid populations at 3 and 10 DAT compared with the untreated control ($p < 0.001$) (Table 2). Diafenthiuron provided the highest suppression, recording the lowest jassid density at both 3 DAT (0.09 $leaf^{-1}$) and 7 DAT (0.38 $leaf^{-1}$), followed by Acephate and Acetamiprid. Thiamethoxam was the least effective, while the control maintained the highest infestation at both observation periods. Spider and ladybird beetle populations were significantly affected by treatments at both observation times. The untreated control consistently recorded the highest abundance of both natural enemies. Among insecticides, Acetamiprid maintained relatively higher spider (0.40 $plant^{-1}$) and ladybird beetle populations (0.40-0.47 $plant^{-1}$), indicating comparatively lower toxicity. Diafenthiuron and Imidacloprid showed moderate adverse effects, whereas Acephate and Thiamethoxam caused the greatest reductions in natural enemy abundance.

Effect of insecticidal treatments on jassid and associated natural enemies after the application of third spray: After the third spray, all insecticides significantly reduced jassid populations at 3 DAT compared with the untreated control (3.34 $leaf^{-1}$; $p < 0.001$) (Table 3). Diafenthiuron was most effective (0.16 $leaf^{-1}$), followed by Acetamiprid (0.26 $leaf^{-1}$) and Acephate (0.27 $leaf^{-1}$), while Imidacloprid showed moderate control and Thiamethoxam was least effective (2.32 $leaf^{-1}$). At 7 DAT, Diafenthiuron maintained the lowest jassid density (0.78 $leaf^{-1}$), followed by Acetamiprid and Acephate, whereas Imidacloprid and Thiamethoxam recorded

Table 2. Effect of selected insecticides on jassid population (per leaf) and associated natural enemies (per plant) after second spray.

Treatments	Jassid/leaf		Natural enemies/plant			
			Spider		Ladybird beetles	
	3DAT	7DAT	3DAT	7DAT	3DAT	7DAT
Imidacloprid	0.51c	1.97b	0.20c	0.27b	0.27bc	0.40a
Thiamethoxam	1.56b	2.11b	0.20c	0.33b	0.20c	0.20b
Diafenthiuron	0.09f	0.38c	0.27c	0.33b	0.27bc	0.40a
Acetamiprid	0.26d	0.57c	0.40b	0.40b	0.40ab	0.47a
Acephate	0.21e	0.57c	0.20c	0.27b	0.20c	0.27b
Control	3.19a	3.37a	0.60a	0.87a	0.47a	0.40a
Sig. Level	***	***	***	**	**	**
SEM (±)	0.02	0.11	0.05	0.16	0.08	0.06
CV %	2.67	7.12	43.91	39.49	25.95	16.98
LSD (0.05)	0.05	0.19	0.14	0.29	0.14	0.11

Means within a column followed by the same letter(s) do not differ significantly according to the LSD test at $p \leq 0.05$. *** = Significant at 0.1% level of probability; ** = Significant at 1% level of probability. SEM = Standard error of the mean.

higher populations; the control remained highest (3.84 leaf^{-1}) ($p < 0.001$). Spider abundance differed at 3 DAT ($p < 0.05$) but not at 7 DAT. The control supported the highest spider population; Diafenthiuron retained comparatively more spiders among treated plots, while Acephate and Thiamethoxam caused complete suppression at 3 DAT. Ladybird beetle populations were significantly affected at both observations. Acetamiprid maintained relatively higher populations, whereas Imidacloprid, Thiamethoxam, Diafenthiuron, and Acephate caused strong suppression; the control consistently recorded the highest abundance.

Effect of insecticidal treatments on jassid and associated natural enemies after the application of fourth spray: Following the fourth spray, all insecticidal treatments significantly reduced jassid populations at 3 DAT relative to the untreated control (3.10 leaf^{-1}; $p < 0.001$) (Table 4). Diafenthiuron provided the highest suppression (0.26 leaf^{-1}), followed by Acetamiprid (0.74 leaf^{-1}) and Acephate (0.92 leaf^{-1}), and while Imidacloprid showed moderate efficacy and Thiamethoxam was least effective (1.95 leaf^{-1}). At 7 DAT, Diafenthiuron maintained the lowest jassid

Table 3. Effect of selected insecticides on jassid population (per leaf) and associated natural enemies (per plant) after third spray.

Treatments	Jassid/leaf		Natural enemies/plant			
			Spider		Ladybird beetles	
	3DAT	7DAT	3DAT	7DAT	3DAT	7DAT
Imidacloprid	0.54c	2.45b	0.07bc	0.27ab	0.00b	0.07c
Thiamethoxam	2.32b	2.45b	0.00c	0.07b	0.00b	0.00c
Diafenthiuron	0.16d	0.78d	0.13ab	0.27ab	0.00b	0.13bc
Acetamiprid	0.26d	1.43c	0.07bc	0.27ab	0.20a	0.27ab
Acephate	0.27d	1.75c	0.00c	0.07b	0.00b	0.00c
Control	3.34a	3.84a	0.20a	0.47a	0.27a	0.33a
Sig. Level	***	***	*	NS	***	**
SEM (±)	0.12	0.20	0.07	0.17	0.05	0.09
CV %	10.77	9.72	86.68	71.56	59.21	69.08
LSD (0.05)	0.22	0.37	0.12	0.30	0.08	0.16

Means within a column followed by the same letter(s) do not differ significantly according to the LSD test at $p \leq 0.05$. *** = Significant at 0.1% level of probability; ** = Significant at 1% level of probability; * = Significant at 5% level of probability; NS = non-significance. SEM = Standard error of the mean.

density (1.01 $leaf^{-1}$), followed by Acetamiprid and Imidacloprid; Acephate and Thiamethoxam recorded higher populations, and the control remained highest (3.70 $leaf^{-1}$) ($p < 0.001$). Spider populations differed significantly at both observations ($p < 0.05$). At 3 DAT, Acetamiprid and the control supported higher spider abundance, Diafenthiuron and Imidacloprid showed moderate reductions, while Thiamethoxam and Acephate caused complete suppression. By 7 DAT, spider numbers partially recovered, with the highest populations in Acetamiprid and control plots and the lowest under Acephate. Ladybird beetle populations were unaffected at 3 DAT but differed at 7 DAT ($p < 0.01$), with Acetamiprid sustaining the highest abundance, Imidacloprid and Diafenthiuron intermediate levels, and Thiamethoxam and Acephate remaining most suppressive.

Table 4. Effect of selected insecticides on jassid population (per leaf) and associated natural enemies (per plant) at 3 and 7 days after treatment (DAT) of fourth spray.

Treatments	Jassid/leaf		Natural enemies/plant			
			Spider		Ladybird beetles	
	3DAT	7DAT	3DAT	7DAT	3DAT	7DAT
Imidacloprid	1.43c	1.74d	0.07bc	0.13b	0.07ab	0.20ab
Thiamethoxam	1.95b	2.61b	0.00a	0.13b	0.00b	0.00c
Diafenthiuron	0.26f	1.01f	0.07a	0.20ab	0.07ab	0.19ab
Acetamiprid	0.74e	1.46e	0.20a	0.33a	0.20ab	0.27a
Acephate	0.92d	2.21c	0.00a	0.07b	0.00b	0.07bc
Control	3.10a	3.70a	0.27a	0.33a	0.27a	0.20ab
Sig. Level	***	***	*	*	NS	**
SEM (±)	0.04	0.08	0.08	0.10	0.11	0.07
CV %	2.89	3.66	85.86	48.61	58.71	45.18
LSD (0.05)	0.07	0.14	0.25	0.29	0.19	0.12

Means within a column followed by the same letter(s) do not differ significantly according to the LSD test at $p \leq 0.05$. *** = Significant at 0.1% level of probability; ** = Significant at 1% level of probability; * = Significant at 5% level of probability; NS = Non-significance. SEM = Standard error of the mean.

Effect of insecticidal treatments on jassid and associated natural enemies after the application of fifth spray: After the fifth spray, all insecticidal treatments significantly suppressed jassid populations at 3 DAT compared with the untreated control (3.51 leaf^{-1}; $p < 0.001$) (Table 5). Diafenthiuron was most effective (0.28 leaf^{-1}), followed by Acetamiprid (0.60 leaf^{-1}) and Acephate (0.94 leaf^{-1}), whereas Imidacloprid showed moderate efficacy and Thiamethoxam was least effective (2.33 leaf^{-1}). At 7 DAT, Diafenthiuron maintained the lowest jassid density (0.67 leaf^{-1}), with Acetamiprid and Acephate performing similarly, while Imidacloprid and Thiamethoxam recorded higher populations; the control remained highest (3.64 leaf^{-1}) ($p < 0.001$).

Table 5. Effect of selected insecticides on jassid population (per leaf) and associated natural enemies (per plant) after fifth spray.

Treatments	Jassid/leaf		Natural enemies/plant			
			Spider		Ladybird beetles	
	3DAT	7DAT	3DAT	7DAT	3DAT	7DAT
Imidacloprid	1.39c	2.02b	0.00b	0.13b	0.00b	0.20b
Thiamethoxam	2.33b	2.45b	0.00b	0.07b	0.00b	0.00c
Diafenthiuron	0.28f	0.67d	0.00b	0.20b	0.00b	0.20b
Acetamiprid	0.60e	1.29c	0.26a	0.53a	0.27a	0.40a
Acephate	0.94d	1.31c	0.00b	0.00b	0.00b	0.00c
Control	3.51a	3.64a	0.33a	0.53a	0.33a	0.53a
Sig. Level	***	***	***	**	***	***
SEM (±)	0.10	0.32	0.07	0.15	0.06	0.09
CV %	6.54	16.70	71.02	62.77	60.30	41.45
LSD (0.05)	0.18	0.57	0.21	0.46	0.11	0.16

Means within a column followed by the same letter(s) do not differ significantly according to the LSD test at $p \leq 0.05$. *** = Significant at 0.1% level of probability; ** = Significant at 1% level of probability. SEM = Standard error of the mean.

Spider abundance differed significantly at both 3 and 7 DAT. At 3 DAT, spiders were present only in the control and Acetamiprid plots, while all other treatments caused complete suppression. By 7 DAT, spider populations partially recovered, with Acetamiprid and the control supporting the highest densities, Diafenthiuron showing moderate abundance, Imidacloprid and Thiamethoxam lower levels, and Acephate remaining fully suppressive. Ladybird beetle populations were also significantly affected at both observations ($p < 0.001$). At 3 DAT, beetles were recorded only in the control and Acetamiprid plots. At 7 DAT, Acetamiprid sustained the highest beetle population among treatments, followed by Imidacloprid and Diafenthiuron, whereas Thiamethoxam and Acephate continued to cause complete suppression.

Overall mean number of jassid per leaf after application of five consecutive sprays: Across five consecutive sprays, all insecticidal treatments significantly reduced mean jassid population per leaf compared with the untreated control, which consistently recorded the highest infestation (Fig. 1). The lowest population was recorded in Diafenthiuron-treated plots (0.53 leaf^{-1}), followed by Acetamiprid

(0.86 leaf^{-1}) and Acephate (1.10 leaf^{-1}). Imidacloprid-treated plots showed a mean population of 1.48 leaf^{-1}, whereas Thiamethoxam recorded 2.20 leaf^{-1}. The highest jassid population was observed in the untreated control (3.47 leaf^{-1}).

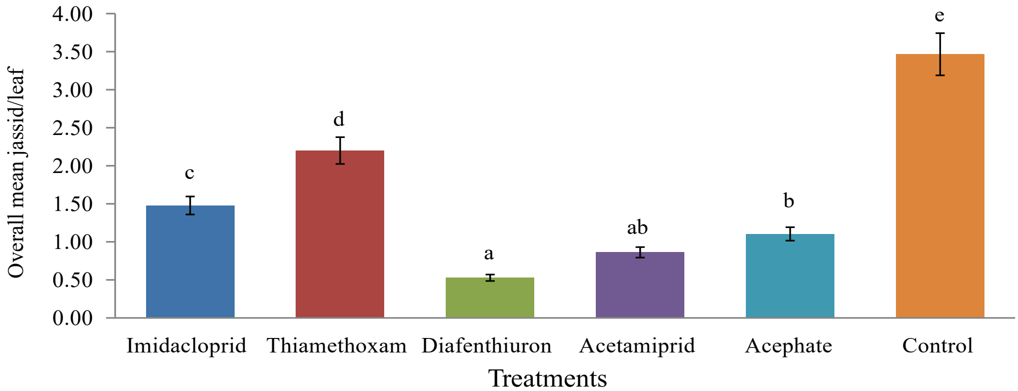

Fig. 1. Overall mean (± SE) jassid (*Amrasca biguttula biguttula*) population per leaf across five consecutive sprays under different insecticide treatments.

Overall mean percent reduction of jassid population over the untreated control: Mean percent reduction of jassid population over the untreated control differed significantly among insecticides (Fig. 2). Diafenthiuron recorded the highest suppression (84.77%), followed by Acetamiprid (75.13%) and Acephate (68.15%). Imidacloprid showed moderate efficacy (57.36%), while Thiamethoxam was the least effective (36.53%).

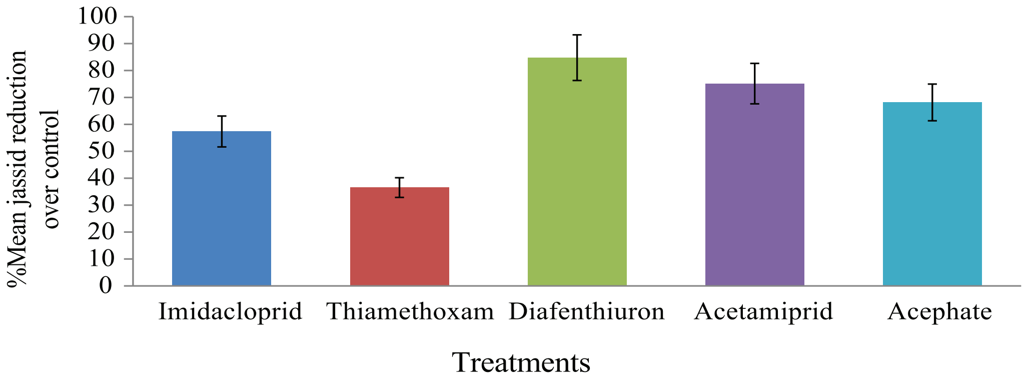

Fig. 2. Mean percent reduction of jassid (*Amrasca biguttula biguttula*) population over untreated control following insecticide applications.

Overall mean number of natural enemies/plant after application of five consecutive sprays: Mean predator abundance differed significantly among treatments (Fig. 3). Spiders and ladybird beetles were most abundant in the untreated control (0.51 and 0.39 plant^{-1}, respectively). Among insecticides, Acetamiprid and Diafenthiuron conserved relatively higher predator populations (spiders: 0.21-0.33; ladybird beetles: 0.18-0.32 plant^{-1}), whereas Thiamethoxam and Acephate were most suppressive; imidacloprid showed intermediate effects. Overall, Acetamiprid and Diafenthiuron were comparatively safer to natural enemies, indicating better compatibility with IPM.

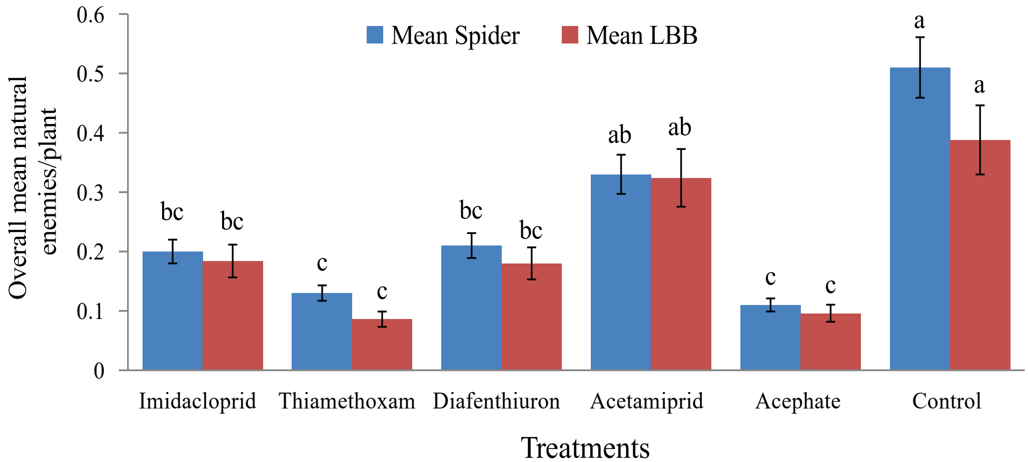

Fig. 3. Effect of different insecticidal treatments on the mean abundance of natural enemies (spiders and ladybird beetles per plant) at 3 and 7 days after treatment.

Seed cotton yield and economics of cotton: Seed cotton yield differed significantly among treatments, with Diafenthiuron producing the highest yield (2713.99 kg/ha), followed by Acetamiprid (1868.31 kg/ha) and Acephate (1802.47 kg/ha) (Table 6). Imidacloprid achieved moderate yield (1668.73 kg/ha), whereas Thiamethoxam and the untreated control had the lowest yields (985.59 and 412.76 kg/ha, respectively). Correspondingly, net returns were highest for Diafenthiuron (124979 Tk/ha) and favorable for Acetamiprid (46584 Tk/ha) and Acephate (52346 Tk/ha), while Thiamethoxam and control plots incurred negative net returns. The benefit-cost ratio (BCR) was greatest for Diafenthiuron (1.85), indicating superior economic efficiency, followed by Acephate (1.41) and Acetamiprid (1.33), and Imidacloprid

(1.09), respectively. The lowest benefit-cost ratio (0.69) was recorded in the untreated control plots followed by Thiamethoxam (0.81) treated plots. These results highlight Diafenthiuron as the most profitable treatment, combining high yield with strong economic returns.

Table 6. Effect of different insecticidal treatments on seed cotton yield, production cost, gross returns, net returns, and benefit-cost ratio (BCR)

Treatments	Seed Cotton Yield (Kg/ha)	Production Cost (Tk/ha)	Gross Returns (Tk/ha)*	Net Returns (Tk/ha)	BCR
Imidacloprid	1668.73c	152593	166873	14280	1.09
Thiamethoxam	985.59d	121728	98559	-23169	0.81
Diafenthiuron	2713.99a	146420	271399	124979	1.85
Acetamiprid	1868.31b	140247	186831	46584	1.33
Acephate	1802.47b	127901	180247	52346	1.41
Control	412.76e	60000	41276	-18724	0.69
Sig. Level	***	-	-	-	-
SEM (±)	52.93	-	-	-	-
CV %	3.36	-	-	-	-
LSD (0.05)	95.11	-	-	-	-

Means within a column followed by the same letter(s) do not differ significantly according to the LSD test at $p \leq 0.05$. *** = Significant at 0.1% level of probability; SEM = Standard error of the mean. *Seed Cotton Rate-100 Tk/Kg.

DISCUSSION

Across all sprays and observation periods, Diafenthiuron consistently maintained the lowest jassid population at both 3 and 7 DAT, indicating rapid knockdown and prolonged residual activity. Acetamiprid and Acephate provided moderate yet consistent suppression across sprays. Imidacloprid showed variable performance, with moderate reduction at 3 DAT but comparatively higher populations at 7 DAT, suggesting shorter persistence. Thiamethoxam consistently recorded the highest jassid populations among treated plots and was therefore the least effective, indicating limited residual effectiveness under the prevailing field conditions. These results are consistent with findings reported by other researchers. Diafenthiuron has been reported as an effective control agent against *A. biguttula* (Babu and Santharam 2000; Aslam *et al*. 2004). Razaq *et al.* (2005) reported that Diafenthiuron and Acetamiprid were the most effective in suppressing jassid populations below the economic threshold level (ETL), with Acetamiprid-treated plots recording the lowest population (0.43 leaf^{-1}). Similarly, Sahito *et al*. (2017) observed that both Diafenthiuron and Acetamiprid caused higher mortality and effectively reduced jassid densities to 1-1.5 leaf^{-1}. Supporting these findings, Dutta *et al*. (2017) and Maqboo *et al*. (2003) identified Diafenthiuron as the most efficient chemical against cotton jassid. Bontha and Mallapur (2017) also recorded the lowest mean leafhopper population (1.26/leaf) in plots treated with a combination of Diafenthiuron 50 WP + Carbendazim 50 WP, followed by Diafenthiuron alone. Kumar *et al.* (1999) reported the efficacy of Acetamiprid 20% SP against cotton leafhopper up to 10 days after treatment, which was further confirmed by Kolhe *et al*. (2009).

Diafenthiuron showed the highest efficacy against jassid, providing maximum population reduction over untreated control of both the cases (84.77%), indicating superior field performance. Acetamiprid and Acephate offered moderate suppression, whereas Imidacloprid was less effective. Thiamethoxam performed poorly, with minimal reduction over the control and a negative response compared with farmers' practice, suggesting inadequate control under field conditions. Halappa and Patil (2014) conducted an experiment against cotton leafhopper, *Amarasca biguttula biguttula* (Ishida), and Diafenthiuron 50 WP was found most effective against leafhopper with 76.23% reduction over the untreated control. Supporting these findings, Razaq *et al*. (2004), and Parvez *et al*. (2011) also observed that both cotton and okra crops experienced notable decreases in jassid populations when compared to untreated control. Additionally, studies by Babu and Santharam (2000), Aslam *et al*. (2004), and Badgujar *et al*. (2014) reported that plots treated with Diafenthiuron 50 SC achieved the highest reduction in infestation over the control, recorded 86.39%, against cotton jassids in okra.

Although all tested insecticides reduced natural enemy populations, Acetamiprid was comparatively less toxic and relatively safer for both spiders and ladybird beetles. Diafenthiuron exhibited moderate suppression of spiders, whereas Imidacloprid, Acephate, and Thiamethoxam resulted in marked reductions or complete suppression at early observation periods. The higher sensitivity of spiders to these insecticides may be related to their broad-spectrum activity and contact toxicity. Ladybird beetles were found to be highly sensitive to most insecticidal treatments across sprays. Acetamiprid consistently recorded higher ladybird beetle populations compared to other insecticides, indicating comparatively safer effects. Diafenthiuron and Imidacloprid showed moderate adverse effects, while Acephate and Thiamethoxam resulted in severe suppression or complete elimination of ladybird beetles at both observation periods. The pronounced reduction of ladybird beetle populations under Acephate and Thiamethoxam treatments may be attributed to their broad-spectrum insecticidal activity and high contact toxicity. The results of the present study are consistent with those of Patil *et al*. (2000), who reported no adverse effects of Acetamiprid on predator populations. Similarly, Acharya *et al.* (2002) observed that Acetamiprid (20 g a.i./ha) was relatively safer for predatory ladybird beetles. In line with this, Bharpoda *et al*. (2014) reported higher spider populations in plots treated with Diafenthiuron 50 WP @ 0.05% and Acetamiprid 20 SP @ 0.01%, suggesting comparatively lower toxicity. Halappa and Patil (2014) further confirmed that Diafenthiuron 50 WP, Acetamiprid 20 SP were relatively safe to natural enemies, including coccinellids, chrysopids, micromus, and spiders. Conversely, Rao (1986) reported that acephate at 0.5 kg a.i./ha exerted a harmful effect on the predator *M. sexmaculatus*.

The significant differences in seed cotton yield among insecticidal treatments closely reflected their relative effectiveness in jassid suppression. Diafenthiuron produced the highest yield (2713.99 kg/ha) and economic return (Tk. 124,979/ha; BCR 1.85), indicating superior biological efficacy and profitability. Acetamiprid, Acephate, and Imidacloprid resulted in moderate yield gains and returns, consistent with their intermediate control levels. Babu and Santharam (2000) and Badgujar *et al*. (2014) also reported that the highest cotton yield (1.25 t/ha) was obtained from plots treated with Diafenthiuron 50 SC. Similarly, Yesmin (2023) found that Diafenthiuron outperformed other insecticides, achieving the highest yield (2.15 t/ha), the best benefit-cost ratio (1.67), and significant reductions in jassid population (89.45%), resulting in a 69.76% increase in cotton yield. Khan (2011) also observed that Acetamiprid 20 SP was more effective than other tested insecticides in managing sucking pests and enhancing seed cotton yield.

CONCLUSION

In conclusion, Diafenthiuron proved highly effective in suppressing jassid populations but exhibited moderate adverse effects on natural enemies, indicating the need for cautious application. Acetamiprid emerged as the most balanced option, providing satisfactory jassid control while conserving higher populations of spiders and ladybird beetles. The concurrence of effective pest suppression with better preservation of beneficial arthropods highlights the suitability of Acetamiprid and Diafenthiuron, when judiciously applied, in sustainable IPM programs.

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