Acta Entomology and Zoology

E-ISSN: 2708-0021
P-ISSN: 2708-0013
https://www.actajournal.com
AEZ 2023; 4(2): 50-55
Received: 02-11-2023
Accepted: 04-12-2023

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Eco-friendly management practices against jassid (*Amrasca biguttula biguttula*) infestation in okra at Jhapa District

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DOI: https://doi.org/10.33545/27080013.2023.v4.i2a.114

Abstract
This experiment was conducted in the okra field at Gauradaha Agriculture Campus in Jhapa District, between March to June 2023 to evaluate eco-friendly practices through different treatments against jassid (*Amrasca biguttula biguttula)* in okra. The layout was carried out to fit the experiment into Randomized Complete Block Design (RCBD) with 7 treatments and 3 replications using a variety Arka Anamika. The treatments were: Agri-spray oil 99% EC (4 ml/ltr), Cow-urine (200ml/ltr), Neem oil (2ml/ltr), Tobacco (200 ml/ltr), Eucalyptus (200 ml/ltr), Mugwort (200ml/ltr) and Control with water spray. Treatments were applied 3 times using a foliar spray method. Following 3 sprays, observations were made on each spray on the 2nd, 4th and 6th days of application. Highest Population Reduction over Control (PROC) i.e. 74.27%, 38.62% and 36.36% of jassids was found in first, second and third spray of agri-spray oil followed by tobacco i.e. 62.57%, 31.21%, 37.45% and neem oil i.e. 59.69%, 23.47%, 20.97% respectively and was found to be significant in each three sprays of treatments. Based on overall performance, agri-spray oil performed better by reducing the pest population and producing highest yield.Among botanicals, tobacco was found to be superior for controlling pests. Therefore, the application of eco-friendly pesticides can reduce the use of synthetic pesticides that are costly and possess a large toxicity to natural enemies and negative impact on human health and environment.

Keywords: *Abelmoschus esculentus*, botanicals, eco-friendly, jassid, okra, insecticide resistance

1. Introduction
The sole notable vegetable crop in the Malvaceae family is okra (*Abelmoschus esculentus*). Although frost can harm the crops, okra is one of the world's most heat and drought-tolerant vegetable species, also it can withstand thick clay soils and sporadic wet spells. (Singh *et al.*, 2014) [21]. In Nepal, the total production of okra is 24-32mt/ha (MoALD, 2022) [17]. It is widely cultivated in Jhapa, Morang, Saptari, Bara, Chitwan, Rautahat, Kailali and Dhanusa (Jha *et al.*, 2018) [11]. Since all pests that attack okra are either polyphagous or oligophagous and obtain a large number of host plants year-round, the prevalence of pests in okra is extremely high. (Subba *et al.*, 2022) [23]. *Amrasca biguttula biguttula* affects the production of okra in a measurable amount. Jassid through sucking, draws out the sap from the leaves underside, causing the margins to curl upward, eventually decreasing production. (Bhandari *et al.*, 2022) [5]. It has been noted that in course of suckling plants sap, both adults and nymphs inflict harm. (Bhutto *et al.*, 2017) [6]. Jassid infestation varied in different growth stages of okra plants and hampered okra production severely (Alam *et al.*, 2013) [16]. The defining trait of a jassid attack of sucking causes the color to turn gray, or it might cause the crop of okra to fall (crinkle) by injecting poisonous saliva into the plant tissues. (Lohar, 2001) [15]. Plants infected with jassids are easily identified by the emergence of globular, transparent, mucilaginous particles. (Yendembm *et al.*, 2018) [27]. Various studies have been conducted to control it. The majority of research in Nepal is focused on chemical management and a few biocontrol agents. A Limited research and findings in this area mask the magical properties of the plant extracts that enable the botanicals to curb the rising populations of insects (Ahmad, 2020) [1]. Chemical control of the pest has not now been desirable due to its role in destabilization of ecosystem, breaking the delicate balance between insect pests and their natural enemies and development of insecticide resistance in insect pests (Ullah *et al.*, 2012) [22].

Farmers use conventional pesticides for the management of pest in their field and follow traditional plant protection measures. Gandhi *et al.* (2006) [9] illustrated that insecticidal seed treatment is a viable alternative to spray and granular applications. Admire 200 SL had significant effect in controlling jassid (Anonymous 2005) [2]. Chemical treatment (Chloropyriphos 50% EC and cypermethrin 5% EC) was found to be effective in controlling the Jassid population (Bhandari *et al.*, 2022) [5]. Since 1945, plant pathogen-caused crop damages have been minimized through the use of synthetic insecticides. (Boulogne *et al.*, 2012) [7]. Nevertheless, using pesticides can have negative effects on the environment, including soil erosion, eutrophication of rivers, groundwater pollution, overuse of water, and the emergence of illnesses and weeds that are resistant to chemical management. (Lichtfouse *et al.*, 2009) [14]. Adoptions of IPM strategies ensure safety of environment (Shabozoi *et al.*, 2011) [19]. Balikai *et al.* (2004) [4] found the plant extracts were safer to the predators and other natural enemies as compare to the chemicals. Smith (1999) [28] coined the phrase "Biological Control" to refer to the process of bringing in natural enemies that are exotic insects in order to permanently suppress insect pests. (Waage *et al.*, 1988) [25]. The natural enemies associated with jassid were spider, lady bird beetle, ant and crysopa sp (Wagen *et al.*, 2015) [29]. Neem oil is a better pesticide due to its repellent, insecticidal, nematicidal, bactericidal, and fungicidal activities (Pascoli *et al.*, 2019) [18]. As per (Sultana *et al.*, 2016) [24] reports, the outcomes demonstrated the efficacy of botanical extracts (jute seed, leaves of urmoi and custard apple) in controlling jassid infestation. Therefore, we focus to suggest best botanical pesticide to increase yield of okra without negative impact in environment through this research paper.

2. Materials and Methodology

2.1 Research Location

The experiment was carried out in the research field of Institute of Agriculture and Animal Science (IAAS), Gauradaha Agriculture Campus located at Gauradaha Municipality-2 of Jhapa district of eastern Nepal. The research site is 79 m above sea level and is situated at 26° 33' 42" N latitude and 87° 43' 02" E longitude.

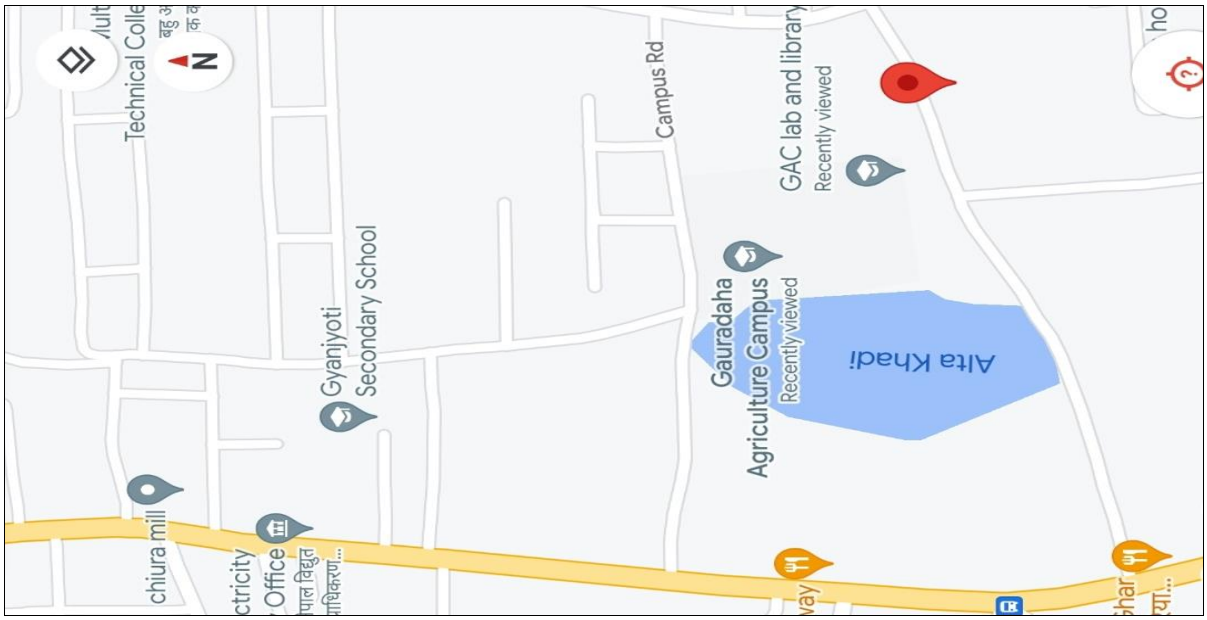

Fig 1: Google Map of Gauradaha Municipality

2.2 Experiment and Treatment Details

The experiment was conducted on Randomized Complete Block Design (RCBD) with 3 replication and 7 treatments. The total area of experimental plot was 240 m^2 (20 m*12 m). The spacing between replication was 1m and between treatments was 0.75 m. Each replication contained 7 plots with the area of 4.5 m^2 (2.5 m*1.8 m) per plot. A total 30 plants were maintained at spacing 50 cm (Row-Row) × 30 cm (Plant-Plant). Out of 30 plants 5 plants were randomly selected as sample plants and tagged with the yellow woolen rope.

Leafy dry tobacco was collected from Gauradaha bazaar. Eucalyptus and Mugwort were collected from the college area and spread in open room for air drying at room temperature for 1 week to lower down the moisture content. Also, Fresh cow urine was collected from near cow shed. Neem oil and Agri-spray oil was taken from the lab. Dried leaves and plant material of the tobacco, eucalyptus and mugwort was crushed to powdered form using electric mixture. The powder thus obtained was soaked in water overnight to form concentration 10% (w/v) each. And then insecticidal spray is prepared with 1:4 ratio for cow urine, tobacco, eucalyptus and mugwort with water. 2 ml of neem oil and 4 ml of agri-spray oil was taken in 1liter of water for spraying. Spraying was done at 7 days intervals. Hand sprayer was used for spraying. There were seven treatments for the pest management which is listed below.

Table 1: List of treatments with their name, notation, and doses

S. N.	Notation	Treatments	Dose (per liter of water)
1.	T_1	Control	N/A
2.	T_2	Agri-spray oil	4ml (99% EC)
3.	T_3	Cow-urine	200 ml
4.	T_4	Neem oil	2 ml
5.	T_5	Tobacco	200 ml (10% w/v)
6.	T_6	Eucalyptus	200 ml (10% w/v)
7.	T_7	Mugwort	200 ml (10% w/v)

Table 2: Randomization of treatments in replication

R3	R2	R1
T_1	T_2	T_3
T_2	T_3	T_4
T_3	T_4	T_5
T_4	T_5	T_6
T_5	T_6	T_7
T_6	T_7	T_1
T_7	T_1	T_2

2.3 Data Collection and Observation

The parameters for the data collection were insect population, yield, length and diameter of the fruit. The first sign of jassid were seen earlier after 23 DAS. The data of number of insect population were collected from 20 days after the sign of jassid. Three foliar spray of insecticides were done by hand sprayer at the interval of 7 days from 46 DAS. Similarly, matured fruits are harvested manually in different times and data were collected of yield, length and diameter of fruits. First harvest on April 25 after 46 DAS and subsequent harvest was done after certain interval when the fruits are matured. Primarily data was recorded from field and secondarily through various sources such as research proceeding, journals, annual reports, books, web pages related to the study. The insect population were calculated 1 day before spraying insecticide and after spraying insecticide in 2, 4 and 6 days from randomly selected 5 plants from each plot. Yield, length, and diameter of okra from each plot were recorded. Yield were converted later in metric ton.

2.4 Statistical Data Analysis

The collected data were tabulated and processed on Microsoft Excel (2016). The one-way ANOVA was done to check the significance level and the means were separated by using L.S.D. at 5%. Data were analyzed using Gen Stat software (15th Edition).

Calculation

PROC (%) =1- (Ta*Cb/Tb*Ca)*100

Where,
PROC=Population Reduction Over Control.
Ta=Population of insects after treatment application.
Tb=Population of insects before treatment application.
Ca=Population of insect in control after treatment application.
Cb=Population of insect in control before treatment application.

Increase in Yield over control (%) = (T-C)/C*100

Where,
T=Yield from treated plot
C=Yield from the untreated plot (Control Plot)

Log transformation: It is done to minimize error.

3. Results

Table 3: Effect of different treatments against okra jassid (*Amrasca biguttula biguttula*) after 1st biopesticide sprays at Gauradaha, Jhapa

Treatment	Insect population (No. Per Plant)	2 DAS	PROC	4 DAS	PROC	6 DAS	PROC
Control (Water)	63.93^{a}	75.81^{c}		86.59^{c}		108.59^{d}	
Agri-spray oil	69.73^{a}	21.27^{a}	74.27	31.99^{a}	66.12	40.47^{a}	65.83
Neem oil	75.40^{a}	39.60^{ab}	55.71	49.12^{ab}	51.90	59.69^{b}	53.39
Cow urine	69.33^{a}	47.82^{b}	41.83	58.62^{b}	37.57	67.73^{bc}	42.48
Mugwort	71.13^{a}	52.20^{b}	38.11	64.18^{b}	33.38	76.95^{c}	36.31
Eucalyptus	56.47^{a}	42.90^{ab}	35.93	56.53^{b}	26.09	66.29^{bc}	30.88
Tobacco	68.35^{a}	29.16^{ab}	64.02	38.84^{a}	58.04	43.45^{a}	62.57
F-Test	Ns	**		***		***	
$LSD_{(0.05)}$	36.26	23.13		16.37		13.99	
CV%	30.6	29.9		17		12.1	
SEM±	11.96	7.62		5.40		4.61	

Where, CV= Coefficient of Variation, DAS= Days After Spray, PROC= Population Reduction Over Control, ***=significant at 0.1% level of significance, **=significant at 1% level of significance, *= significant at 5% level of significance, NS= Non-Significant, LSD= Least Significant Difference, SEM=Standard Error Mean. The figure in parentheses is log10 transformation.

Different bio-pesticides were tested against okra jassids. The above table showed the standard mean values of jassid population in okra before and after treatment application in comparison with control. The data showed that mean standard population of jassid decline sharply after 2 days of application in treatment of agri-spray oil (21.27) followed by tobacco (29.16), neem oil (39.60). Similarly, at four days after spray, agri-spray oil has lowest insect population which is at par with other treatments tobacco (38.84), neem oil (49.12) and Eucalyptus (56.53). Similarly at 6 days after spray, mean standard population of jassids increases but remain below ETL level, lowest insect count was recorded from agri-spray oil (40.46) which is at par with tobacco (43.45), neem oil (59.69) and Eucalyptus (66.29). The Population Reduction over Control (PROC) at 2, 4, 6 day after spray was found highest on agri-spray oil (74.27, 66.12 and 65.83) respectively. Highest number of insect population was recorded from the control plot in all sprays.

Table 4: Effect of different treatments against okra jassid (*Amrasca biguttula biguttula*) after 2nd bio-pesticide sprays at Gauradaha, Jhapa

Treatment	Insect Population (No. per plant)	2DAS	PROC	4DAS	PROC	6DAS	PROC
Control (Water)	108.59^{d}	106.50^{d}		112.73^{d}		115.32^{d}	
Agri-spray oil	40.47^{a}	24.36^{a}	38.62	34.98^{a}	16.73	30.66^{a}	28.66
Neem oil	59.69^{b}	44.80^{b}	23.47	52.44^{b}	15.37	53.57^{b}	15.49
Cow urine	67.73^{bc}	53.99^{bc}	18.72	61.75^{bc}	12.17	54.65^{b}	24.02
Mugwort	76.95^{c}	63.08^{c}	16.41	67.79^{c}	15.13	68.42^{c}	16.27

Eucalyptus	66.29^{bc}	52.91^{bc}	18.61	61.30^{bc}	10.92	63.73^{bc}	9.47
Tobacco	43.45^{a}	29.31^{a}	31.21	34.89^{a}	22.64	32.30^{a}	30.00
F-Test	***	***		***		***	
$LSD_{(0.05)}$	13.99	13.16		12.85		13.30	
CV%	12.1	14.00		12.1		11.6	
SEM±	4.61	4.34		4.24		4.38	

Where, CV= Coefficient of variation, DAS= Days after spray, PROC= Population reduction over control, ***=significant at 0.1% level of significance, **=significant at 1% level of significance, *= significant at 5% level of significance, Ns= non-significant, LSD= least significant difference, SEM=standard error mean. The figure in parentheses is log10 transformation.

The above table showed the standard mean values of jassid population in okra before and after treatment application in comparison with control. The data showed that mean standard population of jassid decline after 48 hours of application in treatments of agri-spray oil (24.36) followed by tobacco (29.31), neem oil (44.80). Similarly at 4 days after spray tobacco has lowest insect population which is at par with other treatments agri-spray oil (34.98), neem oil (52.44) and eucalyptus (61.30). Similarly at 6 days after spray mean standard population of jassids slightly decreases in agri-spray oil, tobacco and cow urine but slightly increases in neem oil, mugwort and eucalyptus. Lowest insect count was recorded from agri-spray oil (30.66) which is at par with tobacco (32.30), neem oil (53.57) and cow urine (54.65). The Population Reduction over Control (PROC) at 2nd day of spray was found highest on agri-spray oil (38.62). Similarly at 4 days and 6 days after spray highest PROC was found in tobacco (22.62) and (30.00) respectively. Highest number of insect population was recorded from control plot in all sprays.

Table 5: Effect of different treatments against okra jassid (*Amrasca biguttula biguttula*) after 3rd bio-pesticide sprays at Gauradaha, Jhapa

Treatment	Insect Population (No. per plant)	2DAS	PROC	4DAS	PROC	6DAS	PROC
Control (Water)	115.32^{d}	114.28^{d}		120.77^{d}		116.67^{d}	
Agri-spray oil	30.66^{a}	20.18^{a}	33.58	21.34^{a}	33.40	19.74^{a}	36.36
Neem oil	53.57^{b}	45.39^{b}	14.49	46.86^{b}	16.47	42.83^{b}	20.97
Cow urine	54.65^{bc}	48.18^{bc}	11.03	51.10^{bc}	10.71	50.04^{b}	9.49
Mugwort	68.42^{c}	61.79^{c}	8.86	63.10^{c}	11.93	66.77^{c}	3.54
Eucalyptus	63.73^{bc}	49.56^{bc}	21.52	52.38^{bc}	21.51	49.25^{bc}	23.61
Tobacco	32.30^{a}	23.19^{a}	27.55	23.06^{a}	31.82	20.44^{a}	37.45
F-Test	***	***		***		***	
$LSD_{(0.05)}$	13.30	10.33		10.36		10.47	
CV%	11.6	11.5		10.4		11.8	
SEM±	4.38	3.41		3.42		3.45	

Where, CV= Coefficient of Variation, DAS= Days After Spray, PROC= Population Reduction Over Control, ***=Significant at 0.1% level of significance, **=significant at 1% level of significance, *= significant at 5% level of significance, NS= Non-Significant, LSD= Least Significant Difference, SEM=Standard Error Mean. The figure in parentheses is log10 transformation.

The above table showed the standard mean values of jassid population in okra before and after treatment application in comparison with control. The data showed that mean standard population of jassids decline after 48 hours of application in treatments of agri-spray oil (20.18) followed by tobacco (23.19), neem oil (45.39). Similarly, at 4 days after spray, agri-spray oil (21.34) has lowest insect population which is at par with tobacco (23.06), neem oil (46.86) and cow urine (51.10). Similarly at 6 days after spray mean standard population of jassids decreases in agri-spray oil, tobacco, neem oil, mugwort and cow urine but slightly increase in mugwort. Lowest insect count was recorded from agri-spray oil (19.74) which is at par with tobacco (20.44), neem oil (42.83) and eucalyptus (49.25). The Population Reduction over Control (PROC) at 2nd and 4th days was found highest on, agri-spray oil (33.58) and (33.40) respectively. Similarly at 6 days after spray PROC was found highest in tobacco (37.45). Highest number of jassids population was recorded from control plot in all sprays.

4. Discussion

Of all the sprays, biochemical pesticides agri-spray oil was found to be more effective against others treatments in controlling jassid population. Among botanical extract, tobacco was found to be most effective. According to the study from (Hu *et al.*, 2019) [10], suggests that agrochemical sprays have the ability to dissolve leaf waxes and that, when applied to plant surfaces, they may cause the release of pesticides from surfactant micelles. Utilizing an emulsion of oil and water (dosage recommendations range from 2 to 4%), Eassto Agricultural Spray Oil is sprayed on several insect species. (Si, 2006).Highest Population Reduction Over Control (PROC) i.e. 74.27%, 38.62% and 33.58% of jassid was found in first, second and third spray of agri-spray oil and was found to be significant in each three sprays of treatments followed by tobacco i.e. 64.02%, 31.21% and 27.55% respectively. The nicotinoids acts on the central nervous system of insect leading to the irreversible blockage of postsynaptic nicotinergic acetylcholine receptor (Khater, 2012) [12]. In our research study Eucalyptus and Neem oil have been found to be promising botanical extract after tobacco. Bagade (2010) [3] reported that bio-pesticides extracted from the neem were effective for reducing the jassids feeding on okra. Neem oil is a better pesticide due to its repellent, insecticidal, nematicidal, bactericidal, and fungicidal activities (Pascoli *et al.*, 2019) [18]. Consequently, neem and tobacco use in commercial farming is attracting regulatory restrictions leading to 2 percent decline per year in synthetic pesticides use in favor of 10 percent increase of bio-pesticides as alternative agrochemicals (Damalas and Koutroubas, 2018) [30]. In addition to the following treatments cow urine and mugwort showed less response in comparision to agrospary

oil, tobacco and neem oil. Due to high content of urea in cow urine which is toxic to most of the organisms, the pests and insects etc. will not attack the leaves and buds of the crop plants. Due to pungent and bad smell of the extract most of the pests and insects which are attracted due to nectar and fragrance get repelled, preventing the plant (Kumawat *et al.*, 2014) [13]. Moreover, the untreated (control) ranked least among different treatments. All the plant extract treatments were significantly better than control treatments.

5. Summary and Conclusion

This research was conducted to know the effectiveness of different bio-pesticides against jassid in campus field at Gauradaha Municipality-2, Jhapa. *Amrasca biguttula biguttula* is considered the most destructive sucking pest of okra crop. The crop is susceptible to various insect pests of which jassid are most predominant. The experiment was carried out at Randomized Complete Block Design compromising 7 treatment and 3 replications. The bio-pesticide was sprayed 3 times at 7 days interval. Our study focused on the potential of seven treatments on the management of *Amrasca biguttula biguttula* under open field conditions. Agri-spray oil is proved to be the most efficacious pesticides with the minimum insect count, highest yield and BC ratio followed by botanical extract tobacco and neem oil respectively. The research findings revealed useful information and perspectives for the application of bio-pesticides. Giving special emphasis, tobacco and neem oil was deployed being environmentally safe strategies. Bio-pesticide are biodegradable and degrade into harmless molecules in the presence of sunlight within hours or days so, safer for both the user and the environment.

Based on moderate to high efficacy levels of botanical extract, as well as low toxicity to natural enemies and minimum impact on human health, we conclude that bio-pesticides can be incorporated in future IPM programme and organic farming in vegetable cultivation. Additionally, the incorporation of bio-pesticide with other IPM tactics may decrease the usage of pesticides and, as a result, residues on fruits, thereby enhancing the quality and safety of food. Our study may help to decide on the most suitable bio-pesticide for the management of jassid if many other similar kinds of research is conducted in several fields of different locations in different time.

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