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Evaluation of insecticides against jassid (*Amrasca biguttula biguttula* Ishida) and fruit borer (*Earias vittella* Fabricius) on okra during *pre-kharif* season

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Abstract
The investigation on the evaluation of insecticides against jassid and fruit borer was conducted in the research farm of Uttar Banga Krishi Viswavidyalaya, Pundibrar, Cooch Behar, West Bengal, India during *pre-khairf* season of 2015-2016. Out of six insecticides evaluated, except Neem all other insecticides performed well at higher levels in suppression of pest infestation and percent reduction of damage. However, Imidacloprid (25g a.i/ha), Acephate (500 g a.i/ha), and Agniastra an organic insecticide (25 ml/L) proved better with respect to pest suppression as well as the yield of marketable okra. The highest yield was recorded from the Imidacloprid (25g a.i/ha) sprayed plots followed by Agniastra (25ml/L) i.e. 12.72 t/ha and 12.21 t/ha respectively. Although, Imidacloprid (25g a.i/ha), was found superior over all insecticides in all aspects, but considering, the health and production of chemical-free export produce, Agniastra (25ml/L) may be preferred by sacrificing a little yield.

Keywords: Evaluation, insecticides, jassid, fruit borer, okra, *pre-kharif*

Introduction
Okra, *Abelmoschus esculentus* L. (Moench) belongs to family Malvacea, commonly known as bhindi is one of the important vegetable crops grown in tropical and sub-tropical parts of the world (Pandita *et al.*, 2010) [1]. Okra has occupied a prominent position among the export-oriented vegetables in India because of its high nutritive value, palatability, and long self-life. Okra has tremendous export potential accounting for 60% of fresh vegetable export (Sharma and Arora, 1993) [2] and earns 30% exchange earnings from the export of vegetables next to the onion.

Like other crops, okra also suffers from several abiotic and biotic stresses of which damage due to insects and other pests is considered a major constraint. In all the stages of the crop, from seedling to harvesting, the okra is suffered from one or more pests. Pest incidence in okra is very high because all the pests attacking okra are polyphagous or oligophagous, getting a good number of host plants round the year. More than 72 number of insect-pest species attack the okra crop of which, the sucking pests like jassid (*Amrasca biguttula biguttula* Ishida), aphid (*Aphis gossypii* Glover), whitefly (*Bemesia tabaci* Genn.) and mite (*Tetranychus cinnabarinus* Boisd.), fruit borers like *Earias vittella* (Fab.), *Earias insulana* (Bois) and *Helicoverpa armigera* (Hub) are known to cause economic damage to the crop (Rao and Rajendran 2003; Chandra and Subhag, 2012; Birah *et al.*, 2012; Karthik *et al.*, 2015, Kumar and Sing, 2021, Mohammad *et al.*, 2018, Das *et al.*, 2011, Lohar, 2001) [3, 4, 5, 6, 7, 8, 9, 10]. These insect-pests infest the crop throughout vegetative as well as reproductive stages causing ample reduction in yield (Satpathy and Rai, 1999) [11].

The fruit borers alone were reported to cause damage to the extent of 3.5 to 90 percent to okra in different parts of the country (Srinivasan and Narayanaswamy, 1960; Rawat and Sahu, 1973 [13]; Krishnaiah *et al*., 1976; Srinivasan and Krishnakumar, 1983; Chaudhary and Dadheech, 1989; Mandal *et al*., 2006) [12, 17]. Krishnaiah (1980) [18] reported about 40 to 56 Percent loss in okra due to the leafhopper. There was a reduction of 49.8 and 45.1 percent in height and number of leaves, respectively due to the attack of leafhopper (Rawat and Sahu, 1973) [13]. It has already been mentioned that the okra crop whenever or wherever is grown, is highly attacked by insects and other pests which substantially decline the yield of fruit.

Due to the heavy pest-load tremendous volume of insecticides are used to manage the insect-pests of okra. It is a matter of deep concern that fruits are plucked and marketed even after a day of spraying. Since the tender fruits of okra are taken after a little cooking, there is every possibility of retaining toxic residue in the foodstuff (Amjad *et al*., 2020) [19]. Moreover, during export, there is also the risk of rejection of the whole consignment due to the presence of pesticide residue. It is mention-worthy to note here that despite leading state in okra production sharing 18.4% of the total national production of okra, West Bengal has no share in export. Export is mainly restricted in some areas of Maharashtra. This is only due to lack of endeavor to produce export quality okra; mostly related to the production of chemical residue-free produce mainly concerned with the application of synthetic pesticides. This situation calls for the formulation of an ecologically safe, economically viable, and self-sustainable pest management strategy for okra under an organic production system for export-quality produce. Keeping in view present investigations were, therefore, carried out to evaluate the efficacy of microbial/organic/plant-based non-synthetic pesticides for safer health and environment.

Materials and Methods

The field experiments were conducted in 2015 and 2016 at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India during the *pre-kharif* (15th February-14th May) seasons in 2 years. The experimental domain is situated in the terai region of West Bengal between 26° 19’86”N latitude and 89°23’53”E longitude at an elevation of 43.0 m above mean sea level and the land topography is medium upland having good drainage and irrigation facilities. The experiment was laid out in Randomized Block Design (RBD) consisting of 6 treatments and replicated 3 times. The 6 treatments were T1=Agniastra @ 25ml/L, T2=Neem @ 2.5g *a.i.* /ha, T3=Imidacloprid @ 25g *a.i./*ha, T4=Acephate @ 500g *a.i./*ha, T5=Spinosad @ 80g *a.i./*ha, T6=Emamectin benzoate @ 25g *a.i./*ha and T7=Untreated. The variety arka anamika was grown directly in the plot size 5 X 3 maintaining spacing of 60 X 30 cm. Instead of application of NPK, jeewamrita was applied by diluting after the final tilth of land at afternoon hours and repeated at every 15 days interval. Three round of spray was done at 14 days interval to protect the crop from insect-pests infestation.

Preparation and application of indigenous microbial culture

The indigenous microbial culture, jeewamrita was prepared as the method followed by Palekar (2005) [20]. The components of indigenous microbial culture were fresh 5 kg cow-dung, 5 l cow urine, 1 kg molasses, 1 kg chickpea dust (Gram), one hand full soil (from bund), 100 l Water. Fresh cow dung was kept and hanged in mosquito net in the drum containing 100 l of water in such a way that it may dip in. After 24 h, mosquito net containing cow dung was squeeze by hands within drum as much as possible and then cow urine, molasses, chickpea dust, handful of virgin soil were added. For next 3 days, the same is stirred thrice by a wooden or bamboo stick daily. The indigenous material was prepared after 4–5 days and was ready to use.

Preparation of organic pesticides

Organic pesticide was prepared by following the methods as designated agniastra by Palekar (2005) [20]. The ingredients used for the preparation of organic pesticides were 3.5 kg neem leaves, 350 g garlic paste, 350 g green chili, 350 g tobacco powder and 10 l of cow urine. All the ingredients were mixed in a bowl and boiled for 45 m to 1 h. After boiling it was kept in room for 48 h. The mixture was strained by cloth poured in the bottle which can be kept in bottle for 3 month in cool and dry place and became ready for use.

Data collection

Insect-pest data were collated at weekly intervals from 10 randomly selected plants. Jassid data was collected from 3 leaves/plants, each from the upper, middle, and lower canopy)/plant and average were made thereafter. Whereas, bored fruit were collected at each harvest and calculated in terms of damage fruits (in no.) and percent reduction of damage due to application of insecticides.

Yield

Data of okra yield were recorded from each plot that was weighed through electrical balance and later converted into t/ha.

Data analysis

The statistical data analysis was performed by SAS software (Ver. 9.2). One way anova was performed for each of the parameters and separation of the means was done using the Least Significant Difference (LSD) test at 5% significant level.

Results

Management of major insect-pests of okra

The synthetic insecticides acephate @ 500g *a.i.*/ha and Imidacloprid @ 25g *a.i.*/ha proved their superiority over organic insecticides like Agniastra@ 25ml/Land Neem @ 2.5g *a.i.*/ha as well as biologically originated ones like Spinosad @ 80g *a.i.*/ha and Emamectin benzoate @ 25g *a.i.*/ha in reducing the population of jassid and fruit borer infesting okra in respect to population-level.

Jassid *(Amrasca biguttula biguttulla* Ishida*)*

Data of pooled mean of two years after 1st spray (Table 1) revealed that synthetic insecticides, Imidacloprid @ 25g *a.i.*/ha and Acephate @ 500g *a.i.*/ha caused the highest reduction of the jassid, of 69.16 and 68.15% reduction respectively followed by Agniastra @ 25ml/L (61.97% reduction).

After 2nd spray the best results was achieved from the synthetic insecticides namely, Acephate @ 500g *a.i.* /ha and Imidacloprid @ 25g *a.i.* /ha (72.68% and 71.39% reduction of the population respectively). This was followed by Agniastra @ 25ml/L providing 63.58% reduction of the jassid population. The lowest reduction of 30.94% was recorded from the Neem @ 2.5g *a.i.* /ha.

After 3rd spray the highest percentage of reduction was obtained from Acephate @ 500g *a.i.* /ha and Imidacloprid @ 25g *a.i.* /ha (82.74 and 81.04% respectively), followed by Emamectin benzoate @ 25g *a.i.* /ha and Agniastra @ 25ml/L (72.75 and 71.79% reduction of population). The performance of plant-based insecticide Neem @ 2.5g *a.i.* /ha was found least in all the sprayings and accounted for only 26.93-48.44% reduction of jassid population.

Fruit borer (*Earias vittella* Fabricius)

Pooled data of two years after 1st spray (Table 1) revealed that all the insecticides except Neem @ 2.5g *a.i.* /ha performed well. The best results were obtained from Imidacloprid @ 25g *a.i.*/ha in respect of percentage of bored fruit and reduction of damage (2.67% and 55.72% respectively) followed by Acephate @ 500g *a.i.*/ha (2.85 and 55.24% respectively) and Agniastra @ 25ml/L (2.97% and 53.64% respectively). These three insecticides were found superior to all other insecticides under present studies. The highest percentage of bored fruit and the lowest percentage reduction was recorded from Neem @ 2.5g *a.i.* /ha (4.39% and 20.78% respectively).

After 2nd spray the performance of Emamectin benzoate @ 25g *a.i.* /ha (55.24% reduction of damage) was found significantly superior to synthetic insecticide Imidacloprid @ 25g *a.i.*/ha (53.42% reduction) and Agniastra @ 25 ml/L (52.81% reduction). In the untreated plot, the fruit damage percentage was 19.83%.

After 3rd spray, the highest percentage of bored fruit and percent reduction of damage was obtained from Acephate @ 500g *a.i.*/ha (2.03% and 66.74% respectively) followed by Imidacloprid @ 25g a.i./ha (1.91% and 64.96% respectively). However, the difference between the two insecticides is non-significant. Better results were also recorded from Agniastra @ 25 ml/L (1.75 and 54.05% respectively) which was statistically at par with Imidacloprid @ 25g a.i./ha. However, Neem @ 2.5g *a.i.* /ha again performed poorly over all other insecticides (7.32%and 26.17% bored fruit and percentage reduction respectively).

Table 1*:* Effect of insecticides on pest infestation and their percent reduction in damage during *prekharif* season: 2015-16

Treatments	First spray (Pooled mean of two years)				Second spray (Pooled mean of two years)				Third spray (Pooled mean of two years)				Yield (t/ha) (Pooled mean of two years)
	Jassid		Fruit borer		Jassid		Fruit borer		Jassid		Fruit borer		
	No./leaf	Reduction %-age	%-age of bored fruit	Reduction %-age	No./leaf	Reduction %- age	% -age of bored fruit	Reduction %- age	No./leaf	Reduction %- age	% -age of bored fruit	Reduction %- age	
T1=Agniastra @ 25ml/L	3.46d (1.99)	61.97c (51.92)	2.97e (9.92)	53.64b (47.09)	2.99f (1.87)	63.58c (52.88)	4.88f (12.77)	52.81c (46.61)	0.87f (1.70)	71.79d (58.03)	1.75g (7.60)	64.05b (53.16)	12.21ba
T2=Neem @ 2.5g *a.i./*ha	6.48b (2.64)	29.07e (32.63)	4.39b (12.09)	20.78e (27.12)	10.55b (3.32)	30.94f (33.79)	12.54b (20.74)	19.27e (26.04)	7.39b (2.81)	36.47f (37.15)	7.32b (16.70)	26.17e (30.77)	8.62e
T3=Imidacloprid @ 25g *a.i./*ha	3.25e (1.94)	69.16a (56.27)	2.67g (9.40)	55.72a (48.29)	3.51e (2.00)	71.39b (57.66)	5.26e (13.25)	53.42b (46.96)	1.36e (1.36)	81.04b (64.45)	1.91f (7.94)	64.96b (53.70)	12.72a
T4=Acephate @ 500g *a.i./*ha	3.25e (1.94)	68.15b (55.64)	2.85f (9.72)	55.24a (48.01)	3.53e (2.01)	72.68a (58.49)	6.17d (14.38)	51.42d (45.81)	1.36e (1.36)	82.74a (65.45)	2.03e (8.20)	66.74a (54.78)	12.18b
T5=Spinosad @ 80g *a.i./*ha	4.56c (2.25)	52.29d (46.31)	3.32d (10.49)	47.03d (43.29)	6.28c (2.60)	54.19e (47.40)	6.94c (15.28)	51.10d (45.63)	3.51c (2.00)	64.11e (53.19)	2.92c (9.83)	58.09ed (49.65)	11.00d
T6=Emamectin benzoate @ 25g *a.i./*ha	4.57c (2.25)	51.45d (45.83)	3.42c (10.66)	50.99c (45.57)	6.00d (2.55)	56.53d (48.75)	6.14d (14.35)	55.24a (48.01)	2.61d (1.76)	72.75c (58.53)	2.70c (9.83)	61.24c (51.50)	11.41c
T7=Untreated	9.05a (3.09)	-	6.47a (14.74)	-	18.10a (4.31)	-	19.83a (26.44)	-	16.10a (4.07)	-	14.42a (22.32)	-	7.70f
Pr>F	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
LSD	0.022	0.4413	0.0278	0.7115	0.023	0.4157	0.2474	0.3242	0.0116	0.5373	0.0327	0.4320	0.3217

Note: *Figure in the parenthesis indicates square root transformed value in case of effect of pesticides on No./leaf of jassid and angular transformed value in the case of reduction percentage of jassid, percentage of bored fruit and reduction percentage of bored fruit; same letter in column are not significantly different at 5% level of probability*

All the insecticides except Neem @ 2.5g a.i./ha gave significantly higher yield of okra over untreated check. The highest yield was recorded from Imidacloprid @ 25g a.i./ha (12.72a) followed by Agniastra @ 25ml/L (12.21ba) and Acephate 75 SP @ 500g a.i./ha (12.18b). Other treatments, Emamectin benzoate @ 25g a.i./ha and Spinosad @ 80g a.i. /ha produced 11.41 and 11.00 t/ha yield respectively which stood 4th and 5th in position. Whereas untreated and Neem @ 2.5g a.i./ha recorded lowest yield recording 8.62 and 7.70 t/ha respectively.

Discussions

Under the present investigation after 3 rounds of spray with Imidacloprid @ 25g a.i./ha at 15 days interval reduced the population to 1.47 against 14.50/leaf in untreated control. Agarwal *et al*. (2010) [21] also reported that two sprays of imidacloprid 70 WG @ 40 g/ha rendered very good protection of crop against the early season sucking pests. Imidacloprid @ 5.0 ml/litre was the most effective against leaf hopper as per Dhanalakshmi and Mallapur (2008) [22].

In *pre-kharif* crop Agniastra @ 25ml/L, the botanical insecticide followed the synthetic one with 65.84% reduction with 2.41/leaf jassid population. This result is in conformity with Jayakumar (2002) [23] who reported that NSKE + cow urine + garlic extract, chilli extract + cow urine, garlic extract + cow urine, neem oil + garlic extract and clerodendron extracts + Vitex negundo leaf extract were effective at par with oxydemeton methyl against leafhopper. According to Dhanalakshmi (2006) [24] NSKE + garlic-chilliextract + kerosene (GCK) + cow-urine (CU) was most effective treatment which caused 77.80% reduction in the population of okra leafhopper. The registered protection from Neem @ 2.5g a.i. /ha was 32.25% in *pre-kharif*, leaving 8.00 jassid/leaf. Rosaiah (2001) [25] also reported that NSKE (5 and 10%) and neem (0.5%) were less effective in reducing jassid population. Azadirachtin at the rate of 3g a.i. /ha was also reported to be non-effective against okra jassid at Orissa (Mishra, 2002) [26]. Jat and Jeyakumar (2006) [27] recorded 20.4, 34.4 and 42.5% reduction of jassid population with 1, 2 and 3% neem oil respectively. All the reports as discussed above are in agreement with the present investigation.

Three rounds of spray at an interval of 15 days, suppressed the fruit borer infestation at a higher tune (Table 1). In agreement to the present study Dhar and Bhattacharya (2015) [28] also recorded that imidacloprid 17.8% SL resulted in the lowest infestation of fruit borer as evident from the percentage of damaged fruits (5.58%) in Malda. Similar observations were also made by Kodandaram *et al*. (2010) [29] and Rajashekhar *et al*. (2016) [30] who reported lowest incidence of shoot and fruit borer due to the application of imidacloprid. On the contrary Dabhi *et al*. (2012) [31] added that the treatment with imidacloprid @ 25g a.i. /ha was less effective in reducing the fruit borer incidence. The results under the present investigation is at par with to Basavaraj *et al*. (2016) [32] were significantly maximum (57.58%) fruit damage/plant was recorded from imidacloprid 40g a.i/ha.

Under the present investigation Neem @ 2.5g a.i. /ha stood last among the treatments which only gave 22.08 with 8.08% damaged fruit. The findings of the present study were well supported by Ambekar *et al*. (2000) [33] where various neem products were less efficient than synthetic pesticides against okra fruit borer and recorded 27.25, 28.38 and 29.58% fruit borer infestations respectively. Srivastava *et al*. (2014) [34] also recorded lowest protection with neem oil (27.31, 31.44 and 35.88%). The present study also supported Satpathy and Rai (1999) [11] where neem sprays at the rate of 2.5 ml/l were found less effective. Similar reports were made by Gupta and Mishra (2006) [35] where neem oil (0.5%) failed to provide effective decrease in *Earias vittella* incidence. However, results by Ghosh *et al*. (1999) [36] was found at par with the present study where it was observed that 39% damaged okra fruit upon application of neem which was the least among other pesticides.

Satya Prasad (2000) [37] observed the highest marketable yield (25.83t/ha) of okra with application of imidacloprid. The yield of okra fruits in treatment with imidacloprid 17.8% SL was found 11.63 kg/14.4m2 (Dhar and Bhattacharya, 2015) [28] and 36.65 t/ha (Aarwe *et al*., 2017) [38].

The yield in untreated check was 4.83 t/ha (Chowdhary *et al*., 2010) [39]; 2.37 t/ha (Aarwe *et al*., 2017) [39]; 2.29 t/ha (Patil *et al*., 2002) [40] which is much lower than the present result. In the present study, the yield in untreated plots was 7.70, 7.45 and 7.82 t/ha respectively.

It is well known that okra fruits are plucked at frequent intervals and fruits are used to take after a little cooking. Therefore, there is every possibility of retaining toxic residue in the food, particularly whenever, synthetic insecticides are applied. The present investigation was carried out under organic system of production with a specific objective. The basic principle of the present study was to find out efficacious insecticides from non-synthetic origin for producing export quality. It is noteworthy to mention here that the pest population levels were always become lower under such organic system of production which made easy to suppress the pest population at lower level with spraying of insecticides.

Despite the presence of various insect pests only jassid and fruit borer were considered as major ones because of their ability to cause economic damage. Activities of other pests were ignored due to their lower population level.

Analysis of results revealed that synthetic insecticides in general and Imidacloprid @ 25g a.i. /ha in particular gave excellent control. In few cases microbial based insecticides also provided better control. However, the efficiency of Agniastra @ 25ml/L could not be ignored. In most of the sprays over three seasons its position was next to imdacloprid 17.8 SL @ 25g a.i./ha or acephate75 SP @ 500g a.i. /ha or both. Most of the cases it provided better control than microbial-based insecticides. The most interesting feature of the results are the variation in effectiveness among the three groups of insecticides were not highly rather statistically non-significant in most of the spray over seasons.

Unlike jassid, agniastra @ 25ml/L persistently proved better to suppress fruit borer infestation. Its position was next to Imidacloprid 17.8 SL @ 25g a.i. /ha or Acephate 75 SP @ 500g a.i. /ha or even Emamectin benzoate @ 25g a.i. /ha. However, the performance of neem@ 2.5g a.i. /ha was very less. Still, it could provide better control of jassid. These informations may be taken into account whenever a holistic pest management programme would be undertaken.

Conclusions

Considering all aspects of the present studies Agniastra @ 25ml/L might be selected for its better efficacy against the pest as well as better productivity. Further it better efficacy, also fits well under organic system of production for producing chemical-free export quality okra by sacrificing little yield which may be compensated from low cost inputs for raising the crop and management of pest.

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Conflict of interest

The authors have not declared any conflict of interest.

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