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Efficacy of Newer Group of Insecticides against Whitefly on Okra, *Abelmoschus esculentus* L. (Moench)

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ABSTRACT: The present experiment was undertaken to study the "Efficacy of newer group of insecticides against whitefly on okra, *Abelmoschus esculentus* L. (Moench) during *Kharif* season 2018 at the vegetable research farm, B.H.U., Varanasi. The experiment consisted nine treatments including control. Concerning the efficacy of insecticides it was observed that Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 72.5 + 38.5 g a.i ha^{-1} was found to be very effective against whiteflies followed by Indoxacarb14.5% + Acetamiprid 7.7% SC @58+30.8 g a.i ha^{-1} and Acetamiprid 20% SP @ 38.5 g a.i ha^{-1} while Cypermethrin 10% EC @ 600 g a.i ha^{-1} found least effective after the 3rd insecticide spraying. Whereas, rest of treatments like Indoxacarb 14.5% SC @ 72.5 g a.i ha^{-1}, Chlorpyrifos 50% + Cypermethrin 5% EC@500+50 g a.i ha^{-1}, Chlorpyrifos 50% EC @ 600 g a.i ha^{-1}, Chlorpyrifos 50% + Cypermethrin 5% EC 375+37.5 g a.i ha^{-1} and Fenpropathrin 30% EC @ 100 g a.i ha^{-1}showed moderate efficacy against whitefly.

Keywords: okra crop, *Abelmoschus esculentus* L., insecticides, whitefly,

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench), commonly known as lady's finger or bhendi belonging to family Malvaceae, is an important warm season vegetable crop cultivated widely in tropical and sub-tropical regions of the world (Alam and Hossain 2008). Okra is native to Ethiopia. It is an important commercial vegetable crop grown throughout the year in tropical and sub-tropical tropical regions of the world.

In India its fruits are cooked as vegetable, matured pods and stem have been used in paper industry where as whole plant is used as clarifier in jaggery production. The ripe seed of 'okra' are, sometimes roasted and ground as a coffee substitute, while the seed-powder has been used as substitute for the aluminum salts for water purification. Moreover, okra mucilage is suitable for medicinal and industrial applications. (Akinyele and Temikotan 2007).

Nutritionally okra is fat and cholesterol free, very low in sodium, low in calories, and good source of vitamin A, vitamin C, vitamin B6 and of the thiamin. Okra green fruits contain water (88%), carbohydrates (7.7%), proteins (2.2%), calcium (0.09%), phosphorus (0.04%), iron (0.0051%), vitamin A-58 IU, vitamin B- 63 IU and vitamin C 16 mg/100g (Baloch *et al*., 1990).

Okra requires long and warm growing season. The crop is highly sensitive to frost and the seeds do not germinate below 18°C. It grows well in all types of soil ranging from sand to clay, however best yields are obtained in loose, friable and well manured loamy soils with pH ranging from 6 to 6.8. In India okra is being cultivated around the year in *kharif*, *rabi* and summer season. However, several biotic and abiotic factors are responsible for low yield. About 20 pest species have been reported on this crop (Butani and Verma, 1976) among them shoot and fruit borer (*Earias vittella* Fabricius.), leaf hopper (*Amrasca biguttula* Ishida)), whiteflies (*B. tabaci* Genn) and Aphids (*Aphis gossypii* Glover) cause severe economic losses to crop. Besides causing damage, the sucking pests are also act as vectors causing irreversible damage to the crop. The repeated use of systemic insecticides has resulted in the development of resistance in the insect pest, with disturbance the agrecosystem by affecting the non targets (Dittrich *et al.,*1990). Hence, the present study was carried out to evaluate the efficacy of newer molecules with novel mode of action to find out a viable option for sustainable management of sucking insect pest of okra.

Whitefly (*B. tabaci*) is also the notorious and major pest of okra (Dubey *et al.,* 1999). Whiteflies feed by tapping into the phloem of plants, introducing toxic saliva and decreasing the plants' overall turgor pressure. Since whiteflies congregate in large numbers, susceptible plants can be quickly overwhelmed. Further harm is done by mold growth encouraged by the honeydew whiteflies secrete. It not only reduces the growth but also transmit pathogenic diseases (Sheedi, 1980; Dhaliwal *et al.,* 1981).

Chemical control against the sucking pests in vogue is not effective and is a rather difficult task in combating because of their distributional pattern in the crop canopy, the higher reproductive potential and development of insecticide resistance. Sucking pests have developed resistance to almost all conventional and synthetic insecticides and also developing resistance to multiple classes of insecticides (Palumbo *et al*., 2001). human health hazards, destruction of the beneficial fauna, resurgence of minor pests and environmental pollution (Mahapatro and Gupta 1998). In view of these facts, recent advances in research are being directed towards development of safer and effective insecticides which are relatively safe to natural enemies and reduce insecticide load in the environment. Keeping in view the economic importance of okra and the losses caused by the pests.

Field experiments were conducted by Preetha *et al.* (2009) in two crop seasons with Ajeet-333 okra to evaluate the efficacy of Neonicotinoid, Imidacloprid as foliar application against jassid, *Amrasca biguttula* (Ishida) and whitefly, *Bemisia tabaci* (Gennadius). Imidacloprid 17.8 SL at 25 g a.i. ha^{-1} was found effective against jassids and whiteflies. The other Neonicotinoid, Thiamethoxam also provided similar levels of protection as that of Imidacloprid. The conventional insecticide, Methyl Demeton (125 g a.i. ha^{-1}) was less effective.

The effect of Acetamiprid 20 SP, at 20, 30 and 40 g a.i./ha, was compared with the standard insecticides Triazophos 40 EC at 500 ml/ha, Monocrotophos 36 SL at 200 ml/ha and with an untreated control. Imidacloprid 70 WS at 20 g a.i./ha was included. Based on the economic threshold level of the whitefly, 2 sprays of the insecticides were initiated at 25 days after sowing. The Acetamiprid, Imidacloprid, Triazophos and Monocrotophos resulted in significant reduction of the YVMV incidence and mean whitefly population compared to the control treatment. The spray with the insecticides recorded higher cost: benefit ratio in fruit yield compared to the control (Gowdar *et al*., 2007).

Different rates of Thiomethoxam were tested by Bhalala *et al*. (2006) against okra cv. Parbham Kranti infested with aphid, Aphis gossypii, jassid, *Amrasca biguttula*, whitefly, *Bemicia tabaci* and mite, *Tetranychus cinnabarinus*. The okra crop sprayed with Thiomethoxam 25 WG at two higher doses (50 and 37.5 g a.i./ha) showed effective control of aphid, jassid, whitefly and mite population. Whitefly and mite populations remained at par with Monocrotophos treatment.

Results of experiments conducted during *kharif* 2003 and 2004, in Karnal, Haryana, India, showed that Imidacloprid at 2 ml as well as Thiamethoxam and Carbosulfan each at 2 g/kg seed were quite effective in controlling jassid (*A. biguttula*). Imidacloprid at 2 ml, Thiamethoxam at 2 g and Carbosulfan at 4 g/kg seed were effective in controlling the whitefly (*Bemisia tabaci*). Okra seed yield was higher in Thiamethoxam, Imidacloprid and Carbosulfan treatments (Rana *et al*., 2006).

MATERIAL AND METHOD

General details about experiment: The experiments was carried out at Vegetable Research Farm, IAS, BHU, Varanasi. The alluvial soils of this geographical region in general are reported to be flat, well drained and moderately being less in available nitrogen and medium in available phosphorus and potash. The normal pH varies from 7.2 - 8.4. The climate of this region is typically sub-tropical which is characterized by extremes of weather conditions particularly during summer and winter seasons. The average rainfall is reported to be 1100 mm per annum.

Methods of recording observations: The pest population of whiteflies, *Bemisiatabaci* (Gennadius), both nymphs and adults, were record during the vegetative, flowering and fruiting stage on three leaves (1 top + 1middle + 1 bottom) of three randomly selected plants with an interval of seven days.

Bio efficacy of selected insecticide molecules that are known to have different mode of actions were tested at their respective recommenced field concentrations against whitefly of okra. The experimental layout uniform size plot 3.0 m × 1.8 m and replicated thrice. Okra variety Kashi Mohini (VRO-3) was sown in a well prepared field on 20 July 2018. The row to row and plant to plant spacing maintained were 45 × 20 cm. There were ten treatments under study (including untreated control).

Application of insecticides. Spraying was done during morning hours using a knapsack sprayer. The sprayer and the container used for preparing the spray fluid were thoroughly cleaned with water after each spray and rinsed with the insecticides to be used next. The spraying was done to the point of run-off for ensuring thorough coverage of the plant surface. The quantity of the spray fluid used was @ of 500 litres per ha. The first insecticidal application was given when the pest reached to ETL. The rest of insecticidal applications were given on the need based coinciding the incidence and severity of the pest.

Field Observations. Whitefly pest's population were recorded at one day before spraying as pre treatment count and at 1, 3, 5 and 10 days after spraying as post treatment counts. For recording the incidence of different sucking pests on okra, three plants were randomly selected from each plot. From each plant top, middle and bottom leaves were considered Percent reduction over control: The per cent reduction of the test insect population over control was worked out in order to judge and express the efficacy of the respective treatments against it. The field bio-efficacy of test insecticides in terms of per cent reduction in the pest population over control was calculated by using Henderson and Tilton's formula (1955).

$$\text{Percent efficacy} = 1-\left[\frac{Ta}{Tb} \times \frac{Cb}{Ca}\right] \times 100$$

Where,

Ta= Population in the treated plot after spray

Tb= Population in the treated plot before spray

Ca= Population in the control plot after spray

Cb = Population in the control plot before spray

Yield: The yield data of marketable fruit at different pickings in each treatment were reported separately and subjected to statistical analysis to test the significance of mean yield in different treatments. The per cent increase in yield over control in each treatment was calculated by using following formula.

$$\text{\% increase of yield over control} = \frac{\text{Yield in treatment - Yield in control}}{\text{Yield in control}} \times 100$$

Statistical analysis: The data thus obtained was transformed to square root values and subjected to analysis of variance. After determination of significance of difference between the treatment means at (0.05) percent probability, critical difference was calculated in order to compare the treatment means.

RESULT AND DISCUSSION

First insecticidal spray

The initial population of whiteflies on various experimental plots including untreated control a day before first insecticidal spray was found in the range of 4.08 to 6.18 per 3 leaves (Table 1). One day after 1st insecticidal spray reduction in whitefly population over control was recorded to be highest in Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 72.5+ 38.5 g a.i ha^{-1} (85.74) treated plots followed by Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 58+30.8 g a.i ha^{-1} (70.49%) which was found at par with Indoxacarb 14.5% SC @ 72.5 g a.i ha^{-1} (62.19) while the other treatment plots showed the per cent field efficacy in the following order: Acetamiprid 20% SP @ 38.5 g a.i ha^{-1} (58.87%) > Chlorpyrifos 50% + Cypermethrin 5% EC @ 500+50 g a.i ha^{-1} (50.65) > Cypermethrin 10% EC @ 70 g a.i ha^{-1} (45.84) > Chlorpyrifos 50% + Cypermethrin 5% EC @ 375+37.5 g a.i ha^{-1} (45.52%) > Fenpropathrin 30% EC @ 100 g a.i ha^{-1} (32.67%) > Chlorpyrifos 50% EC @ 600 g a.i ha^{-1} (29.31). The mean whitefly population per 3 leaves one day after treatment in different plots varied from 1.23 to 7.75.

Table 1: Efficacy of different insecticides against whitefly in okra crop during *Kharif* 2018 (1st Spray).

Tr. No.	Insecticide	Doses g a.i/ha	1DBS	Average* number of whiteflies/3leaves/plant and per cent field efficacy at different days after 1st spray									
				1DAS	PFE	3DAS	PFE	5DAS	PFE	10DAS	PFE	Overall Mean	Overall PFE
T_1	Chlorpyrifos 50% +Cypermethrin 5% EC	375+37.5	5.05 (2.45)	3.45 (2.10)	45.52	3.53 (2.12)	52.99	4.73 (2.39)	45.85	5.98 (2.64)	38.40	4.42	45.69
T_2	Chlorpyrifos 50% +Cypermethrin 5% EC	500+50	5.09 (2.42)	3.15 (2.03)	50.65	1.98 (1.72)	73.84	3.27 (2.06)	62.86	4.66 (2.38)	52.37	3.26	59.93
T_3	Chlorpyrifos 50% EC	600	5.11 (2.47)	4.53 (2.35)	29.31	4.56 (2.35)	39.99	2.56 (1.87)	71.04	4.16 (2.27)	57.65	3.95	49.50
T_4	Cypermethrin 10% EC	70	5.05 (2.45)	3.43 (2.10)	45.84	4.31 (2.30)	42.61	5.05 (2.42)	42.19	6.75 (2.78)	30.47	4.88	40.28
T_5	Indoxacarb14.5% +Acetamiprid 7.7%SC	58+30.8	4.08 (2.25)	1.51 (1.58)	70.49	0.48 (1.21)	92.09	1.21 (1.48)	82.86	2.97 (1.99)	62.13	1.54	76.89
T_6	Indoxacarb14.5% + Acetamiprid 7.7%SC	72.5+38.5	6.88 (2.62)	1.23 (1.49)	85.74	0.81 (1.33)	92.08	1.13 (1.46)	90.50	2.75 (1.93)	79.21	1.48	86.88
T_7	Indoxacarb14.5% SC	72.5	4.45 (2.33)	2.11 (1.76)	62.19	1.41 (1.55)	78.69	1.86 (1.69)	75.84	3.69 (2.16)	56.86	2.27	68.40
T_8	Acetamiprid 20% SP	38.5	5.08 (2.40)	2.62 (1.90)	58.87	1.35 (1.53)	82.13	2.51 (1.87)	71.44	3.72 (2.17)	61.91	2.55	68.59
T_9	Fenpropathrin 30% EC	100	4.24 (2.28)	3.58 (2.14)	32.67	2.74 (1.93)	56.54	3.77 (2.18)	48.60	4.68 (2.38)	42.58	3.69	45.10
T_{10}	Control		6.18 (2.48)	7.75 (2.78)	0.00	9.19 (3.03)	0.00	10.69 (3.27)	0.00	11.88 (3.44)	0.00	9.87	0.00
SE(m) ±			(0.01)	(0.01)	--	(0.04)	--	(0.06)	--	(0.01)	--	--	--
C.D. at 5%			(0.03)	(0.05)	--	(0.12)	--	(0.18)	--	(0.04)	-	--	--

DBS= Day before spray DAS= Day after Spray PFE= Percent field efficacy

Average*of three replications Figures in the parenthesis are √x+0.5 transformed value where x =Actual number

After 3rd day of first insecticidal sprays the per cent field bio-efficacy was maximum in plots treated with Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 58+38.5 g a.i ha^{-1} (92.09) followed by Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 72.5+38.5 g a.i ha^{-1} (92.08). The per cent field bio-efficacy of other treatments were in the following order: Acetamiprid 20%SP @ 38.5 g a.i ha^{-1} (82.13) > Indaxocarb 14.5 % SC @ 72.5 g a.i ha^{-1} (78.69) > Chlorpyrifos + Cypermethrin 5% EC @ 500+50 g a.i ha^{-1} (73.84) > Fenpropathrin 30 % EC @ 100 g a.i ha^{-1} (56.54) > Chlorpyrifos 50% + Cypermethrin 5% EC @ 375+37.5 g a.i ha^{-1} (52.99) > Cypermethrin 10 % EC @ 70 g a.i ha^{-1} (42.61) > Chlorpyrifos 50% EC @ 600 g a.i ha^{-1} (39.99). All the treatments differed significantly from each other.

Even after 5th and 10th day of first insecticidal sprays Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 72.5 + 38.5 g a.i ha^{-1} treated plot was showed highest per cent field efficacy as 90.50 and 79.21 followed by Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 58 + 30.8 g a.i ha^{-1} as 82.86 and 62.13 respectively while least per cent field efficacy was observed in Cypermethrin 10% EC @ 70 g a.i ha^{-1} as 42.19 and 30.47 followed by Chlorpyrifos 50% + Cypermethrin 5% EC @ 375 + 37.5 g a.i ha^{-1} treated plot as 45.85 and 38.40, respectively.

The overall mean per cent field efficacy after the first sprays was highest observed with Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 72.5+38.5g a.i ha^{-1} treated plots (86.88) followed by Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 58+38.5 g a.i ha^{-1} (76.89) and Acetamiprid 20 % SP @ 38.5 g a.i ha^{-1} (68.59) (Table 1 The rest of insecticides per cent field efficacy after first insecticidal spray was found to be in the following order: Indoxacarb 14.5 % SC @ 72.5 g a.i ha^{-1} (68.40) > Chlorpyrifos 50% + Cypermethrin 5% EC@ 500+50 g a.i ha^{-1} (59.93) > Chlorpyrifos 50% EC @ 600 g a.i ha^{-1} (49.50) > Chlorpyrifos 50% + Cypermethrin 5% EC @ 375+37.5 g a.i ha^{-1} (45.69) >Fenpropathrin 30% EC @ 100 g a.i ha^{-1} (45.10) > Cypermethrin 10% EC @ 600 g a.i ha^{-1} (40.28).

Second insecticidal spray. The initial population of whiteflies on various experimental plots including untreated control a day before second insecticidal sprays was found in the range of 4.09 to 12.02 per 3 leaves (Table 2). One day after 1st insecticidal spray reduction in whitefly population over control was recorded to be highest in Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 72.5 + 38.5 g a.i ha^{-1} (74.64) treated plots followed by Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 58+30.8 g a.i ha^{-1} (73.61%) which was found at par with Chlorpyrifos 50% EC @ 600 g a.i ha^{-1} (53.41), while the other treatment plots showed the per cent field efficacy in the following order Fenpropathrin 30% EC @ 100 g a.i ha^{-1} (53.31%) > Chlorpyrifos 50% + Cypermethrin 5% EC @ 500+50 g a.i ha^{-1} (51.43) > Indoxacarb 14.5% SC @ 72.5 g a.i ha^{-1} (46.20) > Cypermethrin 10% EC @ 70 g a.i ha^{-1} (45.73) > Acetamiprid 20% SP @ 38.5 g a.i ha^{-1} (43.82%) > Chlorpyrifos 50% + Cypermethrin 5% EC @ 375+37.5 g a.i ha^{-1} (42.34%). The mean whitefly population per 3 leaves one day after treatment in different plots including control, varied from 1.18 to 12.95.

Table 2: Efficacy of different insecticides against whitefly in okra crop during *Kharif* 2018 (2nd Spray).

Tr. No.	Insecticide	Doses g a.i/ha	1DBS	Average* number of whiteflies/3leaves/plant and per cent field efficacy at different days after 2nd spray									
				1DAS	PFE	3DAS	PFE	5DAS	PFE	10DAS	PFE	Overall Mean	Overall PFE
T1	Chlorpyrifos 50% +Cypermethrin 5% EC	375+37.5	6.23 (2.68)	3.87 (2.20)	42.34	2.72 (1.92)	88.16	4.11 (2.26)	22.10	5.17 (2.48)	10.78	3.46	40.85
T 2	Chlorpyrifos 50% +Cypermethrin 5% EC	500+50	4.09 (2.42)	2.14 (1.77)	51.43	1.05 (1.43)	73.69	1.71 (1.64)	50.63	3.20 (2.04)	15.88	2.02	47.91
T 3	Chlorpyrifos 50% EC	600	7.75 (2.95)	5.15 (2.48)	53.41	6.29 (2.70)	40.50	7.21 (2.86)	48.35	8.75 (3.12)	43.12	3.97	46.35
T 4	Cypermethrin 10% EC	70	7.03 (2.83)	5.00 (2.45)	45.73	4.75 (2.39)	52.63	5.69 (2.58)	4.43	6.89 (2.80)	35.00	4.32	34.45
T 5	Indoxacarb14.5% +Acetamiprid 7.7%SC	58+30.8	4.15 (2.26)	1.18 (1.47)	73.61	0.78 (1.33)	80.74	1.15 (1.46)	67.28	2.38 (1.83)	38.34	1.37	64.99
T 6	Indoxacarb14.5% + Acetamiprid 7.7%SC	72.5+38.5	5.16 (2.47)	1.41 (1.55)	74.64	0.49 (1.21)	90.27	1.10 (1.44)	74.83	2.27 (1.80)	52.70	1.31	73.11
T 7	Indoxacarb14.5% SC	72.5	5.21 (2.49)	3.02 (2.00)	46.20	1.65 (1.62)	67.55	2.49 (1.86)	43.57	4.07 (2.25)	56.46	2.31	53.44
T 8	Acetamiprid 20% SP	38.5	6.03 (2.65)	4.89 (2.42)	43.82	4.77 (2.40)	54.12	3.39 (2.09)	58.88	4.32 (2.30)	60.77	2.66	54.40
T 9	Fenpropathrin 30% EC	100	6.62 (2.76)	5.41 (2.53)	53.31	4.13 (2.26)	57.43	6.19 (2.68)	26.87	5.87 (2.62)	21.23	3.75	39.71
T 10	Control		12.02 (3.46)	12.95 (3.59)	0.00	17.73 (4.21)	0.00	10.18 (3.34)	0.00	11.18 (3.49)	0.00	11.51	0.00
SE(m) ±			**(0.04)**	**(0.01)**	**--**	**(0.09)**	**--**	**(0.02)**	**--**	**(0.01)**	**--**	**--**	**--**
C.D. at 5%			**(0.14)**	**(0.03)**	**--**	**(0.03)**	**--**	**(0.05)**	**--**	**(0.03)**	**--**	**--**	**--**

DBS=Day before spray DAS=Day after spray PFE= Percent field efficacy
Average*of three replications Figures in the parenthesis are $\sqrt{x+0.5}$ transformed value (where x= Actual number)

After 3rd day of second insecticidal sprays the per cent field bio-efficacy was highest in plots treated with Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 72.5 + 38.5 g a.i ha^{-1} (90.27) followed by Chlorpyrifos 50% + Cypermethrin 5% EC @ 375+37.5g a.i ha^{-1} (88.16). The per cent field bio-efficacy of other treatments were in the following order: Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 58+38.5 g a.i ha^{-1}(80.74) > Chlorpyrifos + Cypermethrin 5% EC @ 500+50 g a.i ha^{-1}(73.69) > Indaxocarb14.5% SC @ 72.5 g a.i ha^{-1} (67.55) >Fenpropathrin 30% EC @ 100 g a.i ha^{-1}(57.43) > Acetamiprid 20% SP @ 38.5 g a.i ha^{-1} (54.12) > Cypermethrin10% EC @ 70 g a.i ha^{-1} (52.63) > Chlorpyrifos 50% EC @ 600 g a.i ha^{-1} (40.50). All the treatments differed significantly from each other.

After 5th and 10th day of second insecticidal sprays Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 72.5+38.5 g a.i ha^{-1} treated plots showed highest per cent field efficacy as 74.83 and 52.70 followed by Indoxacarb14.5% + Acetamiprid 7.7%SC @ 58+30.8 g a.i ha^{-1} as 67.28 and 38.34 respectively while least per cent field efficacy was observed in Cypermethrin 10% EC @ 70 g a.i ha^{-1} as 4.43 and 35.00 followed by Chlorpyrifos 50% + Cypermethrin 5% EC @ 375+37 g a.i ha^{-1} treated plot as 22.10 and 10.78, respectively.

The perusal of overall mean per cent field efficacy of various insecticide formulations after second sprays revealed that, highest efficacy was observed with Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 72.5+38.5 g a.i ha^{-1} treated plots (73.11) followed by Indoxacarb14.5% + Acetamiprid 7.7% SC @ 58+38.5 g a.i ha^{-1} (64.99) and Acetamiprid 20 % SP @ 38.5 g a.i ha^{-1} (54.40) (Table 2). The rest of insecticides per cent field efficacy after second insecticidal spray was found to be in the following order: Indoxacarb 14.5 % SC @ 72.5 g a.i ha^{-1} (53.44) > Chlorpyrifos 50% + Cypermethrin 5% EC @ 500+50 g a.i ha^{-1} (47.91) > Chlorpyrifos 50% EC @ 600 g a.i ha^{-1} (46.35) > Chlorpyrifos 50% + Cypermethrin 5% EC @ 375+37.5 g a.i ha^{-1} (40.85) > Fenpropathrin 30% EC @ 100 g a.i ha^{-1} (39.71) > Cypermethrin 10 % EC @ 70 g a.i ha^{-1} (34.45).

Third insecticidal spray. The initial population of whiteflies after two sprays and a day before third insecticidal sprays on various experimental plots including untreated control was found in the range of 2.52 to 7.21 per 3 leaves (Table 3). One day after 1st insecticidal spray reduction in whitefly population over control was recorded to be highest in Indoxacarb 14.5% + Acetamiprid 7.7 % SC @ 72.5+38.5 g a.i ha^{-1} (70.60%) treated plots followed by Indoxacarb 14.5% + Acetamiprid 7.7 % SC @ 58+30.8 g a.i ha^{-1} (70.23%) which was found at par with Acetamiprid 20% SP @ 38.5 g a.i ha^{-1} (57.57) while the other treatment plots showed the per cent field efficacy in the following order: Indoxacarb 14.5% SC @ 72.5 @ (48.10) > Chlorpyrifos 50% + Cypermethrin 5% EC@ 500+50 g a.i ha^{-1} (32.36) > Cypermethrin 10% EC @ 70 g a.i ha^{-1} (29.92%) >Fenpropathrin 30% EC @ 100 g a.i ha^{-1} (28.91%) > chlorpyrifos 50% + Cypermethrin 5% EC @ 375+37.5 g a.i ha^{-1} (24.98%) > Chlorpyrifos 50% EC @ 600 g a.i ha^{-1} (22.59). The mean whitefly population per 3 leaves one day after treatment in different plots varied from 0.71-6.91.

After 3rd day of third insecticidal spray the per cent field bio-efficacy was highest in plots treated with Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 72.5+38.5 g a.i ha^{-1} (82.74) followed by Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 58+38.5 g a.i ha^{-1} (79.52). The per cent field bio-efficacy of other treatments were in the following order: Indaxocarb 14.5 % @ 72.5 g a.i ha^{-1} (70.72) > Acetamiprid 20 % SP @ 38.5 g a.i ha^{-1} (61.58) > Chlorpyrifos 50% + Cypermethrin 5% EC @ 375+37.5g a.i ha^{-1} (43.38) >Fenpropathrin 30 % EC @ 100 g a.i ha^{-1} (42.38) > Chlorpyrifos + Cypermethrin 5% EC @ 500+50 g a.i ha^{-1} (39.89) > Chlorpyrifos 50% EC @ 600 g a.i ha^{-1} (27.41) > Cypermethrin 10 % 70 g a.i ha^{-1} (25.88). All the treatments differed significantly from each other.

After 5th and 10th day of third insecticidal sprays Indoxacarb 14.5% + Acetamiprid 7.7%SC @ 72.5+38.5 g a.i ha^{-1} treated plot was showed highest per cent field efficacy as 70.57 and 36.74 followed by Acetamiprid 20 % SP @ 38.5 g a.i ha^{-1} 69.33 and 52.90 respectively. While least per cent field efficacy was observed in Cypermethrin 50 % EC @ 600 g a.i ha^{-1} as 18.01 and 14.08 followed by Fenpropathrin 30 % EC @ 100 g a.i ha^{-1} treated plot as 27.23 and 23.50 respectively.

After three sprays the overall mean per cent field efficacy was highest observed with Indoxacarb14.5% + Acetamiprid 7.7% SC @ 72.5+38.5 g a.i ha^{-1} treated plots (65.16) followed by Indoxacarb14.5% + Acetamiprid 7.7%SC @ 58+38.5 g a.i ha^{-1} (60.77) and Acetamiprid 20 % SP @ 38.5 g a.i ha^{-1} (60.34) (Table 3). The rest of insecticides per cent field efficacy after third insecticidal sprays was found to be in the following order: Indoxacarb 14.5% SC @ 72.5 g a.i ha^{-1} (50.05) > Chlorpyrifos 50% + Cypermethrin 5% EC @ 500+50 g a.i ha^{-1} (35.33) > Chlorpyrifos 50% EC @ 600 g a.i ha^{-1} (34.76) > Chlorpyrifos 50% + Cypermethrin 5% EC @ 375+37.5 g a.i ha^{-1} (32.67) >Fenpropathrin 30% EC @ 100 g a.i ha^{-1} (30.50) > Cypermethrin 10 % EC @ 70 g a.i ha^{-1} (21.97).

Table 3: Efficacy of different insecticides against whiteflies in okra cropduring*Kharif* 2018 (3rd Spray).

Tr. No.	Insecticide	Doses g a.i/ha	1DBS	Average* number of whiteflies/3leaves/plant and per cent field efficacy at different days after 3rd spray									
				1DAS	PFE	3DAS	PFE	5DAS	PFE	10DAS	PFE	Overall Mean	Overall PFE
T_1	Chlorpyrifos 50% +Cypermethrin 5% EC	375+37.5	4.59 (2.36)	3.30 (2.07)	24.98	2.39 (1.84)	43.38	2.24 (1.80)	32.98	1.79 (1.67)	29.35	2.43	32.67
T_2	Chlorpyrifos 50% +Cypermethrin 5% EC	500+50	3.98 (2.23)	2.58 (1.89)	32.36	2.20 (1.78)	39.89	1.75 (1.65)	39.61	1.55 (1.59)	29.45	2.02	35.33
T_3	Chlorpyrifos 50% EC	600	4.03 (2.24)	2.99 (1.99)	22.59	2.69 (1.92)	27.41	1.37 (1.54)	53.31	1.43 (1.55)	35.72	2.12	34.76
T_4	Cypermethrin 10% EC	70	6.03 (2.65)	4.05 (2.24)	29.92	4.11 (2.26)	25.88	3.60 (2.14)	18.01	2.86 (1.96)	14.08	3.65	21.97
T_5	Indoxacarb14.5% +Acetamiprid 7.7%SC	58+30.8	3.61 (2.14)	1.03 (1.42)	70.23	0.68 (1.29)	79.52	0.97 (1.40)	63.10	1.39 (1.54)	30.25	1.02	60.77
T_6	Indoxacarb14.5% + Acetamiprid 7.7%SC	72.5+38.5	2.52 (1.87)	0.71 (1.30)	70.60	0.40 (1.18)	82.74	0.54 (1.24)	70.57	0.88 (1.36)	36.74	0.63	65.16
T_7	Indoxacarb14.5% SC	72.5	3.90 (2.21)	1.94 (1.71)	48.10	1.05 (1.42)	70.72	1.35 (1.53)	52.46	1.53 (1.59)	28.93	1.47	50.05
T_8	Acetamiprid 20% SP	38.5	3.00 (2.00)	1.22 (1.47)	57.57	1.06 (1.42)	61.58	0.67 (1.29)	69.33	0.78 (1.33)	52.90	0.93	60.34
T_9	Fenpropathrin 30% EC	100	5.02 (2.45)	3.42 (2.10)	28.91	2.66 (1.91)	42.38	2.66 (1.91)	27.23	2.12 (1.76)	23.50	2.71	30.50
T_{10}	Control		12.50 (3.53)	13.20 (3.63)	0.00	12.05 (3.47)	0.00	12.25 (3.50)	0.00	14.22 (3.77)	0.00	5.69	0.00
SE(m) ±			**(0.01)**	**(0.03)**	--	**(0.05)**	--	**(0.01)**	--	**(0.03)**	--	--	--
C.D. at 5%			**(0.04)**	**(0.11)**	--	**(0.15)**	--	**(0.03)**	--	**(0.09)**	--	--	--

DBS= Day before spray DBS= Day after spray PFE= Per cent field efficacy
Average*of three replications Figures in parenthesis are $\sqrt{x+0.5}$ transformed value (where x = Actual number)

The results of the present investigation reveaded that the treatment Indoxacarb14.5% + Acetamiprid 7.7% SC @ 72.5 + 38.5g a.i ha^{-1} against was the most effective insecticide against okra whiteflies followed by Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 58 + 38.5 g a.i ha^{-1} and Acetamiprid 20 % SP @ 38.5 g a.i ha^{-1} were significant superior over all the other treatments in bringing down the whitefly population. The treatments comprising Indoxacarb 14.5%SC @ 72.5 g a.i ha^{-1}, Chlorpyrifos 50% + Cypermethrin 5% EC @ 500 + 50 g a.i. ha^{-1} and Chlorpyrifos 50% + Cypermethrin 5% EC @ 375+37.5 g a.i. ha^{-1} also found more efficacy next to above treatment in controlling whitefly population while Cypermethrin 10% EC @ 600 g a.i ha^{-1} recorded very least per cent field efficacy followed by Fenpropathrin 30% EC @ 100 g a.i ha^{-1}. The present results are also similar with the findings of Gowder *et al*. (2007) who stated that Fipronil and Indoxacarb treated plots showed minimum whitefly population.

Influence of treatment on yield (Table 4). All the insecticidal treatments gave significantly higher yields of okra over untreated check. Among the treatments Indoxacarb 14.5% SC @ 72.5 g a.i ha^{-1} and Indoxacarb 14.5% + Acetamiprid 7.7% SC @ 72.5+38.5 g a.i ha^{-1} were the best and most effective formulations which recorded the highest yield of marketable fruits. This is probably due to the better control of insect pests leading to less infestation and reduced losses in yield. Earlier Maurya *et al*. (2014); Dhaka *et al*. (2016) reported that Indoxacarb treated plots produced higher yield compared to other treatments.

Table 4: Impact of insecticidal treatments on okra crop yield.

Tr. No.	Insecticide	Doses g a.i/ha	Fruit yield (q/ha)	% Increase of yield over control
T_1	Chlorpyrifos 50% +Cypermethrin 5% EC	375+37.5	83.71*	12.01
T_2	Chlorpyrifos 50% +Cypermethrin 5% EC	500+50	87.34	16.90
T_3	Chlorpyrifos 50% EC	600	93.96	25.76
T_4	Cypermethrin 10% EC	70	80.82	8.17
T_5	Indoxacarb14.5% +Acetamiprid 7.7%SC	58+30.8	95.53	27.86
T_6	Indoxacarb14.5% + Acetamiprid 7.7%SC	72.5+38.5	108.34	45.01
T_7	Indoxacarb14.5% SC	72.5	110.20	47.50
T_8	Acetamiprid 20% SP	38.5	85.22	14.07
T_9	Fenpropathrin 30% EC	100	86.64	15.96
T_{10}	Control		74.71	

*Average of three replication

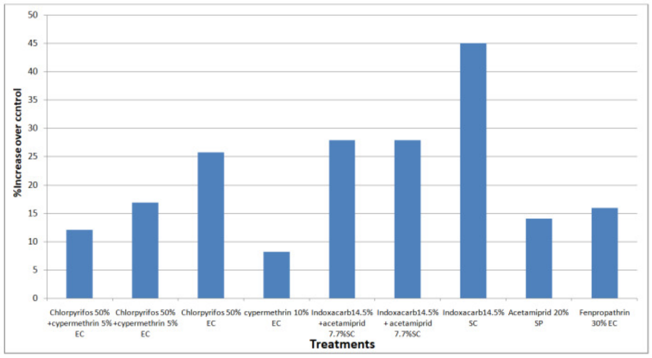

Fig. 1. Impact of insecticidal treatments on okra yield.

CONCLUSION

From the present result Indoxacarb 14.5% SC @ 72.5 g a.i ha^{-1}, Indoxacarb14.5% + Acetamiprid 7.7% SC @ 72.5+38.5 g a.i ha^{-1} treated plots were the best and most effective which recorded the highest yield of marketable fruits.

FUTURE SCOPE

The scope of the study was to encompass pesticide use in production system-determine what type of chemical products are the most appropriate tools for ecologically based pest management. identify the circumstances under which chemical pesticides may be required in future pest management. Explore the most promising opportunities to increase benefits and reduce health and environmental risks of pesticides use.

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REFERENCES

Akinyele, B. O. and Temikotan, T. (2007). Effect of variation in soil texture on the vegetative and pod characteristics of okra (*Abelmoschus esculentus* (L.) Moench). *International Journal of Agricultural Research*, *2*: 165-169.

Alam, A. K. M. A. and Hossain, M. M. (2008). Variability of different growth contributing parameters of some okra (*Abelmoschus Esculentus* L.) accessions and their interrelation effects on yield. *Journal of Agriculture & Rural Development*, *6*: 25-35.

Baloch, A. F., Qayyum, S. M and Baloch, M. A. (1990). Growth and yield performance of okra (*Abelmoschus esculentus* L) cultivars. *Gomal University Journal of Research*, *10*: 191.

Bhalala, M. K., Patel, B. H., Patel, J. J., Bhatt, H. V. and Maghodia, A. B. (2006). Bio-efficacy of Thiomethoxam 25 WG and various recommende dinsecticide against sucking pest complexof okra (*Abelmoschus esculentus* L. Moench). *Indian Journal of Entomology*, *68*(3): 293-295.

Butani, D. K. and Verma, S. (1976). Insect pest of vegetables and their control; onion and garlic. *Pesticides*, *10*(11): 33-35.

Dhaka, S. S., Rai, M. K and Kumar, R. (2016). Relative efficacy of novel insecticides and biopesticides against *Earias vittella* (Fab.)inokra. *Annals of Plant Protection Sciences*, *24*(2): 271-275.

Dhaliwal, J. S., Sidhu, M. S. and Singh, G. (1981). Effect of different dates of sowing on sorghum and the incidence of red leaf spot disease and major insect pests in Punjab. *Journal of Agriculture Research,* Ludhiana. *18*: 400- 405.

Dittrich,V. Ernst, G.H., Ruesch, O. and UK, S.(1990). Resistance mechanisms in sweet potato whitefly (Homoptera: Aleyrodidae) population from Sudan, Turkey, Guatemala and Nicaragua. *Journal of Economic Entomology, 83*: 1665-1670.

Dubey, V. K., Bhagat, K. P., Kaushik, U. K and Yadav, Y. K. (1999). Insect pest succession studies on okra. *Journal of Applied Zoological Researches*, *10*(2): 144-145.

Gowdar, S. B., Babu, H. N. R and Reddy, N. A. (2007). Efficacy ofinsecticideson okra yellow vein mosaic virus and whitefly vector, *Bemisia tabaci* (Guenn.). *Annals of Plant Protection Sciences*, *15*(1): 116-119.

Mahapatro, G.K and Gupta, G.P. (1998). Pesticide induced resurgence. *Pestology*, *22*: 14-20.

Maurya, K. K., Sandeep Singh., Singh, R. S and Maurya, S. P. (2014). The evaluation of different insecticides against shoot and fruit borer (*E. vitt ella*) onokracrop. *Journal of Experimental Zoology, 17* (2): 843-847.

Palumbo, J. C., Horowitz, A. R. and Prabhaker, N. (2001). Insecticidal control and resistance management for *Bemisiatabaci*. *Crop Protection*, *20*: 739-765.

Preetha, G., Manoharan, T., Stanley, J and Kuttalam, S. (2009). Evaluation of imidacloprid against okra jassid, *Amrasca biguttula* (Ishida) and whitefly, *Bemisia tabaci* (Gennadius). *Indian Journal of Entomology*, *71*(3): 209-214.

Rana, S. C., Singh, P. B., Pandita, V. K and Sinha, S. N. (2006). Evaluation of insecticides as seed treatment for control of early sucking pests in seed crop of okra. *Annals of Plant Protection Sciences*, *14*(2): 364-367.

Sheedi, M. A. (1980). Arthropods associated with okra (*Hibiscus esculentus* L.) crop. *M. Sc. thesis,* Sindh Agriculture University, Tandojam. pp.58.

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