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Efficacy of chemical and botanical insecticides against sucking insect pest complex on Okra (*Abelmoschus esculentus* L. Moench)

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Abstract
The present investigation was carried out to study the bioefficacy of some insecticides against sucking insect pest of okra during *kharif* season 2015 at the Vegetable research farm, JNKVV, Jabalpur, Madhya Pradesh. The treatments imidacloprid 17.8% SL (35.6 g a.i./ha) was found to be significantly effective against jassid *Amrasca biguttula biguttula* (Ishida), aphid *Aphis gossypii* Glover and whitefly *Bemisia tabaci* (Gennadius) as it recorded lowest population. The next effective treatments was difenthiuron 50 WP (300 g a.i./ha), followed by imidacloprid 17.8% SL @ 17.8 g a.i./ha and thiamethoxam 25% WG @ 25 g a.i./ha, but found at par to each other against all the sucking insect pest of okra. Whereas other insecticides emamectin benzoate 5% SG @ 12 g a.i./ha and emamectin benzoate 5% SG @ 10 g a.i./ha were the next group of better treatments. Treatment NSKE 5% @ 750 g a.i./ha although found least effective, but it was significantly superior to control.

Keywords: Jassid, Aphid, Whiteflies, imidacloprid, Okra

1. Introduction
Vegetables constitute an important item of our food, supplying vitamins, carbohydrates and minerals needed for a balanced diet. Their value is important especially in under developed and developing countries like India. Okra (*Abelmoschus esculentus* L. Moench) popularly known as bhindi or lady's finger is an important vegetable crop grown in India[17]. It is a polyploidy, belong to family Malvaceae with $2n = 8x = 72,144$ chromosome. It is an often cross pollinated crop, occurrence of out crossing to an extent of 4-19 per cent with the maximum of 42.2 per cent is noticed with insect assisted pollination [9].

Okra is a "scavenger" crop where more valuable crops had been previously cultivated to scavenge any fumigation benefits or residual fumigation benefits or residual fertilizer. This is the only vegetable which can be grown throughout the year. Its cultivation fetches handsome income to the growers [5].

India is a major vegetable producing and consuming country, vegetables form an important dietary component. Among them okra, *Abelmoschus esculentus* L. Moench, is one of the popular and commercially cultivated vegetable crops is an important crop grown throughout the year [3]. Besides India, okra is also grown in many tropical and subtropical parts of the world. Tender fruits are used as vegetables or in culinary preparations as sliced and dried pieces. It is also used for thickening of gravies and soups, because of its high mucilage content. The roots and stems of okra are used for cleaning cane juice [8]. The matured fruits and stems containing crude fibre are used in paper industry. Okra is cultivated for its immature fruits to be consumed as a fresh and canned food as well as for seed purpose.

Okra is widely cultivated in plans of the India with acreage of 524.0 mha. and production 6203.0 MT and productivity 11.83 MT/ha. In Madhya Pradesh, okra is grown in 26.51 mha. area with production of 305.90 MT and 11.5 MT/ ha productivity [6].

The shoot and fruit borer, *E. vittella* is a serious pest while among the sucking pests, okra jassids, *Amrasca biguttula biguttula* (Ishida), whitefly, *Bemisia tabaci* (Gennadius) and aphids (*Aphis gossypii* Glover) are considered as major sucking pests cause significant damage to the crop [4]. The productivity of okra is low due to many factors and one of the most important constraints in production is the attack of insect pests. Aphid (*A. gossypii*), shoot and fruit borer, *Earias insulana* (Boisduval) and *E. vittella* (*fabricius*) and Jassid, *A. biguttula biguttula*

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(*Ishida*) are most serious pests of okra and cause 45.00-57.10% damage to fruits [20, 16].

The sucking pest complex of okra includes aphids, leaf hoppers, whiteflies, thrips and mites causes 17.46% yield loss and failure to control them in initial stages was reported to cause 54.04% yield loss [7, 4]. The idea of controlling pests by using various agro-techniques in combination with selective use of insecticides making compatible with other components of the management of okra pests are gaining importance as the most effective measure.

The present investigation done to observe the efficacy of chemical and botanical insecticides against sucking insect pest complex on okra (*A. esculentus* L. Moench).

2. Materials and Methods
The present experiment entitled, "Efficacy of Chemical and Botanical Insecticides against Sucking Insect Pest Complex on Okra (*Abelmoschus esculentus* L. Moench)" was carried out at the Vegetable research farm, JNKVV, Jabalpur, Madhya Pradesh during *kharif* season 2015.

2.1 Method of observation
Pre treatment observations were recorded 24 hours before spraying and post treatment observation were taken 1st, 5th, 7th, and 10th day after application of treatment. A total of six leaves, each two leaves from upper, middle and lower canopy of the plant were carefully examined for the presence of total nymphs and adults of jassid (*A. biguttula biguttula* Ishida), aphid (*A. gossypii* Glover), whitefly (*B. tabaci* Genn.). Observations were carried out on 5 randomly selected plants, twice in a standard week.

Table 1: Treatment details of Insecticides

Treatment code	Treatments	a.i. g/ha	Dose g/ml/ha
T$_1$	NSKE 5%	750	15000
T$_2$	Difenthiuron 50 WP	300	600
T$_3$	Imidacloprid 17.8% SL	17.8	100
T$_4$	Imidacloprid 17.8% SL	35.6	200
T$_5$	Thiamethoxam 25% WG	25	100
T$_6$	Emamectin benzoate 5% SG	10	200
T$_7$	Emamectin benzoate 5% SG	12	240
T$_8$	Control	-	-

2.2 Statistical Analysis of data
(i) Correlation and regression studies
Correlation and regression of the abiotic factors on major insects were worked out by using the formula as suggested by [19].

$$Correlation\ 'r' = \frac{\sum xy - \frac{\sum x . \sum y}{n}}{\sqrt{\left\{\sum_x 2 - \frac{((\sum x)^2)}{n}\right\}\left\{\sum_y 2 - \frac{((\sum y)^2)}{N}\right\}}}$$

Regression $\hat{Y} = a + bx\ (R^2)$
a = Intercept.
b = Regression coefficient.
R^2 = Coefficient of multiple determination.
Test of significance 'r'

$$t = \frac{r}{\sqrt{1 - r^2}}\sqrt{n - 2}$$

(ii) Analysis of variance
Following analysis of variance were used-

Table 2: Skeleton of Analysis of Variance (ANOVA)

Sources of variance	D.F.	S.S.	M.S.S.	Fcal.	F tab.
Replication	(r-1)	SSR	VR	VR/VE	
Treatments	(t-1)	SST	VT	VT/VE	F at 5% (t-1), (r-1) (t-1)
Error	(r-1) (t-1)	SSE	VE	-	-
Total	(r.t-1)	-	-	-	-

where,
r = number of replications
t = number of treatments
VR = replication mean sum of square
VT = treatment mean sum of square
VE = error mean sum of square

The significance among different treatment means was judged by critical difference (C.D.) at 5% level of significance for comparison among the treatments, for which the marginal means of each treatment was considered.

The following formula was used for various estimations:

Standard error of mean = SEm± = $\sqrt{\frac{Ems}{r}}$

Critical difference (C.D.) = SEm ± X √2 x t0.05
where,
Ems = error mean sum of square
t = 't' value at 5% level at error d.f.
r = number of replications
SEm± = Standard error of any treatment mean
CD = Critical Difference

3. Results and discussion
3.1 Jassid
On the basis of overall mean of three sprays, all the insecticidal treatments significantly reduced the jassid population as compared to control (127.50 jassids/30 leaves). Among the treatments, imidacloprid 17.8% SL @ 35.6 g a.i./ha. was found to be significantly effective among all the treatments as it recorded lowest jassid population (31.72 jassids/30 leaves). The next effective treatment was difenthiuron 50 WP @ 300 g a.i./ha (40.77 jassids/30 leaves) followed by imidacloprid 17.8% SL @ 17.8 g a.i./ha (50.66 jassids/30 leaves) and thiamethoxam 25% WG @ 25 g a.i./ha (51.83 jassids/30 leaves) but found at par to each other. Emamectin benzoate 5% SG @ 12 g a.i./ha (68.80 jassids/30 leaves) and emamectin benzoate 5% SG @ 10 g a.i./ha (79.88 jassids/30 leaves) were the next group of better treatments. Treatment NSKE 5% @ 750 g a.i./ha (93.36 jassid/30 leaves) although found least effective, but it was significantly superior to control (Table 3).

In conformity to the present findings, Ghosalwad *et al.* [11] also reported that imidacloprid 17.8% at 40 g a.i. was found most effective. Whereas Aarwe *et al.* [1] reported that thiamethoxam 25 WG @ 50 g a.i./ha was found most effective while imidacloprid and emamectin benzoate were found moderate against jassid. Similarly Preetha *et al.* [18], Acharya *et al.*,[2] and Maienfisch *et al.* [15] found that thiamethoxam and imidacloprid showed the similar levels of protection against jassids in okra. In contrary to the present findings Jatav [13] reported that lowest jassid population was recorded in the treatment of emamectin benzoate 5% SG @ 8.5 g a.i./ha.

3.2 Aphid

On the basis of overall mean of three spray, all the insecticidal treatments significantly reduced the aphid population as compared to control (56.38 aphids/30leaves). Among the treatments, imidacloprid 17.8% SL @ 35.6 g a.i./ha. was found to be significantly effective among all the treatments as it recorded lowest aphid population (10.77 aphids/30 leaves). The next effective treatments was difenthiuron 50 WP @ 300 g a.i./ha (18.05 aphids/30 leaves) followed by imidacloprid 17.8% SL @ 17.8 g a.i./ha (23.36 aphids/30 leaves) and thiamethoxam 25% WG @ 25 g a.i./ha (24.22 aphids/30 leaves) but both were found at par to each other. Emamectin benzoate 5% SG @ 12 g a.i./ha (34.13 aphids/30 leaves) and emamectin benzoate 5% SG @ 10 g a.i./ha (42.00 aphids/30 leaves) were the next group of better treatments. Treatment NSKE 5% @ 750 g a.i./ha (48.44 aphid/ 30 leaves) was found least effective among all the insecticide treatments (Table 4).

In accordance with the present findings Ghosal et al., [10] and Konar et al. [14] also reported that imidacloprid 17.8% @ 50 g a.i. and 30 g a.i./ha respectively was found to be most effective against aphids in okra, whereas Maienfisch et al.,[15] reported that thiamethoxam provides excellent control against broad range of commercially important pests including aphids.

3.3 Whiteflies

On the basis of overall mean of third spray, imidacloprid 17.8% SL @ 35.6 g a.i./ha. was found to be significantly effective among all the treatments as it recorded lowest whitefly population (7.00 whiteflies/30 leaves). The next effective treatment was difenthiuron 50 WP @ 300 g a.i./ha (13.75 whiteflies/ 30 leaves) followed by imidacloprid 17.8% SL @ 17.8 g a.i./ha (20.08 whiteflies/30 leaves) and thiamethoxam 25% WG @ 25 g a.i./ha (20.92 whiteflies/30 leaves) but both were found at par to each other. Emamectin benzoate 5% SG @ 12 g a.i./ha (28.58 whiteflies/30 leaves) and emamectin benzoate 5% SG @ 10 g a.i./ha (36.50 whiteflies/30 leaves) were the next better treatments, while NSKE @ 750 g a.i./ha (43.92 whiteflies/30 leaves) was the least effective. All the insecticidal treatments have significantly reduced the whitefly population as compared to control (54.17 whiteflies/30 leaves) (Table 5).

Similarly Preetha et al., [18] also reported that imidacloprid 17.8 SL at 25 g a. i./ha was found effective against jassid and whiteflies, while thiamethoxam also provided similarly level of protection as that of imidacloprd. Whereas Harinkhare,[12] revealed that difenthiuron 50 WP @ 300 g a.i./ha showed lowest population of *B. tabaci*.

Table 3: Efficacy of different insecticides against jassid infesting okra (Mean of all three spray).

Treatment Code	Treatment	Dose g a.i./ha.	Mean population of jassid/30 leaves				Mean	Overall mean of three sprays
			Days after third spray					
			1	5	7	10		
T₁	NSKE 5%	750	86.00 (9.27)	93.33 (9.66)	92.00 (9.59)	93.66 (9.68)	91.25 (9.55)	93.36 (9.66)
T₂	Difenthiuron 50 WP	300	35.66 (5.97)	38.33 (6.19)	38.33 (6.19)	41.33 (6.43)	38.42 (6.20)	40.77 (6.38)
T₃	Imidacloprid 17.8 SL	17.8	44.33 (6.66)	45.66 (6.76)	47.00 (6.86)	48.66 (6.98)	46.42 (6.81)	50.66 (7.11)
T₄	Imidacloprid 17.8 SL	35.6	29.00L (5.39)	30.66L (5.54)	31.00L (5.57)	29.66L (5.45)	30.08L (5.48)	31.72L (5.63)
T₅	Thiamethoxam 25 WG	25	45.66 (6.76)	46.66 (6.83)	48.00 (6.93)	49.33 (7.02)	47.42 (6.89)	51.83 (7.19)
T₆	Emamectin benzoate 5 SG	10	77.00 (8.77)	81.33 (9.07)	82.33 (9.07)	81.33 (9.02)	80.50 (8.97)	79.88 (8.29)
T₇	Emamectin benzoate 5 SG	12	65.66 (8.10)	71.00 (8.43)	71.00 (8.43)	68.00 (8.25)	68.92 (8.30)	68.80 (8.29)
T₈	Control	-	137.66H (11.73)	142.66H (11.49)	132.00H (11.49)	123.00H (11.09)	133.83H (11.56)	127.50H (11.29)
SEm±			0.10	0.13	0.12	0.13	0.08	0.12
CD at 5%			0.31	0.41	0.36	0.39	0.26	0.39

Figures in parentheses are √x square root transformed values, L- Lowest, H- Highest

Table 4: Efficacy of different insecticides against aphid infesting okra (Mean of all three spray).

Treatment Code	Treatment	Dose g a.i./ha.	Mean population of aphid/30 leaves				Mean	Over all mean of three sprays
			Days after third spray					
			1	5	7	10		
T₁	NSKE 5%	750	51.66 (7.19)	49.33 (7.02)	46.33 (6.81)	44.33 (6.66)	47.92 (6.92)	48.44 (6.96)
T₂	Difenthiuron 50 WP	300	17.33 (4.16)	14.66 (3.83)	15.33 (3.92)	12.33 (3.51)	14.92 (3.86)	18.05 (4.83)
T₃	Imidacloprid 17.8 SL	17.8	24.00 (4.90)	22.66 (4.76)	21.33 (4.62)	21.33 (4.62)	22.33 (4.72)	23.36 (4.83)
T₄	Imidacloprid 17.8 SL	35.6	11.33L (3.37)	8.66L (2.94)	6.66L (2.58)	6.66L (2.58)	8.33L (2.82)	10.77L (3.28)
T₅	Thiamethoxam 25 WG	25	25.33 (5.03)	23.66 (4.86)	22.33 (4.73)	22.00 (4.69)	23.33 (4.83)	24.22 (4.92)
T₆	Emamectin benzoate 5 SG	10	45.33 (6.73)	41.66 (6.45)	39.33 (6.30)	37.33 (6.11)	41.00 (6.40)	42.00 (6.48)
T₇	Emamectin benzoate 5 SG	12	36.00 (6.00)	33.66 (5.80)	31.66 (5.63)	30.33 (5.51)	32.92 (5.73)	34.13 (5.84)
T₈	Control	-	59.66H (7.72)	56.33H (7.51)	55.66H (7.46)	52.33H (7.23)	56.00H (7.48)	56.38H (7.50)
SEm±			0.14	0.11	0.12	0.13	0.04	0.09
CD at 5%			0.44	0.33	0.38	0.40	0.14	0.28

Figures in parentheses are √x square root transformed values, L- Lowest, H- Highest

Table 5: Efficacy of different insecticides against whiteflies infesting okra (Mean of all three spray)

Treatment Code	Treatment	Dose g a.i./ha.	Mean population of whitefly/30 leaves Days after third spray				Mean	Over all mean of three sprays
			1	5	7	10		
T₁	NSKE 5%	750	44.33 (6.66)	42.33 (6.51)	43.66 (6.61)	45.33 (6.73)	43.92 (6.63)	45.88 (6.67)
T₂	Difenthiuron 50 WP	300	13.33 (3.65)	14.00 (3.74)	12.33 (3.51)	15.33 (3.92)	13.75 (3.71)	14.52 (3.81)
T₃	Imidacloprid 17.8 SL	17.8	19.33 (4.40)	19.33 (4.40)	20.00 (4.47)	21.66 (4.65)	20.08 (4.48)	20.63 (4.54)
T₄	Imidacloprid 17.8 SL	35.6	6.66L (2.58)	7.00L (2.65)	6.66L (2.58)	7.66L (2.77)	7.00L (2.64)	8.88L (2.97)
T₅	Thiamethoxam 25 WG	25	20.33 (4.51)	20.33 (4.51)	20.66 (4.55)	22.33 (4.73)	20.92 (4.57)	21.44 (4.63)
T₆	Emamectin benzoate 5 SG	10	36.66 (6.06)	34.00 (5.83)	37.33 (6.11)	38.00 (6.16)	36.50 (6.04)	37.52 (6.12)
T₇	Emamectin benzoate 5 SG	12	27.33 (5.23)	26.00 (5.10)	29.66 (5.45)	31.33 (5.60)	28.58 (5.34)	31.08 (5.57)
T₈	Control	-	52.66H (7.26)	53.33H (7.30)	54.33H (7.37)	56.33H (7.51)	54.17H (7.36)	55.36H (7.44)
SEm±			0.08	0.12	0.14	0.12	0.04	0.07
CD at 5%			0.25	0.39	0.44	0.36	0.13	0.23

Figures in parentheses are √x square root transformed values, L- Lowest, H- Highest

4. Conclusion

The bioefficacy of insecticides namely the treatments imidacloprid 17.8% SL (35.6 g a.i./ha) was found to be significantly effective against jassid *A. biguttula biguttula* (Ishida), aphid *A. gossypii* Glover and whitefly *B. tabaci* (Gennadius) as it recorded lowest population. The next effective treatments was difenthiuron 50 WP (300 g a.i./ha), followed by imidacloprid 17.8% SL @ 17.8 g a.i./ha and thiamethoxam 25% WG @ 25 g a.i./ha, but found at par to each other against all the sucking insect pest of okra. Whereas other insecticides emamectin benzoate 5% SG @ 12 g a.i./ha and emamectin benzoate 5% SG @ 10 g a.i./ha were the next group of better treatments. Treatment NSKE 5% @ 750 g a.i./ha although found least effective, but it was significantly superior to

5. Acknowledgement

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