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Population dynamics and comparative efficacy of neem products, bioagents and insecticides against leafhopper of okra *Abelmoschus esculentus* L. Moench

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Abstract
The present investigation entitled "Population dynamics and comparative efficacy of neem products, bioagents and insecticides against Leafhopper of okra *Abelmoschus esculentus* (L.) Moench, cultivar i.e. VNR-22 (Komal) was conducted during July, to November, 2016 at Central Field of agriculture, SHUATS, Allahabad. The occurence of leafhopper (*Amrasca biguttula biguttula*), commenced from 34th standard week (August fourth week) with an average population of 1.45(leafhoppers/3leaves) and then the population gradually increased and reached to its peak level by 41st standard week (October second week) with an average population of 13.77(leafhoppers/3leaves) respectively. There after declined trend was observed as temperature decreased. It was found that population of leafhopper increased with increasing maximum temperature and positively correlated with maximum temperature. Seven treatments i.e., Neemoil@2%, Thiamethoxam@0.2ml/L, *Verticillium lecanii* @2g/L, *Metarhizium anisopliae* @2g/L, *Beauveria bassiana* @2.5g/L, NSKE@5%, and Acetamiprid@0.2ml/L were evaluated against leafhopper (*Amrasca biguttula biguttula.*). Minimum population of hopper infestation was observed in Thiamethoxam with (1.903Leafhoppers/3leaves) followed by Acetamiprid (1.955Leafhoppers/3leaves)< Neem oil (5.023 Leafhoppers/3leaves)< *Beauveria bassiana*(5.685 Leafhoppers/3leaves)< *Verticillium lecanii* (6.178 Leafhoppers/3leaves)< NSKE (6.395 Leafhoppers/3leaves)< *Metarhizium anisopliae* (6.676 Leafhoppers/3leaves)<untreated control (water spray) (9.906 Leafhoppers/3leaves) respectively.

Keywords: Bioagents, neem products, chemical insecticides, whitefly, leafhopper, okra

Introduction
Okra, *Abelmoschus esculentus* (L), a malvaceous vegetable which is cultivated throughout the tropical and warm temperate regions of the world. Among the cultivated fruit vegetables grown in the country, okra (*Abelmoschus esculentus* L. Moench) is one of the important commercially cultivated vegetable crops, popularly called as Bhindi or Lady's finger. One of the important limiting factors in the cultivation of okra is insect pests. Many of the pests occurring on cotton are found to ravage okra crop. As high as 72 species of insects have been recorded on okra (Srinivasa and Rajendran, 2003) of which, the sucking pests comprising of leafhopper (*Amrasca biguttula biguttula* Ishida), whitefly (*Bemisia tabaci* Gennadius) causes significant damage to the crop. Krishnaiah (1980) [4] reported about 40-56 percent losses in okra due to leafhopper. Indiscriminate and injudicious uses of conventional insecticides for management of these insect pests have been causing different environmental hazards including resurgence, resistance and residue problem in food stuff. Therefore, the present experiment was conducted to evaluate some biopesticides along with chemical insecticides for an effective integrated management of leafhopper in okra,along with a brief study of the population dynamics of the pest.

Materials and Methods
The experiment was conducted during kharif season 2016 at the Central Field of Agriculture, S.H.U.A.T.S, Allahabad, Uttar Pradesh, India, in a randomized block design with eight treatments replicated three times using variety VNR-22(Komal) in a plot size of (2m×1.5m) at a spacing of(45×30cm) with recommended package of practices excluding plant protection. For population dynamics of the leafhopper, the population was recorded in weekly interval starting from the appearance of the pest. The observation of the pest was recorded from the five randomly selected plants from every plot. The data was statistically analysed by correlation analysis between weather parameters and leafhopper. Two insecticidal sprays were administrated at15 days interval starting from 35 days after sowing.

The insecticide treatments include Neemoil@2%, Thiamethoxam25WG@0.2ml/L, *Verticillium lecanii* @2g/L, *Metarhizium anisopliae*@2g/L, *Beauveria bassiana* @2.5g/ L, NSKE@5%, and Acetamiprid 20SP@0.2ml/L. Along with untreated control. The spraying was done after the population reaching its ETL. The incidence of leafhopper was recorded from the five randomly selected and tagged plants from each plot. The number of Jassids per leaf were calculated based on the number of insects on three leaves, each taken from top, middle and bottom of each plant. The observations are made a day before followed by 3rd, 7th, 14th days after spraying. Observations were recorded without disturbing the plants to minimise the observational errors. Population of sucking pest was recorded from each net plot and the population was worked out per 3 leaves

Results and Discussion

Studies on the incidence of *Amrasca biguttula biguttula* population with weather parameters are given table 1. The incidence of leafhopper on okra during kharif season 2016 commenced from 34th standard week (August fourth week) with an average population of 1.45(leafhoppers/3leaves) and then the population gradually increased and reached to its peak level by 41st standard week (October second week) with an average population of 13.77 (leafhoppers/3leaves) respectively. There after declined trend was observed and population of leafhopper reached 1.10 (leafhoppers/3leaves). Similar, observations are reported by Aastik Jha *et al.* (2013) [2]. Similarly, Kumawat *et al.* (2000) [5] reported the hopper infestation peak during September and October. The result of efficacy of insecticides on leafhopper infestation of okra has been represented in Table 2. The result revealed that all the treatments proved significantly effective in controlling the leafhopper infestation over untreated plot as evidence from data collected on its incidence on plants. Among the treatments, lowest infestation of leafhopper was recorded in thiamethoxam (1.903Leafhoppers/3leaves) followed by acetamiprid (1.955Leafhoppers/3leaves) which are statistically at par with each other. Treatments Neem oil (5.023 Leafhoppers/3leaves) followed by *Beauveria bassiana* (5.685 Leafhoppers/3leaves) and *Verticillium lecanii* (6.178 Leafhoppers/3leaves), are next best and are at par with each other, followed by NSKE (6.395 Leafhoppers/3leaves) and *Metarhizium anisopliae* (6.676 Leafhoppers /3leaves) are least effective among all the treatments and are at par with each other. Thiamethoxam was found very effective in reducing the infestation of leafhopper. Same trend was observed by Tamoghna Saha *et al.,* (2016) [11] who reported that application of thiomethoxam reduced the hopper incidence. Khaja Rumana Begum *et al*., (2016) [3] studied that thiamethoxam effective against leafhopper recorded lowest infestation and damage. Acetamiprid the next best treatment is also reported to reduce the leafhopper infestation remarkably as that of the thiamethoxam which is supported by Misra *et al.,* (2003) [6] and Rajendran *et al*., (2003) [10].

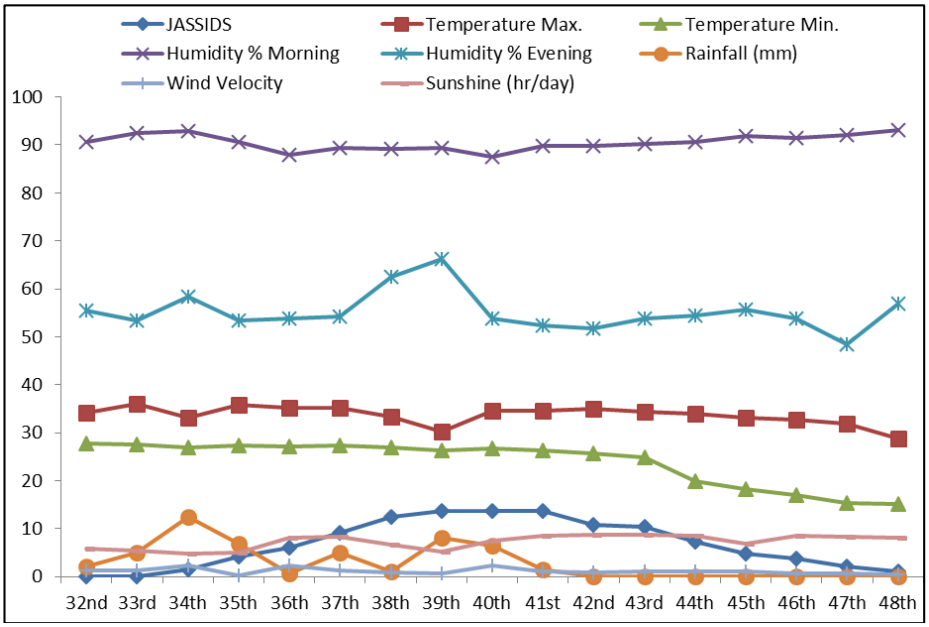

Fig 1: Population dynamics of jassid [*Amrasca biguttula biguttula* (Ishida)] during *Kharif* season in2016.

Table 1: Population dynamics of Leafhopper [*Amrasca biguttula biguttula* (Ishida)] during *Kharif* season in 2016

Standard week	Jassid	Temperature		Humidity %		Rainfall (mm)	Wind Velocity	Sunshine (hr/day)
		Max.	Min.	Morning	Evening			
32nd	0	34.08	27.74	90.57	55.42	2.2	1.33	5.82
33rd	0	35.97	27.51	92.42	53.42	5	1.28	5.34
34th	1.45	33.22	27	92.85	58.28	12.48	2.22	4.8
35th	4.17	35.82	27.28	90.57	53.42	6.94	0.25	5.07
36th	6.13	35.14	27.2	87.85	53.85	0.65	2.26	8.08
37th	9.21	35.25	27.28	89.42	54.28	4.91	1.26	8.34
38th	12.36	33.28	26.87	89.14	62.57	1.14	0.87	6.62
39th	13.59	30.25	26.22	89.42	66.28	8.08	0.66	5.28
40th	13.68	34.65	26.68	87.42	53.85	6.37	2.22	7.45
41st	13.77	34.48	26.34	89.85	52.28	1.42	1.01	8.52
42nd	10.72	35.05	25.77	89.71	51.71	0	0.81	8.77

43rd	10.32	34.37	24.8	90.28	53.71	0	1.01	8.75
44th	7.22	33.97	19.82	90.71	54.42	0	1.08	8.57
45th	4.76	33.14	18.20	91.80	55.70	0.00	1.02	6.90
46th	3.66	32.70	16.90	91.40	53.80	0.00	0.60	8.50
47th	2.16	31.90	15.30	92.00	48.50	0.00	0.60	8.40
48th	1.1	28.88	15.15	93.14	57.00	0.00	0.55	8.14
	R	0.103	0.346	-0.754	0.269	-0.013	0.034	0.299
	t=	0.401	1.429	-4.445	1.083	-0.050	0.130	1.212
	Results	NS	NS	S	NS	NS	NS	NS

Table 2: Comparative efficacy of neem products, bioagents and insecticides against Leafhopper of okra *Abelmoschus esculentus* L.Moench., First spray at 35 DAS*

Treatments		Concentration/ Dose	Number of Hoppers / 3 leaves				
			1 DBS	3 DAS	7 DAS	14 DAS	Mean
T_0	Untreated	-	6.240 (2.499)	6.250 (2.499)	7.580 (2.750)	8.120 (2.845)	7.316 (2.709)
T_1	Neemoil	3 ml/L	6.033 (2.452)	3.210 (1.795)	4.100 (2.082)	4.250 (2.065)	3.853 (1.953)
T_2	Thiamethoxam	0.2ml/L	5.926 (2.434)	1.050 (1.025)	1.020 (1.008)	1.030 (1.018)	1.033 (1.015)
T_3	*Metarhizium anisopliae*	2 g/L	6.130 (2.478)	5.250 (2.292)	4.420 (2.103)	5.620 (2.374)	5.096 (2.257)
T_4	*Verticillium lecanii*	2 g/L	6.220 (2.497)	5.130 (2.269)	4.173 (2.048)	5.320 (2.304)	4.873 (2.207)
T_5	NSKE	5 ml/L	6.126 (2.472)	5.220 (2.286)	4.240 (2.051)	5.360 (2.311)	4.940 (2.216)
T_6	Acetamiprid	0.2ml/L	5.840 (2.415)	1.190 (1.098)	1.030 (1.018)	1.050 (1.024)	1.090 (1.044)
T_7	*Beauveria bassiana*	2.5g/L	6.120 (2.467)	4.060 (2.019)	4.170 (2.040)	5.303 (2.308)	4.511 (2.119)
Overall mean		-	6.079	3.920	3.841	4.506	4.089
F- test		-	NS	S	S	S	S
S. Ed. (±)		-	0.159	0.057	0.077	0.068	0.411
C. D. (P = 0.05)		-	0.341	0.122	0.165	0.145	0.881

Figures in parenthesis are Square root transformed values
DBS-Days before spray, DAS-Days after spray, DAS*-Days after sowing

Table 3: Comparative efficacy of neem products, bioagents and insecticides against Leafhopper of okra *Abelmoschus esculentus* L. Moench., Second spray at 55DAS*

Treatments		Concentration/ Dose	Number of Hoppers / 3 leaves				
			1 DBS	3 DAS	7 DAS	14 DAS	Mean
T_0	Untreated	-	12.056 (3.472)	11.560 (3.399)	12.340 (3.517)	13.590 (3.684)	12.496 (3.530)
T_1	Neemoil	3 ml/L	11.966 (3.452)	5.860 (2.424)	5.660 (2.370)	7.060 (2.650)	6.193 (2.486)
T_2	Thiamethoxam	0.2ml/L	11.940 (3.454)	2.800 (1.675)	2.460 (1.565)	3.060 (1.742)	2.773 (1.666)
T_3	*Metarhizium anisopliae*	2 g/L	11.950 (3.458)	8.430 (2.907)	8.320 (2.883)	8.020 (2.839)	8.256 (2.872)
T_4	*Verticillium lecanii*	2 g/L	11.903 (3.451)	7.460 (2.731)	7.530 (2.740)	7.460 (2.739)	7.483 (2.735)
T_5	NSKE	5 ml/L	11.940 (3.454)	8.000 (2.823)	8.060 (2.830)	7.463 (2.735)	7.841 (2.797)
T_6	Acetamiprid	0.2ml/L	12.043 (3.473)	2.860 (1.691)	2.500 (1.575)	3.110 (1.763)	2.823 (1.676)
T_7	*Beauveria bassiana*	2.5g/L	11.953 (3.453)	6.860 (2.617)	6.660 (2.586)	7.066 (2.653)	6.862 (2.613)
Overall mean		-	11.968	6.728	6.691	7.103	6.840
F- test		-	NS	S	S	S	S
S. Ed. (±)		-	0.025	0.208	0.143	0.106	0.388
C. D. (P = 0.05)		-	0.053	0.446	0.306	0.227	0.832

Table 4: Comparative efficacy of neem products, bioagents and insecticides against sucking insect pests of okra *Abelmoschus esculentus* L. Moench. (First and Second spray pooled mean)

Treatments		Concentration/ Dose	Number of Hoppers / 3leaves		
			I-Spray	II-Spray	Overall Mean
T_0	Untreated	-	7.316 (2.709)	12.496 (3.530)	9.906 (3.118)
T_1	Neemoil	3 ml/L	3.853 (1.953)	6.193 (2.486)	5.023 (2.227)
T_2	Thiamethoxam	0.2ml/L	1.033 (1.015)	2.773 (1.666)	1.903 (1.347)
T_3	*Metarhizium anisopliae*	2 g/L	5.096 (2.257)	8.256 (2.872)	6.676 (2.563)
T_4	*Verticillium lecanii*	2 g/L	4.873 (2.207)	7.483 (2.735)	6.178 (2.474)
T_5	NSKE	5 ml/L	4.940 (2.216)	7.841 (2.797)	6.395 (2.513)
T_6	Acetamiprid	0.2ml/L	1.090 (1.044)	2.823 (1.676)	1.955 (1.361)
T_7	*Beauveria bassiana*	2.5g/L	4.511 (2.119)	6.862 (2.613)	5.685 (2.377)
Overall mean		-	4.089	6.840	5.465
F- test		-	S	S	S
S. Ed. (±)		-	0.411	0.388	0.637
C. D. (P = 0.05)		-	0.881	0.832	1.336

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