Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(4): 3138-3144
Received: 07-05-2020
Accepted: 09-06-2020

Vishav Prakash Rahul
CSIR-Indian Institute of Integrative Medicine, Canal Road, Jammu, Jammu and Kashmir, India

Bhumika Kapoor
Project Assistant, CSIR-Indian Institute of Integrative Medicine, Canal Road, Jammu, Jammu and Kashmir, India

Sougata Sarkar
Research Associate, Scientist, CSIR-Indian Institute of Integrative Medicine, Canal Road, Jammu, Jammu and Kashmir, India

Sabha Jeet
Scientist, CSIR-Indian Institute of Integrative Medicine, Canal Road, Jammu, Jammu and Kashmir, India

Corresponding Author:
Vishav Prakash Rahul
CSIR-Indian Institute of Integrative Medicine, Canal Road, Jammu, Jammu and Kashmir, India

Seasonal incidence of *Ocimum* tingid bug, *Cochlochila bullita* Stal (Heteroptera: Tingidae) on three different species of *Ocimum viz. Ocimum basilicum* L., *Ocimum sanctum* L. and *Ocimum kilimandscharicum* Guerke

Vishav Prakash Rahul, Bhumika Kapoor, Sougata Sarkar and Sabha Jeet

DOI: https://doi.org/10.22271/phyto.2020.v9.i4ae.12093

Abstract

The field experiment was conducted on the seasonal incidence *Ocimum* lace bug on three different species of *Ocimum* viz. *Ocimum basilicum* L., *Ocimum sanctum* L. and *Ocimum kilimandscharicum* Guerke at CSIR- IIIM, Chatha Farm, Jammu. The data on seasonal fluctuations of *Ocimum* tingid bug, *Cochlochila bullita* on various species of *Ocimum* such as *Ocimum basilicum* L., *Ocimum sanctum* L. and *Ocimum kilimandscharicum* Guerke were first observed during 33rd standard week of August *i.e.* 0.40 Mean insect/ plant, 0.2 mean insect/plant and 0.20 mean insect/plant, respectively. The maximum lace bug population was recorded on sweet basil during 39th standard week *i.e.* 52.60 mean insect/ plant when weekly mean maximum temperature 29.7 °C, minimum temperature 23.1 °C, morning relative humidity 93.1% and evening relative humidity 75.90 %, rainfall 93.40 mm, and wind speed 2.00 km/hr, respectively. Similarly, the highest peak of lace bug on holy basil and camphor basil were recorded during 39th standard week (51.80 mean insect/plant) and 38th standard week (49.80 mean insect/ plant), respectively. Thereafter, the population of lace bug on various *Ocimum* spp decreased till 1st standard week up to 0.20 mean insect/ plant, respectively. A highly positive significant correlation was exhibited between weekly mean maximum temperature (0.603**) and minimum temperature (0.556**) on *Ocimum basilicum* pest population. Furthermore, the population of *Ocimum* tingid bug on *Ocimum sanctum* exhibited highly positively significant correlation with mean maximum temperature (0.585**) and minimum temperature (0.518*) whereas, on *Ocimum kilimandscharicum* showed a positive correlation with maximum (highly significant) (0.589**) and minimum temperature (highly significant) (0.535**), respectively were noted. The regression analysis indicated that all the weather parameters together were responsible for a significant variation of 57.50 %, 54.50 % and 50.50 % on the *Ocimum* lace bug incidence on three different species of *Ocimum* such as *Ocimum basilicum* L., *Ocimum sanctum* L. and *Ocimum kilimandscharicum* Guerke, respectively.

Keywords: *Ocimum basilicum* L., *Ocimum sanctum* L., *Ocimum kilimandscharicum* Guerke, *Cochlochila bullita* and seasonal incidence

Introduction

The genus *Ocimum* L., of sixth largest family Lamiaceae, commonly called as basil is an important aromatic and medicinal herb, widely distributed in tropical, subtropical, and warm temperate regions of the world (Paton *et al*., 1999) [24]. Due to substantial taxonomical complexity within the genus *Ocimum*, estimates of the species number may vary from 30 (Paton, 1992) [23] to 160 (Pushpangadan & Bradu, 1995) [28]. In India, only nine species of *Ocimum* are found, mainly confined to tropical and peninsular regions (Anonymous, 1966) [1]. Among all of the *Ocimum* species; *O. basilicum* L. (sweet basil), *O. sanctum* L. (holy basil) and *Ocimum kilimandscharicum* Guerke (camphor basil) have extensive distribution, which encompasses the entire Indian subcontinent and its hybrid is now being raised as both *Kharif* and *Rabi* crops in diverse sections of India including Jammu (Gulati and Suri, 1982, Kumar and Kumar, 2018 and Balyan and Pushpangadan, 1988) [13, 18, 4]. According to Pushpangadan & Bradu, 1995 [28] reports on *Ocimum*, *O. basilicum* is a herbaceous perennials with black, ellipsoid, strongly mucilaginous seeds, and *O. sanctum* (Syn. *Ocimum tenuiflorum*), consisting of perennial shrubs with brown, globose, non-mucilaginous, or weakly mucilaginous seeds. Whereas, *Ocimum kilimandscharicum*: an exotic West African species is a perennial shrub with ovoid-oblong, black to brown and mucilaginous seeds (Bhasin, 2012 and Joshi, 2013) [5, 15]. The *Ocimum* spp. extracts and essential oil have antioxidant, antibacterial, antifungal, insecticidal, antimicrobial, antibacterial, antifeedant, carminative, stimulant, antipyretic, and larvicidal activities (Bowers and Nishida, 1980; Elgayyar *et al*. 2001; Bozin *et al*. 2006; Trevisan *et al*. 2006; Gulcin *et al*. 2007; Politeo *et al*. 2007, Sathe *et al*., 2014 and Bhasin, M., 2012) [6, 11, 7, 40, 14, 27, 32, 5]. The *Ocimum* spp. essential oil consists of monoterpenes, sesquiterpenes, and phenylpropanoids which includes linalool, linalyl acetate, geraniol, methyl eugenol, safrole, camphor, 1, 8- cineole and germacren-D, methyl chavicol, eugenol, bergamotene, methyl cinnamate, citral, limonene, methyl cinnamate, caryophyllen-β, anethol, terpinen-4-ol, myrcene, thymol, ocimene, and cinnamaldehyde, respectively of principal use in food and cosmetic industries (Balyan & Pushpangadan, 1988; Vina & Murillo, 2003; Arabaci, 2004; Klimánková *et al.* 2008; Švecová *et al.* 2010 and Daneshian, 2013) [4, 43, 3, 16, 38, 8]. Trevisan *et al*. 2006 [40] found that traditionally *Ocimum* essential oil has been extracted from whole above ground herbage (stems, leaves, and flowers) using steam distillation.

In India, *Ocimum* spp. is grown as a plantation crop under an area about 25,000 ha along with the annual production of around 250-300 tonnes oil (Smitha *et al*, 2014) [36]. In the recent years, there is an increase in the demand of *Ocimum* raw materials in aromatic and pharmaceutical industries, concerns are rising over the loss incurred by the destructive pest i.e. *Cochlochila bullita* Stal (Syn. *Monanthia globulifera* Walk.) (Hemimptera - Heteroptera: Tingidae) known as *Ocimum* Lace Bug or *Ocimum* tingid (Palaniswami and Pillai, 1983 and Livingstone and Yacoob, 1987) [22, 20]. *Ocimum* tingid – *C. bullita* occurs in the old world tropics and it was mostly found in India, Thailand, China, Southern Asia, United States and Malaysia. It affects wide range of related Lamiaceae and several associated culinary and medicinal host plants (Samuel 1939; Sharga 1953; Tigvattnanont 1989; Stonedahl *et al*. 1992) [31, 34, 39, 37] that includes: *Ocimum kilmandscharicum* (camphor basil), *Ocimum basilcum* L. (sweet basil), *Ocimum tenuiflorum* L. (holy basil), *Mentha* spp. (Mint), *Lavandula* spp. (Lavender), *Orthosiphon stamineus* (Java tea) (Sajap & Peng, 2010) [30], *Rosmarinus officinalis* L. (rosemary), *Salvia officinalis* L. (sage), *Carthamus tinctorius* L. (safflower) (Stonedahl *et al*. 1992, Schaefer and Panizzi 2010) [37, 33], *Coleus parviflorus* Bentham (Chinese potato) (Palaniswami and Pillai, 1983 and Mohanasundaram and Rao,1973) [22, 21], *Orthosiphon aristatus* (Java tea, cat whiskers) (Peng *et al*. 2013) [26] and many more. The Adult of *Cochlochila bullita* about 2.5-3.0 mm long and dark brown in color, delicate minute bug that damages the host by feeding on the sap of living plants by piercing the epidermis with their very slender stylet. Their feeding activities may cause great injury by curling and drying of leaf tips, leaf dehiscence, and lowering the flower production (Mohanasundaran & Rao 1973, Palaniswami & Pillai 1983, Schaefer and Panizzi 2010) [21, 22, 33] and finally plasmolysis of the foliage (Sajap and Peng, 2010) [30]. In many instances, nymphs and adults feed gregariously on the leaves and leaving a black spots of excrement on the adaxial surface of a leaves (Giliomme, 2014) [12].

In India, *C. bullita* passes through five generations and infests plants during the summer months from July to December. During adverse/cold climatic conditions *i.e.* during December, adults hibernate in the plant debris and this is pest also found in low population level during the month of May (Giliomee, 2014) [12]. The highest population of lace bug was 67.3 (range 60-72) found in September (Sathe *et al*. 2014) [32] and 43.2 insects per plant was recorded during 52 standard week of December (Kumari *et al*. 2016) [19]. It has been estimated that *C. bullita* causes approximately 27.8 per cent yield loss (Anonymous, 2012-13) [2] and 33.33 per cent herbage yield loss was recorded in unprotected plot when compared with protected plot (Kumari *et al*. 2016) [19]. Therefore, there is need to attain substantial information on the occurrence and behaviour of insect with respective to meteorological factors, the level of insect infestation, the loss incurred by incidence and development of suitable and effective pest management practices in the Jammu region. Keeping the above facts in view, the present experiment was performed to study the seasonal incidence of *Ocimum* lace bug on various species of *Ocimum*.

Materials and Methods

To study the incidence of *Ocimum* lace bug on different species of *Ocimum* viz. *Ocimum basilicum* L., *Ocimum sanctum* L. and *Ocimum kilimandscharicum* Guerke and their correlation with the abiotic factors, the experiment was carried out at an experimental field, CSIR- IIIM, Chatha Farm, Jammu throughout the months from August 2019 to January 2020 on an existing trial using a fixed plot survey. The different species of *Ocimum i.e. Ocimum basilicum*, *Ocimum sanctum* and *Ocimum kilimandscharicum* were raised in bed measured 2.5 X 2 m^2 each, consisting of 4 rows and each row had 5 plants i.e. 20 plants/bed. Population of Ocimum lace bug were noted in the wee hours at weekly intervals by using appropriate sampling method by counting the number of bugs on five plants including twigs (10 cm) and five leaves were selected for observation of insect number. Observation was noted at weekly interval since 33rd meteorological week *i.e*., at start of appearance of lace bug – pest in the field and continued till cession of the lace bug.

The mean number of lace bugs including nymph and adult per plant was obtained by using the following formula (Kumari *et al*. 2016) [19]:

$$\text{Mean number of insects per plant} = \frac{n1 + n2 + n3 + n4 + n5}{5}$$

Where,

n = number of individual per plant

All the recommended agronomic practices were followed for raising the crop. The plots were kept without insecticidal canvas to allow *C. bullita* to multiply throughout the cropping season. The seasonal population of *C. bullita* on different *Ocimum* spp. *i.e. Ocimum basilicum* L., *Ocimum sanctum* L. and *Ocimum kilimandscharicum* Guerke was correlated with the weather parameters *viz*., temperature, rainfall, relative humidity and wind velocity which were recorded from the agro-meteorology section of SKUAST-Jammu and their mean population were calculated using statistical procedures.

Results and Discussions

The seasonal incidences of *Ocimum* tingid bug, *Cochlochila bullita* Stal were recorded at weekly intervals from 33rd Standard Week (SW) to 3rd SW on three different species of *Ocimum viz. Ocimum basilicum* L., *Ocimum sanctum* L. and *Ocimum kilimandscharicum* Guerke during 2019- 2020, respectively and are presented in Table 1.

Seasonal incidence of *Cochlochila bullita* on *Ocimum basilicum* L.

The population of Lace bug, *Cochlochila bullita* on Sweet Basil *Ocimum basilicum* was observed from 33rd standard week *i.e.* at start of appearance of lace bug- pest in the field. The initial population of lace bug started appearing from 33rd standard week of August (0.40 Mean insect/ plant). The weekly mean maximum temperature 32.7ºC, minimum temperature 26.2ºC, morning relative humidity 86 %, evening relative humidity 67.7 %, rainfall 131.10 mm and wind speed 4.60 km/hr, respectively was recorded. The highest peak of *C. bullita* was observed during 39th standard week recording a maximum of 52.60 mean insect/ plant when weekly mean maximum temperature 29.7ºC, minimum temperature 23.1ºC, morning relative humidity 93.1% and evening relative humidity 75.90 %, rainfall 93.40 mm, and wind speed 2.00 km/hr, respectively was recorded. Thereafter, the population of Lace bug on sweet basil decreased till 52th and 1st standard week *i.e.* 0.2 mean insect/ plant at the time of crop harvest (Table 1, Fig. 1).Among the various meteorological variables correlated with pest activity, a positively significant correlation exhibited with weekly mean maximum temperature (0.603**) and minimum temperature (0.556**) and negatively non- significant correlation with relative humidity morning (– 0.248) and evening (– 0.133) on *Ocimum basilicum* pest population. The influence of rainfall and wind speed remained non-significant (Table 2). The multiple linear regression equation was developed for Lace bug on Sweet basil with respect to abiotic factors *i.e.* Y^1= -99.521+ 6.400X_1 -4.821X_2 - 0.841X_3 + 2.006X_4 - 8.591X_5 + 0.063X_6, respectively. The combined influence of the abiotic factors positively influenced the population build-up of Lace bug, *Cochlochila bullita* on *Ocimum basilicum* with the coefficient of determination, R^2 = 0.575 (P= 0.05) (Table 3).

The present findings coincide with Rai *et al.*, 2018[29] who indicated that the highest incidence of *C. bullita* on *Ocimum basilicum* L. was recorded from 38th to 1st meteorological weeks during the three cropping year from 2015 to 2018, while the coefficient of the determination (R^2) between *C. bullita* with the weather parameters was 50%, 74% and 69%, respectively. The results are also in confirmation with the findings of Dhiman and Dutta, 2013[10] who reported that the *C. bullita* population on *O. basilicum* attained peak in September-November at Saharanpur. The study conducted by Zala *et al*., 2016[44] and Peng *et al*., 2014[25] who reported that the first incidence of Lace bug, *Cochlochila bullita* on *Ocimum basilicum* in middle Gujarat and Malaysia during year 2015 and 2010. Whereas, the results obtained by Kumari *et al.*, 2016[19] are contrary to the present findings who reported that the highest bug population accounted was 43.2 insects per plant during the month of December and the relative humidity morning and evening exhibited significant results in increasing the pest population on sweet basil.

Seasonal incidence of *Cochlochila bullita* on *Ocimum sanctum* L.

The *Cochlochila bullita* population on Holy basil *Ocimum sanctum* was observed from 33rd Standard Week of August (0.2 mean insect/plant) onwards and the lace bug population attained its peak during 39th standard week (51.80 mean insect/plant) when corresponding mean maximum temperature 32.7ºC, minimum temperature 26.2ºC, morning relative humidity 86 %, evening relative humidity 67.7 %, rainfall 131.10 mm and wind speed 4.60 km/hr, respectively was recorded. Thereafter, the *Cochlochila bullita* population decreased till 1st standard week on the holy basil up to 0.20 mean insect/ plant (Table 1, Fig.2). The coherent data on correlation coefficient between *Cochlochila bullita* population on *Ocimum sanctum* and weather factors are presented in Table 2. The data signified that the population of *Ocimum* tingid bug exhibited highly positively significant correlation with mean maximum temperature (0.585**) and minimum temperature (0.518*) and negatively non-significant correlation with relative humidity morning (– 0.238) and evening (– 0.177) and non- significant negative correlation with wind speed (– 0.337) and non-significant positive correlation with rainfall (0.077). The regression equation and coefficient of multiple determination of *Ocimum* tingid bug with respect to abiotic factors *i.e.* Y^2= -98.496 + 6.537X_1 - 5.057X_2 - 0.795X_3 + 1.932X_4 - 8.640X_5 + 0.079X_6, respectively. The combined influence of the abiotic factors positively influenced the rise in population of *Cochlochila bullita* on *Ocimum sanctum* with the coefficient of determination, R^2 = 0.545 (P= 0.05) (Table 3).

The result obtained by Sharma and Chaturvedi, 2018 [35] is relatively similar to the present findings who reported that among the weather parameters, maximum and minimum temperature exhibited positive and significant correlation (0.66, 0.59) and non-significantly inverse correlation with relative humidity (–0.09) with the Lace bug population and the mean highest population of lace bug noticed in the month of September (30.6 lace bugs/ plant) and lowest in the October month. This finding is in close conformity with to findings Kumar, 2014 [17] and Sathe *et al*., 2014 [32] who also reported that the maximum population of *C. bullita* per twig was found to be 71.2 and 67.3 (range 60-72) in the month of September. In antithetical to the present study, Das *et al.*, 2020 [9] depicted that the emergence of lace bug *C. bullita* population had a negative and significant correlation with the temperature while, peak population of bugs were reported during winters.

Seasonal incidence of *Cochlochila bullita* on *Ocimum kilimandscharicum* Guerke

The data showed that the earliest detection of *Cochlochila bullita* on *Ocimum kilimandscharicum* during 33rd standard week i.e. 0.20 mean insect/plant when corresponding mean maximum, mean minimum temperatures, rainfall, R.H. evening R.H. morning and wind speed were 32.7ºC, 26.2ºC, 131.10 mm, 86.0 %, 67.7 % and 4.60 km/hr, respectively (Table 1, Fig. 3). An eminent progression was noticed on 38th standard week with the peak activity of 49.80 mean insect/ plant, respectively. The corresponding maximum temperature during 38th SW was recorded to be 32.2°C and minimum temperature of 23.0°C for Lace bug. Among the various meteorological variables, the population of *Cochlochila bullita* on *Ocimum kilimandscharicum* had positive correlation with maximum (highly significant) (0.589**) and minimum temperature (highly significant) (0.535**), whereas, negative and non-significant correlation existed with morning and evening relative humidity (-0.251 and -0.170) and positive non-significant correlations with rainfall (0.095) and a negative non- significant relation with wind velocity (-0.312) during 2019-2020 experimental crop (Table 2). The multiple linear regression equation was developed for *Cochlochila bullita* on *Ocimum kilimandscharicum* with respect to abiotic factors i.e. Y^3= -44.102 + 4.075X_1 – 2.854X_2 - 0.656X_3 + 1.247X_4 - 8.577X_5 + 0.097X_6, respectively. The coefficient of determination (R^2) was found to be 0.505 for lace bug activity on Camphor basil. The overall impact of weather factors on lace bug *Cochlochila bullita* activity on *Ocimum kilimandscharicum* was 50.50 %, respectively (Table 3).

In contrary to *Ocimum basilicum* L. and *Ocimum sanctum* L., the limited attempts has been made to contemplate the population dynamics of *C. bullita* on *Ocimum* *kilimandscharicum*. The study conducted on camphor basil under laboratory conditions by Triveni *et al.*, 2017 [42] and Triveni *et al.*, 2018 [41] found that the incubation period of the eggs of *C. bullita* varied from 8.95 to 10.12 days, nymphs took 12.86 to 17.81 days to complete five instars and total developmental period with a mean of 24.18±0.74 days and furthermore, it attacks not only camphor basil but also related Lamiaceae plants. Besides these, the outbreak of lace bug *C. bullita* in India in 1950, on *Ocimum kilimandscharicum* which was grown for the production of camphor in Kanpur.

Conclusions

Thus, the present study revealed that the overall impact of weather variables highly influenced the incidence of lace bug C. *bullita* on *Ocimum viz. Ocimum basilicum* L. (57.50 %), *Ocimum sanctum* L. (54.50 %) and *Ocimum kilimandscharicum* Guerke (50.50 %). The peak population per plant of lace bug on different *Ocimum viz. Ocimum basilicum* L. (52.60 mean insect/ plant), *Ocimum sanctum* L. (51.80 mean insect/plant) and *Ocimum kilimandscharicum* Guerke (49.80 mean insect/ plant). The activity of lace bug on *Ocimum* spp. was also determined to be greatly influenced by different environmental variables i.e. temperature, relative humidity and wind speed, respectively in Jammu region. The main focus of the present study is to evaluate an eco-friendly and low cost techniques and especially, a timely predicted and region specific weather model and management to protect the farming community from the deprivation of insect pests.

Acknowledgements

We want to express our sincere gratitude to Director, CSIR-Indian Institute of Integrative Medicine and also to Project Investigator, Dr. Sumit Gairola, CSIR-Aroma Mission for providing us assistance to conduct experimental trail. We are very thankful to Dr. Mahender Singh, Senior Scientist and Incharge Agro-meteorology, Sher-e-Kashmir University of Agricultural Sciences and technology, Chatha, Jammu for providing AGRO-METEROLOGICAL DATA the experiment. We express our sincere thanks to Dr. Uma Shankar, Associate Professor, Division of Entomology, SKUAST-J for identifying the insects.

Table 1: Seasonal population fluctuation of *C. bullita* on *Ocimum* spp.

Standard Week	Date	Mean insect/plant (*O. basilicum*)	Mean insect/plant (*O. sanctum*)	Mean insect/plant (*O. kilimandscharicum*)	Maximum Temperature (ºC)	Minimum Temperatue (ºC)	RH Morning (%)	RH Evening (%)	Wind speed (Km/hr)	Rainfall (mm)
33	12-Aug	0.40	0.20	0.20	32.70	26.20	86.00	67.70	4.60	131.10
34	19-Aug	5.60	4.80	2.60	34.60	25.80	84.40	58.30	2.60	9.40
35	26- Aug	13.40	12.60	9.80	35.20	26.70	87.70	61.00	2.10	2.00
36	02- Sep	25.40	22.80	18.80	34.60	25.60	85.40	61.90	2.20	9.00
37	09- Sep	37.40	36.80	33.80	35.00	25.90	87.00	63.40	2.10	3.00
38	16- Sep	45.80	47.80	49.80	32.20	23.00	89.40	61.10	2.30	62.80
39	23- Sep	52.60	51.80	45.20	29.70	23.10	93.10	75.90	2.00	93.40
40	30- Sep	47.80	49.40	36.20	28.80	18.80	88.60	64.60	2.60	21.40
41	07-Oct	38.60	37.60	30.80	30.50	18.60	86.40	52.10	1.60	0.00
42	14- Oct	26.40	31.20	27.00	29.20	17.30	87.30	51.60	2.60	9.20
43	21- Oct	22.20	27.40	25.60	29.30	14.50	84.60	43.60	1.30	0.00
44	28- Oct	22.00	24.60	19.20	28.00	15.80	89.90	52.30	1.30	0.00
45	04-Nov	18.20	17.80	16.40	25.40	13.00	83.10	52.00	3.10	51.80
46	11- Nov	16.60	15.20	13.60	24.00	13.40	89.90	61.70	1.60	2.80
47	18- Nov	13.80	11.40	10.80	22.40	12.40	92.60	63.30	1.50	0.80
48	25- Nov	9.80	11.00	8.80	21.90	9.80	93.10	52.10	1.50	22.00
49	02-Dec	6.60	10.8	4.60	22.40	6.40	90.30	45.60	1.00	0.00
50	09- Dec	3.80	8.60	2.20	16.70	7.80	93.70	72.00	2.80	82.60
51	16- Dec	1.20	2.40	1.00	14.20	8.40	93.70	77.40	2.70	1.20
52	23- Dec	0.20	1.00	1.00	10.50	6.60	90.60	78.00	3.00	0.00
1	30- Dec	0.20	0.20	0.20	15.60	5.90	92.70	65.90	2.20	7.80
2	06-Jan	0.00	0.00	0.00	15.70	6.20	92.70	66.60	4.00	55.60
3	13-Jan	0.00	0.00	0.00	17.20	7.60	91.60	61.60	2.50	0.00

Table 2: Correlation between Seasonal population fluctuations of *C. bullita* with abiotic factors

Incidence of *C. bullita* on *Ocimum* spp.	Temperature (ºC)		Relative humidity (%)		Wind velocity Km/hr.	Rainfall (mm)
	Maximum	Minimum	Morning	Evening		
Mean insect per plant on *Ocimum basilicum*	0.603**	0.556**	-0.248	-0.133	-0.319	0.078
Mean insect per plant on *Ocimum sanctum*	0.585**	0.518*	-0.238	-0.177	-0.337	0.077
Mean insect per plant on *Ocimum kilimandscharicum*	0.589**	0.535**	-0.251	-0.170	-0.312	0.095

**. Significant at the 0.01 level

*. Significant at the 0.05 level

Table 3: Regression equations and co-efficient of multiple determination (R^2) of *C. bullita* in relation to abiotic factors

Incidence of *C. bullita* on *Ocimum* spp.	Regression linear equations of	Corelation co-efficient (r)	Co-efficient of determination (R^2)	Co-efficient of Variation (%)
Mean insect per plant on *Ocimum basilicum*	$Y^1 = -99.521 + 6.400X_1 - 4.821X_2 - 0.841X_3 + 2.006X_4 - 8.591X_5 + 0.063X_6$	0.758	0.575	57.50
Mean insect per plant on *Ocimum sanctum*	$Y^2 = -98.496 + 6.537X_1 - 5.057X_2 - 0.795X_3 + 1.932X_4 - 8.640X_5 + 0.079X_6$	0.738	0.545	54.50
Mean insect per plant on *Ocimum kilimandscharicum*	$Y^3 = -44.102 + 4.075X_1 – 2.854X_2 - 0.656X_3 + 1.247X_4 - 8.577X_5 + 0.097X_6$	0.711	0.505	50.50

Where,

Y^1 - Mean insect per plant on Ocimum basilicum
Y^2- Mean insect per plant on Ocimum sanctum
Y^3- Mean insect per plant on Ocimum kilimandscharicum
X^1- Maximum Temperature
X^2- Minimum Temperature
X^3- Relative Humidity Morning
X^4- Relative Humidity Evening
X^5- Wind Speed
X^6-Rainfall

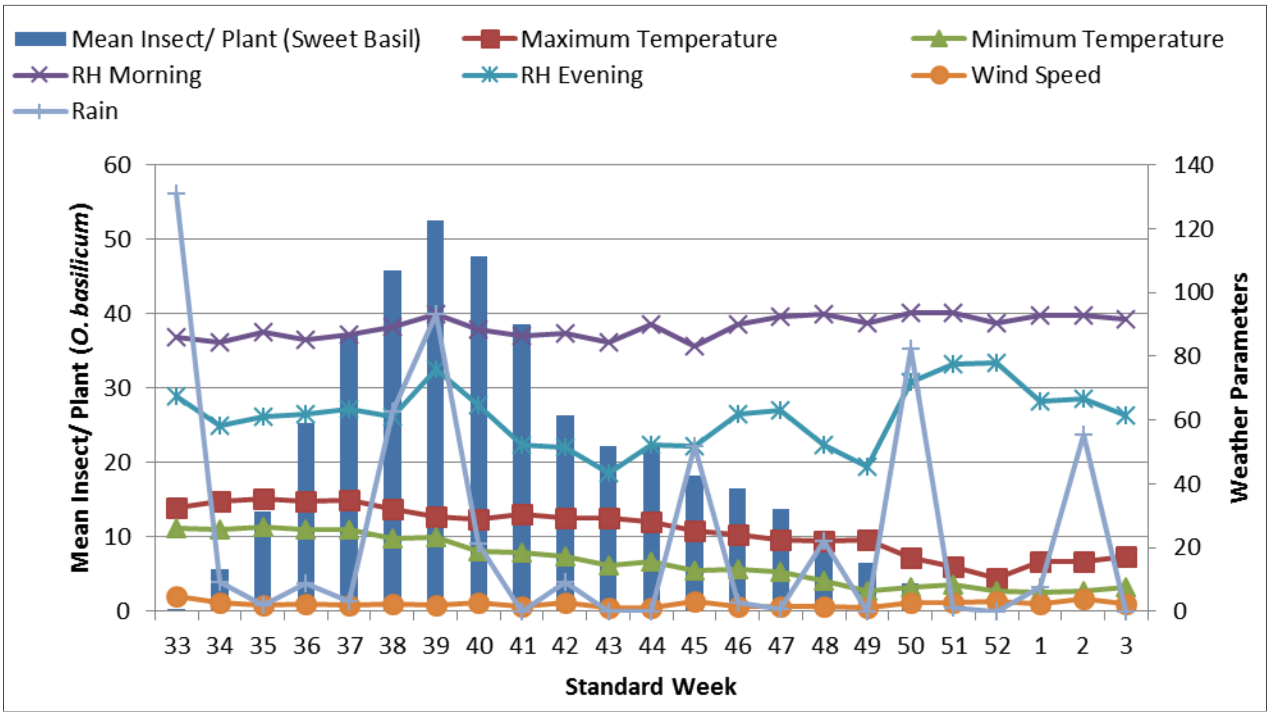

Fig 1: Seasonal population fluctuation of *C. bullita* on *Ocimum basilicum* in relation to abiotic factors

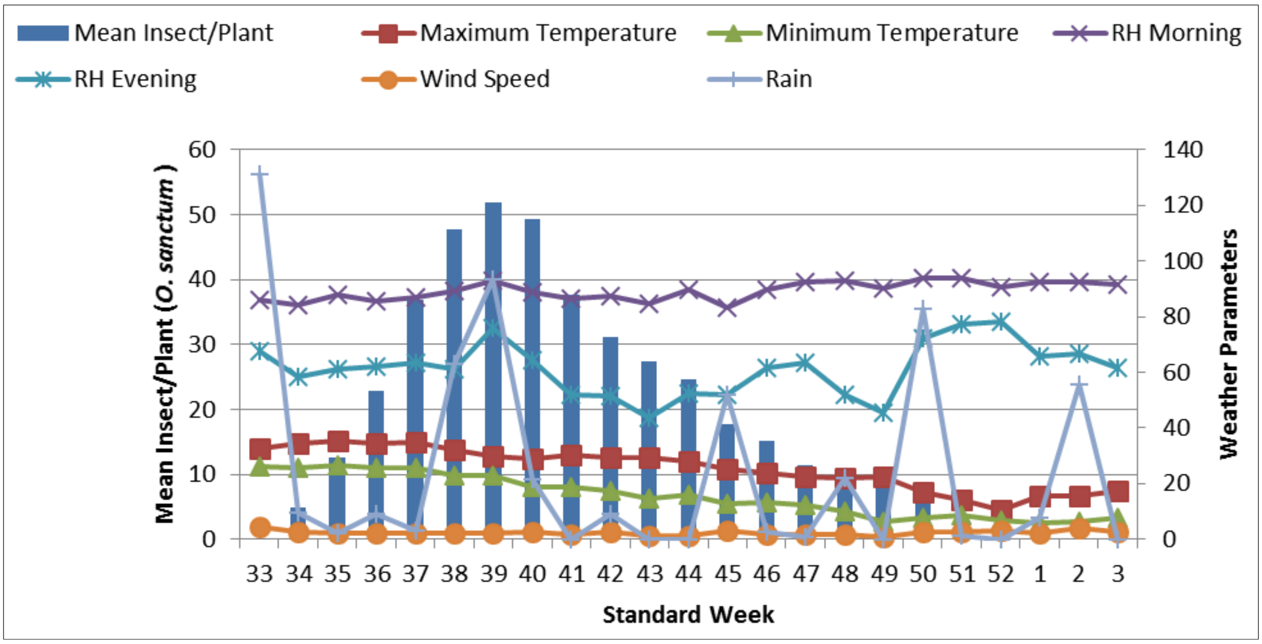

Fig 2: Seasonal population fluctuation of *C. bullita* on *Ocimum sanctum* in relation to abiotic factors

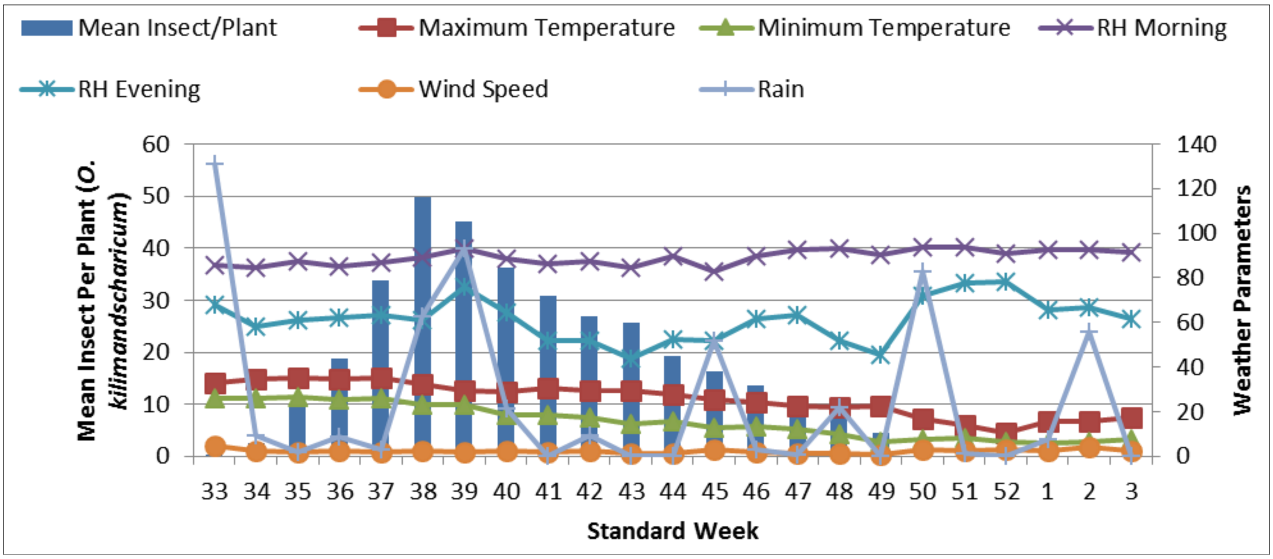

Fig 3: Seasonal population fluctuation of *C. bullita* on *Ocimum kilimandscharicum* in relation to abiotic factors

References

1. Anonymous. The Wealth of India – Raw Materials, CSIR, New Delhi, 1966, III.
2. Anonymous. Assessment of crop loss by the major pests. Annual Report of All India Co-ordinated Research Project on Medicinal and Aromatic Plants and Betel vine, TNAU, Coimbatore, 2012-13, 294 pp.
3. Arabaci O. The effect of nitrogen fertilization and different plant densities on some agronomic and technologic characteristic of *Ocimum basilicum*. Journal of Argonomy. 2004; 3:255-262.
4. Balyan SS, Pushpangadan P. A study on the taxonomical status and geographic distribution of genus *Ocimum*. Perfumes and Flavours Association of India Journal. 1988; 2:13-19.
5. Bhasin M. *Ocimum*- Taxonomy, medicinal potentialities and economic value of essential oil. Journal of Biosphere. 2012; 1:48-50.
6. Bowers WS, Nishida R. Juvocimenes: Potent juvenile hormones mimics from sweet basil. Science. 1980; 209:1030-1032.
7. Bozin B, Mimica N, Simin N, Anackov G. Characterization of the volatile composition of essential oils of some *Lamiaceae* species and the antimicrobial and antioxidant activities of the entire oils. J Agr. Food Chem. 2006; 54:1822-1828. Business Press *Inc*, ISBN: 8178330571.
8. Daneshian M. Evaluation of Basil (*Ocimum basilicum* L.)-Essential oil content and yield under different plant densities and nitrogen levels. Journal of Medicinal Plants and By-Products. 2013; 2:159-162.
9. Das U, Pal S, Ponnusamy N. Biology and Seasonality of Lace bug *Cochlochila bullita* (Stal) (Heteroptera: Tingidae) on Tulsi *Ocimum sanctum* L. International Journal of Bio-resource and Stress Management. 2020; 11(2):114-118.
10. Dhiman SC, Datta O. Seasonal occurrence of *Cochlochila bullita*: A serious pest of *Ocimum basilicum.* Annals of Plant Protection Sciences. 2013; 21(1):176-223.
11. Elgayyar M, Draughon FA, Golden DA, Mount JR. Antimicrobial activity of essential oils from plants against selected pathogenic and saprophytic microorganisms. Journal of Food Protection. 2001; 64:1019-1024.
12. Giliomee JH. First record of the lace bug *Cochlochila bullita* (Hemiptera: Tingidae) as a pest of rosemary in South Africa. African Entomology. 2014; 22(3):670-672.
13. Gulati NK, Suri RK. Biological application of essential oils. Indian perfumere. 1982; 26(2-4):241-248.
14. Gulcin I, Elmastas M, Aboul-Enein HY. Determination of antioxidant and radical scavenging activity of basil (*Ocimum basilicum* L, Family *Lamiaceae*) assayed by different methodologies. Phytotherapy Research. 2007; 2:354-61.
15. Joshi RK. Chemical Composition of the Essential Oil of Camphor Basil (*Ocimum kilimandscharicum* Guerke). Global Journal of Medicinal Plant Research. 2013; 1(2):207-209.
16. Klimánková E, Holadová K, Hajšlová J, Cˇajka T, Poustka J, Koudela M. Aroma profiles of five basil (*Ocimum basilicum* L.) cultivars grown under convential and organic conditions. Food Chemistry. 2008; 107:464-472.
17. Kumar A. The lace bug Cochlochila bullita (Stål), a destructive pest of *Ocimum sanctum* in Jharkand, India. *Phytoparasitica*. 2014; 42(2):295-302.
18. Kumar N, Kumar A. Study the Biology of Lace Bug, *Cochlochila Bullita* (Stal) (Hemiptera: Tingidae) Under Ambient Laboratory Conditions. Journal of Pharmacognosy and Phytochemistry. 2018; SP1:1755-1760.
19. Kumari S, Kumar N, Kumar A. Seasonal Incidence and Damage Intensity of Lace Bug, *Cochlochila bullita* (Stål) (Hemiptera: Tingidae) on *Tulsi*, *Ocimum basilicum* (L.). International Journal of Science, Environment and Technology. 2016; 5(6):4312-4319.
20. Livingstone D, Yacoob MHS. Biosystematics of Tingidae on the basis of the biology and micro-morphology of their Eggs. Proceedings of the Indian Academy of Science. 1987; 96:587-611.
21. Mohanasundaram M, Rao PVS. A note on *Cochlochila bullita* Horvath (Tingidae: Heteroptera) as part of *Coleus parviflorus*, a tuber crop in Tamilnadu. Indian Journal of Entomology. 1973; 35:346.
22. Palaniswami MS, Pillai KS. Biology of *Cochlochila bullita* S., a pest on Chinese potato. Journal of Root Crops. 1983; 9:59-62.
23. Paton A. A synopsis of *Ocimum* L. (Labiatae) in Africa. Kew Bulletin. 1992; 47:405-437.

24. Paton A, Harley MR, Harley MM. *Ocimum*: An overview of classification and relationships. In R. Hiltunen, & Y. Holm (Eds.), *Basil: The genus Ocimum*. Amsterdam: Harwood, 1999, 1-38.
25. Peng TL, Sajap AS, Jeen LH, Hua LS, Chen LW. Occurrence of *Cochlochila bullita* Stål in Malaysia. Serangga. 2014; 19(2):67-76.
26. Peng TL, Sajap AS, Jeen LH, Lee SH, Lum WC. Morphological redescription of *Cochlochila bullita* (Stål) (Heteroptera: Tingidae), a potential pest of *Orthosiphon aristatus* Blume Miq. (Lamiales: Lamiaceae) in Malaysia. Pakistan Journal of Biological Sciences. 2013; 16(23):1786-1790.
27. Politeo O, Jukic M, Milos M. Chemical composition and antioxidant capacity of free volatile aglycones from basil (*Ocimum basilicum* L.) compared with its essential oil. Food Chemistry. 2007; 101:379-385.
28. Pushpangadan P, Bradu BL. Medicinal and aromatic plants. In K. L. Chadha, & R. Gupta (Eds.), Advances in horticulture, New Delhi: Malhotra Publishing House, 1995; 11:627-657.
29. Rai AK, Kumar R, Yadav MK. Weather forecasting model for lace bug, *Cochlochila bullita* (Stål) (Hemiptera: Tingidae) on Tulsi crop. Journal of Entomology and Zoology Studies. 2018; 6(4):1046-1051.
30. Sajap AS, Peng TL. The lace bug *Cochlochila bullita* (Stål) (Heteroptera:Tingidae), a potential pest of *Orthosiphon stamineus,* Bentham (Lamiales: Lamiaceae) in Malaysia. Insecta Mundi. 2010; 136:1-5.
31. Samuel CK. Oviposition of the tinged *Monanthia globulifera* Wlk. Indian Journal of Entomology. 1939; 1:89-99.
32. Sathe TV, Sathe NT, Ghodake D, Sathe A. Sucking insect pests and medicinal value of *Tulsi* (*Ocimum sanctum* L.). Indian Journal of Applied Research. 2014; 4(3). ISSN - 2249-555X.
33. Schaefer CW, Panizzi AR. Heteroptera of economic importance. CRC, New York, New York, 2010, 828p.
34. Sharga US. Bionomics of *Monanthia globulifera* Wlk. (Hemiptera- Heteroptera: Tingidae). Journal of the Bombay Natural History Society. 1953; 51:885-889.
35. Sharma S, Chaturvedi M. Impact of weather parameters on the population dynamics of *Cochlochila bullita* (Stal), infesting *Ocimum tenuiflorum* L. Journal of Entomological Research. 2018; 42(4):545-548.
36. Smitha GR, Varghese TS, Manivel P. Cultivation of *Ocimum*. Extension bulletin, Directorate of Medicinal and Aromatic Plants Research, Anand, Gujarat, India. 2014, 30.
37. Stonedahl G, Dolling W, Du Heaume G. Identication guide to common tingid pests of the world (Heteroptera: Tingidae). International Journal of Pest Management. 1992; 38:438-449.
38. Švecová E, Neugebauerová J. A study of 34 cultivars of basil (*Ocimum* L.) and their morphological, economic and biochemical characteristics, using standardized descriptors. Acta Univ. Sapientiae Aliment. 2010; 3:118-135.
39. Tigvattnanont S. Studies on the bionomics and local distribution of some lace bugs in Thailand: I. *Monanthia globulifera* (Heteroptera: Tingidae). Khon Kaen Agriculture Journal. 1989; 18:200-212.
40. Trevisan MTS, Silva MGV, Pfundstein B, Spiegelhalder B, Owen RW. Characterization of the volatile pattern and antioxidant capacity of essential oils from different species of the genus Ocimum. Journal of Agricultural and Food Chemistry. 2006; 54:4378-4382.
41. Triveni B, Jagadish KS, Rani D, Vasundhara M, Narayanaswamy KC, Naik DJ. Biology and morphological description of *Ocimum* tingid, *Cochlochila bullita* (Stal) (Heteroptera: Tingidae), an important pest of Camphor tulsi, *Ocimum kilimandscharicum* Gurke in Karnataka, India. International Journal of Chemical Studies. 2018; SP4:29-36.
42. Triveni B, Jagadish KS, Rani D. Life table of *Ocimum tingid*, *Cochlochila bullita* (Stal.) on camphor tulsi, *Ocimum kilimandscharicum*, Gurke from South Indian condition. Journal of Entomology and Zoology Studies. 2017; 5(6):1168-1172.
43. Vina A, Murillo E. Essential oil composition from twelve varieties of basil (*Ocimum* spp.) grown in Colombia. Journal of the Brazilian Chemical Society. 2003; 14:744-749.
44. Zala MB, Patel BN, Vegad NM. Report on incidence of lace wing bug, *Monanthia globulifera* Walker on sweet basil (*Ocimum basilicum* L.) in middle Gujarat. Current Biotica. 2016; 10(3):258-260.