Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

Journal of Entomology and Zoology Studies

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(4): 561-568

Received: 16-05-2020
Accepted: 18-06-2020

Rojeet Thangjam
College of Horticulture, CAU (Imphal), Thenzawl, Mizoram, India

Veronica Kadam
College of PG Studies in Agricultural Sciences, CAU (Imphal), Umiam, Meghalaya, India

RK Borah
Department of Entomology, Assam Agricultural University, Jorhat, Assam, India

Kennedy Ningthoujam
College of PG Studies in Agricultural Sciences, CAU (Imphal), Umiam, Meghalaya, India

Corresponding Author:
Rojeet Thangjam
College of Horticulture, CAU (Imphal), Thenzawl, Mizoram, India

Population dynamics of insect pests and their natural enemies in king chilli (*Capsicum chinense* Jacq.) ecosystem in North East India

Rojeet Thangjam, Veronica Kadam, RK Borah and Kennedy Ningthoujam

Abstract
A field experiment was carried out at Assam Agricultural University, Jorhat, India during 2014-16 to investigate the population dynamics of pests and their natural enemies in king chilli ecosystem. During the study, some pests were observed for a considerable period of time and some were present throughout the cropping season. The incidence of cutworm (*Agrotis ipsilon)* was confined only in the seedling stage whereas fruitfly (*Bactrocera latifrons*) during the later stages of the crop and most of the sucking pests and their predators were observed throughout the cropping season with maximum incidence during vegetative to flowering stages of the crop. However, most of the pest population and their natural enemies were low in both the seasons. A significant positive correlation of aphids (r= 0.464, r= 0.487), whitefly (r= 0.442, r= 0.478), fruit fly (r= 0.536, r= 0.704) and spider (r= 0.536, r= 470) was observed with maximum temperature whereas whitefly and leafhoppers showed significant negative correlation (r= -0.641, r= -0.578 and r= -0.684, r= -0.583, respectively) with the average relative humidity during both the seasons. The prey population also had a significant positive influence on coccinellid (r= 0.791, r= 0.528) and spider (r= 0.768, r= 0.683) population in both the seasons.

Keywords: King chilli, seasonal incidence, pests, natural enemies, correlation, assam

Introduction
The North East India is known for its diverse flora and fauna and king chilli (*Capsicum chinense* Jacquin) is an amazing gift of nature as this chilli is one of the hottest chilli in the world with a pleasurable and appetizing aroma. In 2007, Guinness World Records certified that king chilli was the world's hottest chilli, 400 times hotter than Tabasco sauce [1]. The chilli is also an important spice crop grown extensively in this region of India, predominantly in the states of Assam, Manipur and Nagaland and belongs to the family Solanaceae with chromosome number 2n=24. The chilli is called by different names in different regions. In Assam, it is widely called *Bhut Jolokia, Bih Jolokia* or *Naga Jolokia; U-Morok* or *OO-Morok* in Manipur and *Raja Mircha* or *Raja Mirchi* in Nagaland and Ghost pepper or Naga king chilli by the western media [2]. The king chilli has high therapeutic values because of high capsaicin contains as compared to other chillies found in India and also contains a good source of vitamins. This chilli is catching the attention of many growers in the last few decades due to its high demand. The fresh king chilli costs around 300-350 Rs/kg and more than 1500-2000 Rs/kg in dried chilli at local market and is more popular in Manipur and Nagaland. Local entrepreneurs are exporting this chilli to Australia, USA and European countries [3]. This chilli also has high cost benefit ratio per hectare and reach up to 1:11.85 [4]. In Assam, king chilli was found to be infested by insects like *Aphis gossypii*, *Myzus persicae*, *Bemisia tabaci*, *Scirtothrips dorsalis* and *Polyphagotarsonemus latus* [5, 6, 7]. To understand the seasonal incidence of pests and their natural enemies and their correlation with weather parameters, the study was taken up during, 2014-16.

Materials and methods
The study was carried out at the Experimental farm, Assam Agricultural University, Jorhat, Assam (India) for two years during *rabi* 2014-15 and 2015-16. The geographical location of the experimental field is situated at 26º47´North latitude and 94º12´East longitude at an altitude of 86.6 meters above the mean sea level with mostly alluvial and sandy loam soil. The

package and practices for horticultural crops of Assam was followed for growing of king chilli. The extracted of seeds was done from the healthy, uninfected, fully ripen fruits. Sowing was done on 15th September, 2014 and 20th September, 2015 in V type plastic trays filled with coco-peat. The seedlings were then transplanted on 10th January, 2015 and 14th January, 2016 for the study. Recommended doses of manures and fertilizers were applied before transplanting to the field at the rate of 5 tonnes cow dung manure per hector with N:P:K @ 120:60:60/ha. A spacing of 75×75 cm was maintained in 100 m^2 and the activity of pests and their natural enemies were recorded 15 days after transplanting at weekly interval without insecticides application.

For recording the sucking insect pests, 30 plants were randomly selected from the plot and from each plant, the number of insects were recorded from top, middle and bottom canopy of the plant using magnifying lens and express in numbers per leaf. The population of leaf beetle, coccinellids and other bigger insects were also recorded by counting their number on 30 plants selected randomly and expressed in number per plant. For cut worm and fruit fly, the per cent damaged was workout by counting number of damaged plant/fruits and the total number of plant/fruits and expressed in percentage. A simple correlation analysis was made between the mean population density of insects and independent variables to find out the influence of meteorological parameters on the population of the insect pests and their predators. The average values of environmental factors at seven days prior to the date of observations were taken into considerations and the following standard statistical formula was used to calculate correlation coefficient (r):

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

Where, r = co efficient of correlation, N = Number of observation, x = Number of pests, y = Independent variables

The correlation co efficient was then tested for significance by‘t’ test with following formula:

$$t = \frac{r}{\sqrt{(1 - r^2)}} \times \sqrt{n - 2} \quad \text{with (n-2) d.f.}$$

Results and discussions

During the investigation, 19 pest species *viz*., *Aphis gossypii* (Glover), *Myzus persicae* (Sulzer), *Bemisia tabaci* (Gennadius), *Bactrocera latifrons* (Hendel), *Scirtothrips dorsalis* (Hood) and *Polyphagotarsonemus latus* (Banks), *Gryllotalpa africana* (Palisot de Beauvois), *Cofana* sp., *Empoasca* sp., *Amrasca biguttula biguttula* (Ishida), *Sogatella* sp., *Coccus* sp., *Phenacoccus* sp., *Monolepta signata* (Olivier), *Spodoptera litura* (Fabricius), *Orvasca* sp., *Agrotis ipsilon* (Hufnagel), *Blattella* sp. and *Tetranychus* sp. were observed out of which 14 species *viz.*, *A. gossypii*, *B. tabaci*, *Cofana* sp., *Empoasca* sp., *A. biguttula biguttula*, *Sogatella* sp., *M. signata*, *B. latifrons*, *S. dorsalis*, *S. litura*, *Orvasca* sp., *A. ipsilon* and mites (*P. latus* and *Tetranychus* sp.) were recorded since, the population of remaining insect species were quite low and negligible and therefore, their seasonal incidence were not described. Among the natural enemies, coccinellid predators were the dominant group followed by spiders and therefore, their seasonal incidence was described.

Seasonal incidence of pests and their natural enemies in king chilli and their correlation studies during, 2014-16.

Aphids

The aphids (*A. gossypii* and *M. persicae*) were started appearing from second week of February during *rabi*, 2014-15 and observed till last week of May with highest incidence recorded during fourth week of March (4.50 per leaf) (Table 1). However, in 2015-16, the pests were observed throughout the season with maximum population (5.43 per leaf) during second week of May (Table 2). The population of aphids showed positive significant correlation with the maximum temperature (r = 0.464, r = 0.487) and positive but non-significant with minimum temperature (r = 0.081, r = 0.334) and bright sunshine hours (r = 0.144, r = 0.420). However, average relative humidity and total rainfall showed non-significant negative correlation (r = -0.362, r = -0.424 and -0.269, r = -0.301, respectively) in both the seasons (Table 3 and 4). This indicates that the increase in temperature and bright sunshine hours would favour growth and development whereas increase in average relative humidity and total rainfall would lead to suppression of the population. Similar result was also reported by Begam *et al*. [5] who observed that the aphids (*A. gossypii* and *M. persicae*) were started appearing at the early stage of the hot chilli during February with highest incidence during third week of March. However, Meena *et al.* [8] reported that the peak population of *A. gossypii* was observed on chilli during the month of September in Rajasthan. Begam *et al.* [5] and Shivanna *et al.* [9] observed that the population of aphids showed positive correlation with the maximum temperature, minimum temperature and bright sunshine hours.

Whitefly

The population of whitefly (*B. tabaci*) was observed from last week of February to second week of May with maximum population during fourth week of March (0.23 per leaf) in 2014-15 whereas during 2015-16, it was observed from third week of February to second week of June with highest population during third week of April (0.27 per leaf) (Table 1 and 2). Correlation studies revealed that whitefly population showed significant positive correlation with the maximum temperature (r = 0.442) but it was non-significantly associated with the bright sunshine hours (r = 0.379). However, average relative humidity showed negative significant correlation (r = -0.641) whereas it was non-significant with minimum temperature and total rainfall (r = -0.147 and -0.423, respectively) during 2014-15 (Table 3). A significant positive correlation was exhibited with maximum temperature (r = 0.478) and bright sunshine hours (r = 0.587) during 2015-16 whereas it was non-significant with minimum temperature (r = 0.200). The average relative humidity also showed negative significant correlation (r = -0.578) with the whitefly population and non-significant with the total rainfall (r = -0.420) (Table 4). The present findings were in conformity with Buragohain *et al.* [6] and Meena *et al.* [8] who observed that *B. tabaci* appeared on the chilli crop soon after transplanting. Saini *et al.* [10] also reported that the incidence of whitefly was commenced in last week of July in chilli and touched its peak in second week of September (6.8 whiteflies

/ 3 leaves) in Udaipur. Meena *et al.* [8] and Saini *et al.* [10] also reported a positive correlation with maximum and minimum temperature, relative humidity and rainfall. However, Anjali *et al.* [11] reported that whitefly showed significant negative correlation with both maximum and minimum temperature and wind speed while a positive correlation was revealed with mean relative humidity and total rainfall.

Table 1: Incidence of insect pest and their natural enemies in king chilli during *rabi* 2014-15

Date of observations	Pests incidence									
	(Number of insect / leaf)					(Per cent damaged)		(Number of insect / plant)		
	Aphid	*B. tabaci*	Leafhoppers	*S. dorsalis*	Mite	*A. ipsilon*	*B. latifrons*	*M. signata*	Coccinellid beetle	Spider
02-02-2015	0.00	0.00	0.03	0.00	0.00	3.33	0.00	0.03	0.07	0.00
09-02-2015	0.17	0.00	0.00	0.00	0.00	3.33	0.00	0.07	0.20	0.00
16-02-2015	0.40	0.00	0.03	0.00	0.10	6.67	0.00	0.07	0.30	0.10
23-02-2015	0.63	0.03	0.03	0.00	0.17	16.67	0.00	0.17	0.49	0.30
02-03-2015	0.87	0.07	0.07	0.13	0.33	13.33	0.00	0.23	0.50	0.33
09-03-2015	1.93	0.10	0.13	0.17	1.40	10.00	0.00	0.20	0.54	0.40
16-03-2015	3.27	0.20	0.20	0.23	1.67	0.00	0.00	0.23	0.74	0.50
23-03-2015	4.50	0.23	0.33	0.20	1.97	0.00	0.00	0.30	1.00	0.70
30-03-2015	3.27	0.03	0.00	0.17	2.47	0.00	0.00	0.27	0.80	0.53
06-04-2015	2.00	0.00	0.03	0.07	1.37	0.00	0.00	0.20	0.92	0.50
13-04-2015	3.27	0.07	0.07	0.27	2.60	0.00	0.00	0.23	0.77	0.33
20-04-2015	0.33	0.00	0.00	0.07	0.17	0.00	0.00	0.17	0.44	0.40
27-04-2015	0.53	0.03	0.00	0.10	0.40	0.00	0.00	0.20	0.31	0.37
04-05-2015	3.17	0.10	0.03	0.23	0.77	0.00	0.00	0.13	0.37	0.43
11-05-2015	2.47	0.03	0.00	0.03	0.67	0.00	6.67	0.20	0.27	0.33
18-05-2015	1.00	0.00	0.00	0.00	0.00	0.00	8.66	0.07	0.17	0.33
25-05-2015	1.83	0.00	0.00	0.00	0.00	0.00	10.00	0.13	0.13	0.23
01-06-2015	0.00	0.00	0.00	0.00	0.00	0.00	10.26	0.03	0.00	0.20
08-06-2015	0.00	0.00	0.00	0.00	0.00	0.00	13.02	0.07	0.07	0.27
15-06-2015	0.00	0.00	0.00	0.00	0.00	0.00	13.42	0.07	0.03	0.27

****Note:** ***B. tabaci*** **-** *Bemisia tabaci*; ***S. dorsalis-*** *Scirtothrips dorsalis;* ***A. ipsilon*** **-** *Agrotis ipsilon;* ***B. latifrons-*** *Bactrocera latifrons* and ***M. signata-*** *Monolepta signata*

Table 2: Incidence of insect pest and their natural enemies in king chilli during *rabi* 2015-16

Date of observations	Pests incidence									
	(Number of insect / leaf)					(Per cent damaged)		(Number of insect / plant)		
	Aphids	*B. tabaci*	Leafhoppers	*S. dorsalis*	Mite	*A. ipsilon*	*B. latifrons*	*M. signata*	Coccinellids beetle	Spider
05-02-2016	0.03	0.00	0.00	0.00	0.00	3.33	0.00	0.00	0.07	0.00
12-02-2016	0.10	0.00	0.03	0.00	0.07	3.33	0.00	0.07	0.20	0.03
19-02-2016	0.17	0.03	0.03	0.00	0.30	13.33	0.00	0.13	0.27	0.07
26-02-2016	0.23	0.07	0.07	0.03	0.83	6.67	0.00	0.20	0.37	0.10
04-03-2016	1.17	0.17	0.10	0.07	1.00	3.33	0.00	0.10	0.52	0.27
11-03-2016	1.00	0.10	0.23	0.10	1.70	0.00	0.00	0.23	0.86	0.30
18-03-2016	2.03	0.13	0.17	0.13	2.43	0.00	0.00	0.20	1.27	0.37
25-03-2016	2.17	0.10	0.20	0.20	2.73	0.00	0.00	0.23	1.33	0.57
01-04-2016	3.00	0.17	0.27	0.23	3.17	0.00	0.00	0.30	1.40	0.63
08-04-2016	3.87	0.23	0.30	0.27	4.10	0.00	0.00	0.37	1.49	0.73
15-04-2016	4.60	0.27	0.00	0.00	0.00	0.00	0.00	0.07	0.83	0.47
22-04-2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.64	0.33
29-04-2016	0.67	0.00	0.07	0.03	0.17	0.00	0.00	0.23	0.59	0.40
06-05-2016	2.70	0.13	0.20	0.00	0.70	0.00	6.00	0.33	0.60	0.53
13-05-2016	5.43	0.23	0.03	0.00	0.00	0.00	9.23	0.27	0.44	0.47
20-05-2016	0.66	0.00	0.00	0.00	0.00	0.00	13.33	0.17	0.24	0.43
27-05-2016	1.00	0.03	0.00	0.00	0.00	0.00	13.81	0.20	0.27	0.47
03-06-2016	1.63	0.13	0.00	0.00	0.00	0.00	15.38	0.23	0.20	0.40
10-06-2016	2.53	0.17	0.00	0.00	0.00	0.00	15.22	0.00	0.10	0.13

****Note:** ***B. tabaci*** **-** *Bemisia tabaci*; ***S. dorsalis-*** *Scirtothrips dorsalis;* ***A. ipsilon*** **-** *Agrotis ipsilon;* ***B. latifrons-*** *Bactrocera latifrons* and ***M. signata-*** *Monolepta signata*

Table 3: Correlation coefficient (r) and regression equation of pests of king chilli with the weather parameters during rabi 2014-15

Insect pests and Predators	Temperature (◦C)		Average Relative Humidity (%)	Total rainfall (mm)	BSSH (Hr.)	Prey (Number)
	Maximum	Minimum				
Aphids	0.464* y = 0.335x - 8.110	0.081^{NS} y = 0.024x + 0.970	-0.362^{NS} y = 0.078x + 7.713	-0.269^{NS} y = -0.008x + 1.696	0.144^{NS} y = 0.098x + 1.020	-
Whitefly	0.442* y = 0.015x - 0.382	-0.147^{NS} y = -0.002x +	-0.641** y = -0.006x + 0.564	-0.423^{NS} y = -0.000x +	0.379^{NS} y = 0.012x - 0.005	-

		0.080		0.063		
Leafhoppers	0.285^{NS} y = 0.012x - 0.295	-0.278^{NS} y = -0.005x + 0.133	-0.684** y = -0.008x + 0.739	-0.369^{NS} y = -0.000x + 0.068	0.436^{NS} y = 0.017x - 0.023	-
Thrips	0.309^{NS} y = 0.014x - 0.344	-0.022^{NS} y = -0.000x + 0.087	-0.405^{NS} y = -0.005x + 0.552	-0.345^{NS} y = -0.000x + 0.104	0.226^{NS} y = 0.010x + 0.038	-
Mite	0.181^{NS} y = 0.080x - 1.612	-0.063^{NS} y = -0.011x + 0.884	-0.350^{NS} y = -0.046x + 4.414	-0.248^{NS} y = -0.004x + 0.832	0.165^{NS} y = 0.069x + 0.395	-
Cutworm	- 0.297^{NS} y = -0.746x + 23.72	-0.397^{NS} y = -0.421x + 10.05	-0.341^{NS} y = -0.258x + 23.15	-0.342^{NS} y = -0.035x + 3.802	0.310^{NS} y = 0.738x - 0.378	-
Fruit fly	0.536* y = 1.504x - 39.06	0.774** y = 0.918x - 12.74	0.699** y = 0.592x - 43.61	0.454* y = 0.053x + 1.776	-0.664** y = -1.765x + 10.63	-
Leaf beetle	0.346^{NS} y = 0.015x - 0.287	0.084^{NS} y = 0.001x + 0.118	-0.288^{NS} y = 0.003x + 0.452	-0.197^{NS} y = -0.000x + 0.159	0.042^{NS} y = 0.001x + 0.139	-
Coccinellids	0.059^{NS} y = 0.009x + 0.119	-0.149^{NS} y = -0.010x + 0.565	-0.385^{NS} y = -0.018x + 1.859	-0.186^{NS} y = -0.001x + 0.430	0.209^{NS} y = 0.031x + 0.262	0.791** y = 0.254x + 0.157
Spiders	0.536* y = 0.049x - 1.098	0.366^{NS} y = 0.014x + 0.054	-0.037^{NS} y = 0.001x - 0.392	0.101^{NS} y = 0.000x + 0.296	-0.103^{NS} y = -0.009x + 0.346	0.768** y = 0.143x + 0.180

Note: * = Significant at 5% level of probability; ** = Significant at 1% level of probability; NS = Non-significant

Table 4: Correlation coefficient (r) and regression equation of pests of king chilli with the weather parameters during *rabi* 2015-16

Insect pests and Predators	Temperature (◦C)		Average Relative Humidity (%)	Total rainfall (mm)	BSSH (Hr.)	Prey (Number)
	Maximum	Minimum				
Aphids	0.487* y = 0.245x - 5.140	0.334^{NS} y = 0.124x - 0.674	-0.424^{NS} y = -0.132x + 12.57	-0.301^{NS} y = -0.007x + 2.046	0.420^{NS} y = 0.432x + 0.333	-
Whitefly	0.478* y = 0.013x - 0.266	0.200^{NS} y = 0.004x + 0.021	-0.578** y = -0.009x + 0.913	-0.420^{NS} y = -0.000x + 0.128	0.587** y = 0.033x - 0.002	-
Leafhoppers	0.147^{NS} 0.004x - 0.045	-0.042^{NS} y = -0.001x + 0.103	-0.583** y = -0.011x + 1.042	-0.421^{NS} y = -0.000x + 0.120	0.351^{NS} y = 0.023x + 0.014	-
Thrips	0.036^{NS} y = 0.000x + 0.026	-0.071^{NS} y = -0.001x + 0.077	-0.406^{NS} y = -0.006x + 0.585	-0.317^{NS} y = -0.000x + 0.073	0.252^{NS} y = -0.000x + 0.073	-
Mite	0.060^{NS} y = 0.023x + 0.201	-0.091^{NS} y = -0.026x + 1.357	-0.479* y = -0.117x + 10.54	-0.356^{NS} y = -0.006x + 1.229	0.357^{NS} y = 0.288x - 0.018	-
Cutworm	-0.181^{NS} y = -0.001x + 0.044	-0.465* y = -0.002x + 0.053	-0.366^{NS} y = -0.001x + 0.137	-0.348^{NS} y = -0.000x + 0.016	0.272^{NS} y = 0.003x - 0.001	-
Fruit fly	0.704** y = 1.321x - 32.96	0.767** y = 1.062x - 16.24	0.402^{NS} y = 0.467x - 34.94	0.448* y = 0.04x + 1.441	0.090^{NS} y = 0.344x + 2.600	-
Leaf beetle	0.492* y = 0.016x - 0.283	0.408^{NS} y = 0.010x - 0.015	-0.356^{NS} y = -0.007x + 0.788	-0.139^{NS} y = -0.000x + 0.187	0.403^{NS} y = 0.027x + 0.090	-
Coccinellids	0.071^{NS} y = 0.010x + 0.298	0.060^{NS} y = 0.006x + 0.464	-0.312^{NS} y = -0.028x + 2.908	-0.056^{NS} y = -0.000x + 0.606	0.193^{NS} y = 0.057x + 0.409	0.528* y = 0.142x + 0.323
Spiders	0.470* y = 0.031x - 0.546	0.605** y = 0.030x - 0.231	0.052^{NS} y = 0.002x + 0.153	0.282^{NS} y = 0.000x + 0.284	0.153^{NS} y = 0.021x + 0.270	0.683** y = 0.085x + 0.178

Note: * = Significant at 5% level of probability; ** = Significant at 1% level of probability; NS = Non-significant

Leafhoppers

The incidence of leafhoppers (*Cofana* sp., *Empoasca* sp. and *Amrasca biguttula biguttula*) were observed on transplanted king chilli from first week of February to first week of May during 2014-15 with highest incidence during the fourth week of March (0.33 per leaf) (Table 1) whereas in 2015-16, it was observed from second week of February to second week of May with highest incidence during second week of April (0.30 per plant). Thereafter, the incidence of leafhoppers was gradually decreased at fruiting stages of the crop (Table 2). As regards to correlation studies of the present investigation, it was revealed that maximum temperature and bright sunshine hours showed non-significant positive correlation (r = 0.285, 0.147 and r = 0.436, 0.351, respectively) with the leafhoppers population whereas significant and negative correlation was with average relative humidity (r = -0.684, r = -0.583) whereas it was non-significant with minimum temperature (r = -0.278, r = -0.042) and total rainfall (r = -0.369, r = -0.421) in both the seasons (Table 3 and 4). This shows that maximum temperature and bright sunshine hours favour the growth and development of leafhoppers. However, they were adversely affected by minimum temperature, relative humidity and rainfall. The results were in conformity with Begam *et al.* [5] who reported that the incidence of jassid

was observed from first week of February and reach its peak population in the second week of March (1.2 per leaf) and then gradually declined at fruiting stages of the crop. A similar result was also confirmed by Pathan and Bharpoda [12]. However, Buragohain *et al.* [6] reported that the peak period of leafhopper was observed in the month of November and January in king chilli. Begam *et al.* [5] and Tiwari *et al.* [13] reported that the population of jassid showed significant positive correlation with maximum temperature and negative association with the rainfall. Saini *et al.* [10] also reported that the correlation between jassid and maximum temperature was positive but with relative humidity and total rainfall, the correlation was negative and non-significant. However, Kumar and Singh [14] reported that the population of jassid showed non-significant negative correlation with temperature and sunshine hours and it was positive significant correlation with maximum humidity whereas total rainfall and minimum humidity showed non-significant positive correlation.

Thrips

During 2014-15, the incidence of thrips (*S. dorsalis*) was observed from first week of March to second week of May whereas in 2015-16, they were recorded from last week of February to last week of April with maximum population during second week of April (0.27 per leaf) in both the seasons (Table 1 and 2). Similar results was also observed by Begam *et al.* [5] who reported that the activity of thrips, *S. dorsalis* was recorded from last week of February with highest incidence during first week of April in hot chilli. However, Meena *et al.* [8] reported that the population of *S. dorsalis* appeared on the chilli crop soon after transplanting and reach its peak population in first week of October in Udaipur. While comparing the population of thrips with the weather parameters, maximum temperature and bright sunshine hours showed non-significant positive correlation (r= 0.309, 0.036 and r = 0.226, 0.252, respectively) and non-significant negative correlation with minimum temperature (r = -0.022, r = -0.071), average relative humidity (r = -0.405, r = -0.406) and total rainfall (r = -0.345, r = -0.317) in both the seasons (Table 3 and 4). The results indicated that maximum temperature and bright sunshine hours favour the growth and development of thrips population however, they were adversely affected by minimum temperature, relative humidity and rainfall. These findings were in conformity with those of Begam *et al.* [5], Meena *et al.* [8] and Pathipati *et al.* [15] who reported that the relative humidity and rainfall were negatively correlated with thrips population but temperature variation was positively correlated. However, Buragohain *et al.* [6], Kumar and Singh [14] and Roopa and Kumar [16] observed a negative correlation with maximum and minimum temperature whereas relative humidity and rainfall had a positive non-significant correlation with the thrips population. Saini *et al.* [10] also observed a negative correlation with temperature and rainfall in Udaipur with the population of thrips.

Mites

Population of mites (*Polyphagotarsonemus latus* and *Tetranychus* sp.) were started appearing on the field from third week of February to second week of May during 2014-15 whereas in 2015-16, they were observed from second week of February to first week of May and their incidence was recorded highest during second week of April (2.60 and 4.10 per leaf, respectively). Thereafter, the population gradually decreased as the crop ageing towards maturity (Table 1 and 2). Similar results was also reported by Begam *et al.* [5] who observed maximum infestation of mite *P. latus* on chilli during the early stages of the crop and peak activity was found during April-May. However, Meena *et al.* [8] observed peak population of *P. latus* in the second week of September in Udaipur. The correlation with weather parameters revealed that maximum temperature and bright sunshine hours had non-significant positive correlation with the mite population (r = 0.181 and 0.165 respectively) whereas non-significant negative correlation was observed with minimum temperature (r = -0.063), average relative humidity (r = -0.350) and total rainfall (r = -0.248) during 2014-15 (Table 3). During 2015-16, non-significant positive correlation was observed with maximum temperature (r = 0.060) and bright sunshine hours (r = 0.357) whereas average relative humidity showed negative significant (-0.479) and non-significant correlation with minimum temperature and total rainfall (r = -0.091 and r = -0.356, respectively) (Table 4). This revealed that the relative humidity, minimum temperature and rainfall adversely affect population of mite however; maximum temperature and bright sunshine hours favour their population buildup. These findings were in conformity with Singh and Singh [17] and Begam [18] who reported that the incidence of mite population showed a positive correlation with maximum temperature and bright sunshine hours and a negative correlation with relative humidity and total rainfall. However, Meena *et al.* [8] reported that maximum temperature had a negative correlation with the mite population in Udaipur.

Cutworm

The incidence of cutworm, *A. ipsilon* was observed only during the seedling stage of the crop in both the season and their maximum intensity of damage was observed during third and last week of February (16.67 and 13.33 percent respectively) (Table 1 and 2). The population was also negatively associated with the maximum temperature (r = -0.297, r = -0.181), minimum temperature (r =-0.397, r = -1.465), average relative humidity (r = -0.341, r = -0.366) and total rainfall (r = -0.342, r = -0.348) whereas bright sunshine hours showed positive correlation (r = 0.310, r = 0.272) during 2014-15 and 2015-16 respectively (Table 3 and 4). This indicate that an increased in temperature, average relative humidity and total rainfall would results in suppressing the *A. ipsilon* population whereas bright sunshine hours would favour the growth and development of the pest. Similar results were also reported by Begam *et al.* [5] who reported that the density of *A. ipsilon* was peaked during winter and lowest during summer and their incidence was highest during the last week of February. Begam [18] also reported that temperature, average relative humidity and total rainfall has a negative impact on the population of *A. ipsilon* in hot chilli and according to Girradi *et al.* [19] the pest activity was significantly affected by minimum temperature.

Fruit fly

The activity of fruit fly (*B. latifrons*) was observed only at fruiting to harvesting stages of the crop in both the seasons. The incidence of fruit damaged was observed from second week of May till harvesting with maximum damaged during third week of June (13.42%) during 2014-15 (Table 1) and in 2015-16, maximum damaged was observed during first week of June (15.38%) (Table 2). The incidence of fruit fly recorded significant positive correlation with maximum and

minimum temperature (r = 0.536 and 0.774, respectively), average relative humidity (r = 0.699) and total rainfall (r = 0.454) whereas significant and negative correlation was observed with bright sunshine hours (r = -0.664) during 2014-15 (Table 3). In *rabi*, 2015-16, maximum and minimum temperature and total rainfall showed positive significant correlation (r = 0.704, 0.767 and 0.448, respectively) with the fruit fly incidence whereas positive but non-significant correlation was recorded with average relative humidity and bright sunshine hours (r = 0.402 and 0.090, respectively) (Table 4). The results indicated that the population of fruit fly had significant influence with temperature, relative humidity and rainfall. The result was in conformity with Boopathi *et al*. [20] who reported that the highest number of fruit flies (*Bactrocera dorsalis*) was caught during April and June and it was coincided with chilli fruiting period in Mizoram. A similar result was also reported by Ye and Lui [21] who reported that the peak period for *B. dorsalis* was in June or July, depending on the rainfall in China. Nandre and Shukla [22] reported that *B. dorsalis* had significant positive correlation with maximum and minimum temperature and morning relative humidity whereas, it had positive non-significant correlation with average relative humidity and rainfall in Gujarat. Sunil *et al.* [23] also reported that the incidence of fruit fly in *rabi* recorded significant positive correlation with rainfall, maximum temperature and maximum RH in Bengaluru. However, Boopathi *et al*. [20] and Boopathi *et al.* [24] reported that population of fruit flies attracted in methyl eugenol traps were significantly positive correlation with maximum temperature But, the influence of minimum temperature, morning relative humidity, rainfall and rainy days showed a negative correlation with trap catches of fruit flies in capsicum in Mizoram.

Leaf beetle

The incidence of leaf beetle (*M. signata*) was noticed throughout the cropping system from seedling to harvesting in both the season with maximum population at fourth week of March during 2014-15 (0.30 per plant) (Table 1) and second week of April during 2015-16 (0.37 per plant) (Table 2) in king chilli though their infestation was very low. Similarly, Begam *et al.* [5] also reported that *M. signata* acted as minor pests in chilli. The correlation studies revealed a non-significant positive correlation with the maximum and minimum temperature (r = 0.346 and 0.084, respectively) and bright sunshine hours (r = 0.042) whereas average relative humidity and total rainfall showed negative but non-significant correlation with the population of leaf beetle (r = -0.288 and -0.197, respectively) during 2014-15 (Table 3). A significant positive correlation was observed with maximum temperature (r = 0.492) during 2015-16 but minimum temperature and bright sunshine hours showed positive but non-significant correlation (r = 0.408 and 0.403, respectively), whereas negative non-significant association was observed with average relative humidity (r = -0.356) and total rainfall (r = -0.139) (Table 4). The results was in conformity with Begam *et al.* [5] who reported that maximum and minimum temperature and bright sunshine hours showed positive correlation with the population of *M. signata* and a negative correlation was observed with the average relative humidity and total rainfall.

Coccinellid beetle

The incidence of coccinellids were observed throughout the cropping season and population ranged from 0.03 to 1.00 and 0.07 to 1.49 per plant during 2014-15 and 2015-16, respectively (Table 1 and 2). The maximum population of coccinellids (1.00 predators per plant) was recorded during fourth week of March in 2014-15 and in second week of April (1.49 predators per plant) during 2015-16. The maximum population of coccinellids was coincided with the highest population of aphids and whitefly during the study. Similar findings were also observed by Begam *et al.* [5] who reported that the coccinellid predators were started appearing in field during January- February and reached its peak activity during March in *Bhut Jolokia* which coincided with maximum temperature and highest aphid population. Jadhav [25] also reported that the lady bird beetle population was observed from March to May in summer okra and reached its peak population in April when the maximum population of aphids was observed. The correlation studies of coccinellid beetles with the weather parameters and its prey population revealed that the population of coccinellids was significant with positive correlation with the population of its prey (r = 0.791, r = 0.528) in both the seasons (Table 3 and 4). A non-significant positive correlation was observed with maximum temperature and bright sunshine hours (r = 0.059 and 0.209, respectively) whereas minimum temperature, average relative humidity and total rainfall showed non-significant negative correlation (r = -0.149, -0.685 and -0.186, respectively) during 2014-15 with the coccinellids (Table 3). During 2015-16, maximum and minimum temperature and bright sunshine hours showed non-significant positive correlation (r = 0.071, 0.060 and 0.193, respectively) and non-significant negative correlation with average relative humidity and total rainfall (r = -0.312 and -0.056, respectively) (Table 4). The results were in conformity with Lokeshwari *et al*. [26] who reported that the weather parameters had no significant effect on the natural enemies but significant positive correlation was observed with aphid population. However, Begam *et al.* [5] and Jadhav [25] reported that the lady bird population showed positive correlation with maximum and minimum temperature and bright sunshine hours but negative correlation with relative humidity and rainfall.

Spiders

The spiders were started appearing in the field during third week of February to till harvesting of the crop (third week of June) with an incidence of 0.10 and 0.03 per plant, respectively and the highest population was observed (0.70 per plant) during fourth week of March in 2014-15 (Table 1). During 2015-16, the incidence was recorded from third week of February (0.03 per plant) to second week of June (0.37 per plant) with a maximum population (0.73 per plant) during third week of April (Table 2). The correlation studies revealed that the maximum temperature and prey population had a significant positive correlation with the population of spider (r = 0.536 and 0.768, respectively) and in case of minimum temperature and total rainfall they showed positive but non-significant correlation (r = 0.366 and 0.101 respectively). Whereas a non-significant negative correlation was observed with average relative humidity and bright sunshine hours (r = -0.037 and -0.103, respectively) during 2014-15 (Table 3). In 2015-16, a positive significant correlation was recorded with maximum and minimum temperature with prey population (r = 0.470, 0.605 and 0.683, respectively) and a non-significant associated with average relative humidity, total rainfall and bright sunshine hours (r = 0.052, 0.282 and 0.153,

respectively) (Table 4). The present findings were in conformity with Pathan and Bharpoda [12] and Jadhav *et al*. [25] who reported a positive significant effect of maximum and minimum temperature with predatory spider population. However, Singh and Singh [27] observed that maximum temperature had significant negative impact on population fluctuation of spiders in cowpea.

Conclusion

Most of the pest population and their natural enemies were low during the study in both the seasons. The incidence of *A. ipsilon* was confined only in the seedling stage whereas *B. latifrons* during the later stages of the crop and most of the sucking pests and their predators were observed throughout the cropping season with maximum incidence during vegetative to flowering stages of the crop. A significant positive correlation of aphids, whitefly and fruit fly was observed with maximum temperature whereas whitefly and leafhoppers showed significant negative correlation with the average relative humidity in both the seasons. Thus, the finding will helps in developing the management strategy by understanding the population dynamics of major pests of king chilli in the region.

Acknowledgement

The authors gratefully acknowledge the help rendered by Dr. Kumar Gorpade, University of Agricultural Sciences, Dharwad and other taxonomist of NBAIR and GKVK, Bengaluru for identifying the insect specimens.

References

1. Baruah BR. Transmission and integrated management of viral disease complex of Bhut Jolokia. M.Sc. (Agri.) Thesis, Assam Agricultural University, Jorhat (India), 2014.
2. Meghvansi MK, Siddiqui S, Khan MH, Gupta VK, Vairale MG, Gogoi HK *et al*. Naga chilli: A potential source of capsaicinoids with broad-spectrum ethno pharmacological applications. Journal of Ethnopharmacology. 2010; 132:1-14.
3. Singh B, Ghosal S. Bhut Jolokia gets ready for 'spicy' launch. The Economic Times Bangalore, 2010.
4. Parasar I, Deka N. Bhut Jolokia: A viable crop to mitigate the effect of climate change. Seminar on Climate change and climate resilient agriculture held at B. N. College of Agriculture on 18th and 19th March, 2013, 143p.
5. Begam N, Saikia DK, Borkakati RN. Seasonal incidence of major insect pests and their natural enemies of Bhut Jolokia. Annals of Plant Protection Sciences. 2016; 24(2):259-264.
6. Buragohain P, Saikia DK, Borkakati RN, Dutta BC, Rojeet Thangjam. Pest complex and the population dynamics of major pests of *Bhoot jolokia.* Ecology Environment Conservation. 2017; 23(3):265-272.
7. Thangjam R, Borah RK, Saikia DK. Pest complex of king chilli, *Capsicum chinense* Jacquin in Assam, North East India. The Bioscan. 2017; 12(4):2069-2073.
8. Meena RS, Ameta OP, Meena BL. Population dynamics of sucking pests and their correlation with weather parameters in chilli, *Capsicum annum* L. crop. The Bioscan. 2013; 8(1):177-180.
9. Shivanna BK, Gangadhara Naik B, Basavaraja MK, Nagaraja R, Kalleswara Swamy CM, Karegowda C. Impact of abiotic factors on population dynamics of sucking pests in transgenic cotton ecosystem. International Journal Science and Nature. 2011; 2(1):72-74.
10. Saini A, Ahir KC, Rana BS, Kumar R. Population dynamics of sucking pests infesting chilli (*Capsicum annum* L.). Journal of Entomology and Zoology Studies. 2017; 5(2):250-252.
11. Anjali M, Singh NP, Mahesh M, Swaroop S. Seasonal incidence and effect of abiotic factors on population dynamics of major insect pests on brinjal crop. Journal of Environmental Research and Development. 2012; 7(1):431-435.
12. Pathan NP, Bharpoda TM. Succession of major insect pests in okra, *Abelmoschus esculentus* (L.) Moench grown in summer. International Journal of Agricultural Science and Research. 2016; 6(4):111-118.
13. Tiwari G, Prasad CS, Kumar A, Nath L. Influence of weather factors on population fluctuation of pest complex on brinjal. Annals of Plant Protection Sciences. 2012; 20(1):68-71.
14. Kumar M, Singh PS. Population dynamics of major insect pest of blackgram [*Vigna Mungo* (L.) Hepper] in relation to weather parameters. International Journal of Agriculture, Environment and Biotechnology. 2016; 9(4): 673-677.
15. Pathipati VL, Vijayalakshmi T, Naramnaidu L. Seasonal incidence of major pests of chilli in relation to weather parameters in Andhra Pradesh. Pest Management in Horticultural Ecosystems. 2014; 20(1):36-40.
16. Roopa M, Kumar CTA. Seasonal incidence of pests of Capsicum in Bangalore conditions of Karnataka, India. Global Journal of Biology, Agriculture and Health Sciences. 2014; 3(3):203-207.
17. Singh AP, Singh RN. Effects of abiotic factors on the population dynamics of yellow mite, *Polyphagotarsonemus latus* (Banks) on chilli crops in Varanasi. Journal of Insect Science. 2012; 25(3):237-240.
18. Begam N. Incidence and management of insect pests of hot chilli, *Capsicum chinense* Jacq. *M.Sc. (Agri.) Thesis*, Assam Agricultural University, Jorhat (India), 2015.
19. Girradi BS, Lingappa S, Kulkarni KA, Rao KJ. Influence of weather factors on the seasonal activity of cutworm, *Agrotis* spp. (Lepidoptera; Noctuidae). Karnataka Journal of Agricultural Sciiences. 1997; 10(1):36-41.
20. Boopathi T, Singh SB, Ngachan SV, Manju T, Ramakrishna Y, Lalhruaipuii. Influence of weather factors on the incidence of fruit flies in chilli (*Capsicum annuum* L.) and their prediction model. Pest Management in Horticultural Ecosystems. 2013; 19:194-198.
21. Ye H, Lui J. Population dynamics of oriental fruit fly *Bactrocera dorsalis* (Diptera: Tephritidae) in Xishuangbanna, Yunnan Province, China. Frontiers of Agriculture in China. 2007; 1(1):76-80.
22. Nandre AS, Shukla A. Population dynamics of fruit fly [*Bactrocera dorsalis* (Hendle)] on Sapota. Agricultural Science Digest. 2014; 34(1):70-72.
23. Sunil, Tippaiah M, Jayaram CS. Seasonal Incidence of Fruit Borers with Special Reference to Melon Fruit Fly, *Bactrocera cucurbitae* (Coquillet) on Bitter Gourd (*Momordica charantia* L.). Indian Journal of Pure & Applied Biosciences. 2016; 4(3):87-92.
24. Boopathi T, Manju T, Singh SB, Ramakrishna Y, Dutta SK, Singh AKR. Relative abundance of tephritid fruit

flies with methyl eugenol traps in capsicum. Indian Journal Plant Protection. 2015; 43(4):528-531.
25. Jadhav YT, Bhede BV, Shinde DS. Influence of meteorological factors on population build-up of aphids and natural enemies on summer Okra. International Journal of Current Microbiology and Applied Sciences. 2017; 6(3):2527-2537.
26. Lokeshwari RK, Devikarani KH, Singh TK. Seasonal dynamics of *Aphis gossypii* and relative abundance of its coccinellid predators on cucumber. Indian Journal of Entomology. 2010; 72(2):114-116.
27. Singh C, Singh NN. Occurrence of insect-pests infesting cowpea (*Vigna unguiculata* Walpers) and their natural enemy complex in associations with weather variables. Legume Research. 2014; 37(6):658-664.