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Seasonal incidence of aphid, *Aphis gossypii* and coccinellid beetles in tomato ecosystem, *Solanum lycopersicum* L.

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Abstract
Seasonal incidence of aphid, *Aphis gossypii* and its natural enemies were studies at college of agriculture, Assam Agricultural University, Jorhat, Assam during 2015-16 and 2016-17. Aphid reached its peak (9.4 and 9.1/leaf) during March and first fort night of February during 2015-16 and 2016 -17, respectively. During the present investigation, altogether, three species of coccinellid predators were encountered in the tomato ecosystem and these includes *Coccinella transversalis, Micraspis discolour, Coccinella septempunctata.* They showed a significant negative correlation with average relative humidity and a non-significant positive correlation with maximum temperature and also showed a positive significant correlation with aphid population during 2015-16 and 2016-17, respectively. The findings from the current study showed that the coccinellid beetles could able to control the aphid population effectively after correlation and regression analysis.

Keywords: *Aphis gossypii*, *Coccinella transversalis*, *Micraspis discolour*, *Coccinella septempunctata*, seasonal incidence, tomato

1. Introduction
Tomato, *Solanum lycopersicon* L. is one of the important vegetable crop grown in India. It is an herb, grown as annual vegetable crop for its fleshy edible fruits throughout the world and India is the second leading producer of vegetables next to china. Even though, the production and total cultivated area of tomato have increased gradually over the last few years in our country but the productivity is very low compared to the average of the world's yield of 26.29 tonnes per hectare (*Anon*., 2010) [1] due to several abiotic and biotic factors, which includes insect pests. Among different insect pests, aphid, *Aphis gossypii* is an important sucking pest and it is found damaging tomato crop all over the country. Coccinellid beetles are the important predator which feed on aphids and helps to check the pest population. Hence, the present study was conducted to study the population buildup of aphids and coccinellid predators and their relation to weather parameters. Correlation and regression analysis

2. Material and Methods
A field experiment was conducted at Assam Agricultural University, Jorhat, Assam to study the seasonal incidence of aphid and coccinellid predators during 2015-16 and 2016-17. The experiment was laid out in randomized block design in three replications with a plot size of 3 m x 3.5 m. Observations on aphid and coccinellid beetle activity were recorded in weekly intervals by taking five randomly selected plants per plot and counting the population from the top, middle and lower parts of the tomato plant. Correlation studies were carried out to study the influence of meteorological factors like maximum temperature, minimum temperature, relative humidity, total rainfall, bright sunshine hours on the population build up of aphid and also with coccinellid predators and regression analysis was done and represented in the graph.

3. Results and Discussion
3.1 Seasonal incidence of aphid (*Aphis gossypii*)
The results pertaining to seasonal incidence of aphids are presented in Table 1 and Table 2 during 2015-16 and 2016-17 respectively. During 2015-16, the first incidence of *Aphis gossypii* was observed on 7th November'2015 with a mean population of 0.8 aphids per leaf. Afterwards, the population increased to 1.96 aphids per leaf in the 2nd count recorded on 14th

November' 2015. The population gradually showed an increasing trend and attained a peak of 5.34 aphids per leaf on 14th December'2015 and started declining up last week of January'2016 and again attained a peak of 9.4 aphids per leaf on 2nd March' 2016. This was followed by gradual reduction in population recorded on 23rd March'2016.

During the period of study 2016-17, the first appearance of *A. gossypii* was recorded on 10th November'2016 with a mean population of 0.1 aphids per leaf. The population was seen to be gradually increased to 0.33 aphids per leaf in respect of 2nd count recorded on 18th November' 2016. The population attained a peak of 9.1 aphids per leaf on 15th February'2017. This was followed by gradual reduction in population recorded on 24th March' 2017.

Hath and Das (2004) [2] observed maximum aphid population on tomato during the first week of March. Barde (2006) [3] reported that the peak population was observed during the last week of February. Chakraborty (2011) [4] also reported that population of *A. gossypii* was initiated during second fort night of November and gradually increased the population and reached peak in last fort night of February.

3.2 Seasonal incidence of coccinellid predators

Three species of coccinellid predators were observed during the period of study. The appearance of coccinellid predators was started from last fort night of November during both the year of investigation. The data are presented in Table1 and Table 2. The coccinellid predator population ranged from 0.4 to 2.7 predators per plant during 2015-16 and 0.46 to 2.7 during 2016-17, respectively. The maximum population (2.7 predatsors per plant) was recorded during first week of March which coincided with maximum temperature 28.3 ^{0}C and maximum aphid population (9.4 aphids per leaf) during 2015-16. Likewise, during the experimental period of 2016-17, a similar trend of increasing predators (2.7 per plant) was recorded during third week of February which coincided with a temperature of 27.9 ^{0}C and also with aphid population (9.1 aphids per leaf). Khating *et al*. (2016) [5] 0bserved that the population of lady bird beetle was directly dependent upon the incidence level of aphid, leafhoppers and whitefly in field.

3.3 Influence of weather parameters on aphids and coccinellid predators

The correlation studies of the aphids (Table 3 and Table 4) with different meteorological parameters indicated a non significant positive correlation with maximum temperature (r=0.250 and r= 0.003), total rainfall (r= 0.134 and r= 0.013), bright sunshine hours (r=0.343 and r= 0.047) during 2015-16 and 2016-17 respectively. During 2015-16, minimum temperature (r=-0137) showed positive correlation but minimum temperature (r= -0.183) was negatively correlated during 2016-17. However, a significant negative correlation was observed with average relative humidity (r= -0.470 and r=-0.826) during 2015-16 and 2016-17 respectively. This observation was also made by Rishikesh *et al*., (2015) [6] and they found positive correlation with maximum temperature, total rainfall and a negative correlation with minimum temperature and relative humidity. A non-significant correlation was observed with bright sunshine hours (r=0.343, r=-0.047) in the development of aphid population.

Correlation studies (Table 3 and Table 4) of coccinellid predators showed a non-significant but positive correlation with maximum temperature (r= 0.191 and r= 0.208), minimum temperature (r= 0.118 and r=0.003), total rainfall (r= 0.044 and r= 0.017) and bright sunshine hours (r=0.104 and r=0.010). However, average relative humidity (r= -0.469 and r=-0.641) showed significant negative effect on the population build up of the predators during 2015-16 1nd 2016-17, respectively. According to Venkateshwarlu *et al*. (2011) [7], the population buildup of coccinellid were directly influenced by maximum and minimum temperature while they were negatively influenced by morning and evening relative humidity. Meena and Kanwat (2010) [8] observed the negative correlation with relative humidity while rainfall was non-significant.

3.4 Coefficient of correlation (r) and regression equation between coccinellids and *A. gossypii*

Simple correlation and regression equation of coccinellids and *A. gossypii* during 2015-16 and 2016-17 are presented in table 5 and illustrated in Fig.1 (a and b). The data presented in the table 5 showed that the coccinellid predators registered a significant positive correlation with *A. gossypii* population (r= 0.927 and r=0.791) during 2015-16 and 2016-17, respectively. Therefore, in order to formulate a proper eco friendly management practices against aphids, coccinellid beetles can also be utilized effectively to reduce aphid population in the field as they could able to reduce the pest population significantly.

Table 1: Population build up of *Aphis gossypii* and coccinellid predators in relation to meteorological parameters during 2015-16

Date of observation	Temperature (^{0}C)		Average RH (%)	Rainfall (mm)	BSSH (hr.)	No. of aphids/leaf (nymphs & adults)	No. of coccinellid/plant
	Max.	Min.					
5Nov-11 Nov	27.9	19.8	88.5	16.5	17.3	0.1	0
12Nov-18 Nov	30.2	18.0	81	0.0	23.4	0.33	0.6
19Nov -25 Nov	27.5	12.3	80.5	0.0	61.6	1.63	1
26 Nov - 2 Dec	27.7	13.8	78.5	0.0	57.4	2.9	1.5
3 Dec - 9 Dec	27.6	11.8	80	0.0	56.3	3.7	2.3
10Dec -16 Dec	26.5	9.7	79	0.0	61.7	3.1	1
17Dec -23 Dec	26.0	12.6	80.5	0.0	37.4	3.3	0.8
24 Dec-31 Dec	25.0	12.6	82.5	43.5	46.3	2.9	0.6
1 Jan - 7 Jan	25.9	10.7	77.5	0.1	57.6	2.4	0.4
8 Jan - 14 Jan	24.0	9.3	79.5	0.0	46.0	2.1	0.5
15 Jan -21 Jan	24.3	8.0	78	0.0	57.0	1.3	0.2
22 Jan - 28 Jan	26.8	9.1	73.5	0.0	53.3	6.5	1.2
29 Jan - 4 Feb	25.5	11.3	78	2.0	51.1	6.0	1.7
5 Feb - 11 Feb	27.4	12.6	74	0.0	30.1	7.4	2.1
12Feb - 18 Feb	27.9	11.0	69	0.0	49.8	9.1	2.7
19Feb - 25 Feb	25.6	15.0	81	37.4	31.3	3	2

26 Feb - 4 Mar	25.9	15.0	77	0.0	22.3	4.2	1.7
5 Mar - 11 Mar	26.3	14.6	76.5	19.2	35.2	6.7	1.9
12Mar -18 Mar	26.8	14.3	72	10.6	46.7	7.6	2
19Mar -25 Mar	26.3	12.6	82.5	26	34.4	6.8	1.6

*BSSH- Bright Sun Shine Hours

Table 2: Population buildup of *Aphis gossypii* and coccinellid predators in relation to meteorological parameters during 2016-17

Date of observation	Temperature (^{0}C)		Average RH (%)	Rainfall (mm)	BSSH	No. of aphids/leaf (nymphs & adults)	No. of coccinellid/plant
	Max.	Min.					
5 Nov - 11 Nov	27.9	19.8	88.5	16.5	17.3	0.1	0
12 Nov -18 Nov	30.2	18.0	81	0.0	23.4	0.33	0.6
19 Nov -25 Nov	27.5	12.3	80.5	0.0	61.6	1.63	1
26 Nov - 2 Dec	27.7	13.8	78.5	0.0	57.4	2.9	1.5
3 Dec - 9 Dec	27.6	11.8	80	0.0	56.3	3.7	2.3
10 Dec -16 Dec	26.5	9.7	79	0.0	61.7	3.1	1
17 Dec - 23 Dec	26.0	12.6	80.5	0.0	37.4	3.3	0.8
24 Dec- 31 Dec	25.0	12.6	82.5	43.5	46.3	2.9	0.6
1 Jan - 7 Jan	25.9	10.7	77.5	0.1	57.6	2.4	0.4
8 Jan - 14 Jan	24.0	9.3	79.5	0.0	46.0	2.1	0.5
15 Jan -21 Jan	24.3	8.0	78	0.0	57.0	1.3	0.2
22 Jan - 28 Jan	26.8	9.1	73.5	0.0	53.3	6.5	1.2
29 Jan - 4 Feb	25.5	11.3	78	2.0	51.1	6.0	1.7
5 Feb - 11 Feb	27.4	12.6	74	0.0	30.1	7.4	2.1
12Feb - 18 Feb	27.9	11.0	69	0.0	49.8	9.1	2.7
19Feb - 25 Feb	25.6	15.0	81	37.4	31.3	3	2
26 Feb - 4 Mar	25.9	15.0	77	0.0	22.3	4.2	1.7
5 Mar - 11 Mar	26.3	14.6	76.5	19.2	35.2	6.7	1.9
12 Mar - 18 Mar	26.8	14.3	72	10.6	46.7	7.6	2
19 Mar - 25 Mar	26.3	12.6	82.5	26	34.4	6.8	1.6

*BSSH- Bright Sun Shine Hours

Table 3: Correlation coefficient (r) and regression equation of aphid and coccinellid predators of tomato with meteorological parameters during 2015-16

Aphid and coccinellid predators	Temperature		Average Relative humidity (%)	Total rainfall (mm)	BSSH (hr.)
	Maximum	Minimum			
Aphis gossypii	0.250^{NS}	0.317^{NS}	-0.470^{**} Y=31.649-0.403x	0.233^{NS}	-0.189^{NS}
Coccinellid beetles	0.191^{NS}	0.118^{NS}	-0.469* Y=5.94-0.090x	0.044^{NS}	-0.104^{NS}

NS: Non significant,*: Significant at 0.05% level, **: Significant at 0.01% level

Table 4: Correlation coefficient (r) and regression equation of aphid and coccinellid predators of tomato with meteorological parameters during 2015-16

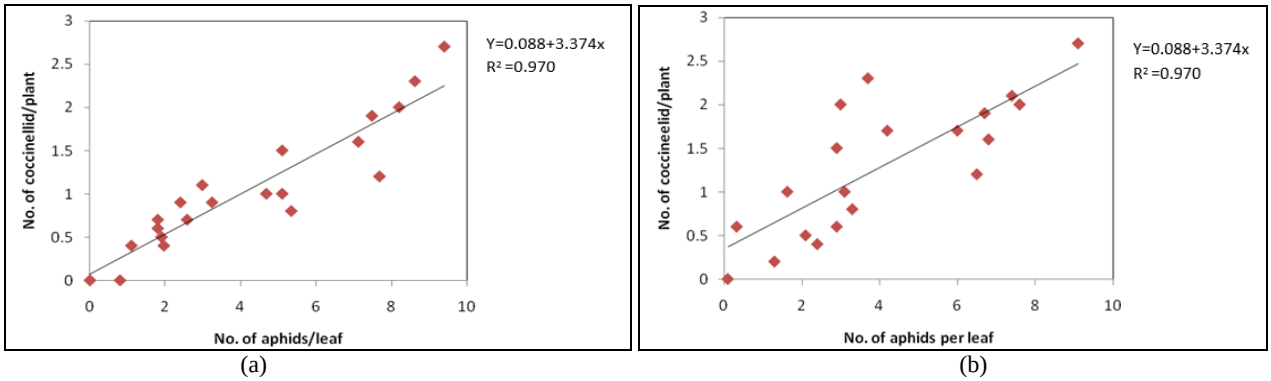
Aphid and coccinellid predators	Temperature		Average Relative humidity (%)	Total rainfall (mm)	BSSH (hr.)
	Maximum	Minimum			
Aphis gossypii	0.019^{NS}	-0.165^{NS}	-0.815^{**} Y=52.324-0.618x	0.016^{NS}	0.033^{NS}
Coccinellid beetles	0.208^{NS}	0.003^{NS}	-0.641^{NS}	0.017^{NS}	0.010^{NS}

NS: Non significant,*: Significant at 0.05% level, **: Significant at 0.01% level

Table 5: Correlation coefficient (r) and regression equation between coccinellid predators and aphid, *Aphis gossypii*

Insects	2015-16	2016-17
Coccinellid predators and *Aphis gossypii*	0.927** y=0.327+3.711x	0.791** y=0.592+2.682x

NS: Non significant,*: Significant at 0.05% level, **: Significant at 0.01% level



(a) (b)

Fig 1: Relationship of coccinellid predators with *A. gossypii* population during 2015-16 (a) and 2016- 17 (b)

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