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Population dynamics of aphids (*Chaetosiphon fragaefolii* Cockerell) on strawberry

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Abstract
Field experiments were carried out at Entomology Research Farm, SKUAST-J Chatha, Jammu for two consecutive years (2017-19) to study the population dynamics of aphids (*Chaetosiphon fragaefolii* Cockerell) on strawberry and impact of different weather parameters on aphid population. The studies witnessed commencement of aphids on strawberry from 3rd to 22nd standard week during both the years, with one peak in 2018 (12th standard week) and two peak populations in 2019 (8th and 12th standard weeks). The aphid population was negatively correlated with weekly mean morning and evening relative humidity (%) and rainfall (mm) and positively correlated with maximum and minimum temperatures (°C).

Keywords: *Chaetosiphon fragaefolii*, aphididae, hemiptera, correlation, seasonal incidence, strawberry aphids

1. Introduction
Strawberry is one of the most popular soft fruits and is widely grown in protected and open conditions in temperate and subtropical countries (Shankar and Abrol, 2019) [10]. The cultivated strawberries (*Fragaria x ananassa* Duch.) are valued for its flavour, fragrance and richness in natural bioactive compounds, especially anthocyanins (Karaagac and Ucurum, 2019) [4]. It occupies a unique place among fruits and is most important soft fruit after grapes. As per the Department of Horticulture, 174 hectares of land is under cultivation of strawberries in J&K which gives a yearly produce of 388 metric tons fruit (Anonymous, 2020) [1]. The varied agro-climatic conditions of the state offer excellent conditions for growing this high value and short duration crop over longer periods. However, strawberry yield and fruit quality is influenced by several factors out of which significant damage is inflicted by insect-pests, more precisely by strawberry aphids, *Chaetosiphon fragaefolii* Cockerell (Homoptera: Aphididae) (Mann, 1994; Mani and Krishnamoorthy, 1996; Day, 1996; Sridhar *et al.*, 2001) [3, 7, 8, 11]. Aphids' infestation is a common phenomenon in strawberry cultivation and its continuous desapping leads to the development of sooty mould (*Capnodium* sp.), resulting into reduced photosynthesis, production, and fruit quality (Krczal, 1982; Rondon *et al.*, 2005; Cedola and Greco, 2010) [2, 5, 9]. *C. fragaefolii* also causes indirect damage through transmission of viruses such as the *strawberry mild yellow edge virus*, *strawberry crinkle virus* and *strawberry mottle virus* (Krczal, 1982) [5]. Thus, keeping in view, the importance of this fruit and the problem posed by aphids (*C. fragaefolii*), the population dynamics of aphids on strawberry and their correlation with different weather parameters was worked out.

2. Materials and Methods
The experimental trials were laid out at Entomology Research Farm, SKUAST-J Chatha, Jammu (32.73°N latitude and 74.87°E longitude) for two consecutive years (2018 and 2019). Strawberry (Variety Chandler) runners were procured and transplanted in 3m×2m plots. The row to row and plant to plant distance were maintained at 45cm×30 cm. Ten plants were randomly selected and tagged for observation. Regular observations were recorded at weekly interval from the day of the appearance of aphids on strawberry. The upper, middle and lower leaves were selected from the randomly selected three plants for population count in each plot. The obtained data was analyzed in a Randomized Block Design (RBD) and was further subjected to correlation and regression analysis with various abiotic factors of environment and the subsequent statistical analysis was worked out. The required weather data was obtained from section of Agro-meteorology, SKUAST-JAMMU for the correlation and regression studies.

3. Results and Discussion

The population dynamics of aphid on strawberry was observed during the cropping season of 2018 and 2019. During 2018, mean aphid population per plant in strawberry ranged from 1.00 to 98.00 (Table 1). Infestation was first observed during 3rd standard week with an initial population of 2.00 aphids per 3 leaves/3 plants. The mean weekly temperature and relative humidity during the period were recorded to be 11.4 °C and 78.05%, respectively. The population was observed to be increasing gradually till 12th standard week of March 2018 recording a maximum of 98.00 aphids per 3 leaves/3 plants. During this period, the weekly mean temperature and relative humidity were observed 18.05°C and 71.75%, respectively. The population of aphid then decreased till 22nd standard week on the same crop up to 1.00 aphid per 3 leaves/3 plants. Thus, there was one peak of aphid population build-up observed during March on strawberry cropping season during 2018. During 2019, the data regarding population dynamics of aphids on strawberry is depicted in (Table 2). The results obtained showed that population of aphid again commemorated in 3rd SW (5.00 aphids/3 leaves/3 plants) when mean temperature (maximum and minimum), relative humidity (morning and evening), and rainfall, during the period were recorded to be 17.2 °C, 7.6 °C, 91.6 and 61.6%, 0.0 mm, respectively. The aphid population increased in 8th SW (104.0 aphids/3 leaves/3 plants) and reached its peak, when mean temperature (maximum and minimum), relative humidity (morning and evening), and rainfall during the period were recorded to be 23.3 °C,10.1°C, 86.7, 47.3% and 0.00 mm, respectively. Again, after few weeks with some fluctuations in the aphid population, it attained the 2nd peak (98.0 aphids/3 leaves/3 plants) in the 12th standard week. Thus, 2019 constituted two peaks of aphid population on strawberry crop. Thereafter, the aphid population starts declining and recorded the lowest population during 22nd standard week. The corresponding weather parameters were found to be 26.0 °C, 13.9°C, 83.1%, 51.3% and 9.00 mm, respectively during the 2nd peak population of aphids. Zemfirov (1973) found that in Bulgaria, aphid (*C. fragaefolii*) over-winters in the adult stage and parthenogenetic reproduction begins in late March and the peak infestation was observed during July followed by a depression and then a peak was observed in October and November. The difference in his finding and the present investigations may be due to differences in agroclimatic zones where the studies have been conducted.

Table 1: Mean population dynamics of aphids (*Chaetosiphon fragaefolii*) on strawberry during 2018.

SW	Weekly mean population dynamics of aphids/3 leaves/3 plants	Max. T (°C)	Min. T (°C)	Rh1 (%)	Rh2 (%)	Rainfall (mm)
3	2.00	17.4	5.4	91.7	64.4	5.4
4	12.00	16.6	4.4	93.4	53.4	41.6
5	9.00	18.3	6.0	90.4	55.4	8.8
6	29.00	18.4	8.0	91.3	57.0	59.2
7	74.00	19.2	9.4	93.6	65.9	20.6
8	38.00	20.3	8.6	91.3	58.6	67.8
9	70.00	18.0	6.3	92.3	56.6	11.2
10	88.00	22.4	8.8	91.1	49.0	0.0
11	95.00	24.3	9.1	91.3	46.1	10.8
12	98.00	25.2	10.9	91.9	51.6	14.2
13	91.00	29.1	13.5	89.0	44.4	0.0
14	81.00	33.4	15.9	80.9	37.1	0.0
15	87.00	33.8	17.8	81.4	38.7	7.2
16	51.00	30.2	17.1	77.1	43.4	26.8
17	37.00	37.1	17.9	57.6	22.9	8.4
18	28.00	36.6	18.3	42.4	18.7	0.0
19	21.00	38.5	19.6	47.9	23.9	0.0
20	11.00	34.9	20.9	58.6	32.0	0.6
21	6.00	37.1	21.1	58.3	28.6	5.0
22	1.00	43.1	21.7	46.4	24.6	0.0

* Mean of three replications

Table 2: Mean population dynamics of aphids (*Chaetosiphon fragaefolii*) on strawberry during 2019.

SW	Weekly mean population of aphids/3 leaves/3 plants	Max. T (°C)	Min. T (°C)	Rh1 (%)	Rh2 (%)	Rain (mm)
3	5.00	17.2	7.6	91.6	61.6	0.0
4	21.00	18.2	6.0	90.0	55.6	0.0
5	14.00	16.6	5.1	92.1	64.0	18.2
6	66.00	19.0	4.8	91.9	49.7	0.0
7	78.00	24.3	8.5	93.3	47.1	0.0
8	104.00	23.3	10.1	86.7	47.3	9.2
9	94.00	24.5	11.8	90.4	52.4	20.0
10	74.00	20.5	10.7	88.6	61.4	35.4
11	68.00	24.2	10.2	81.0	53.6	40.8
12	98.00	26.0	13.9	83.1	51.3	9.0
13	91.00	25.3	14.0	81.6	61.1	50.4
14	81.00	28.0	13.2	77.1	44.4	6.8
15	68.00	32.7	17.2	74.4	39.4	0.0
16	31.00	30.9	17.2	67.4	44.3	15.0

17	37.00	32.4	18.6	69.3	38.9	4.0
18	28.00	34.0	20.1	66.3	36.1	11.0
19	21.00	35.3	19.7	61.6	32.3	2.2
20	11.00	34.7	19.2	59.7	30.4	5.8
21	6.00	41.8	20.9	48.9	18.2	0.0
22	1.00	33.7	21.9	64.1	47.0	10.8

* Mean of three replications

3.1 Correlation analysis

Correlation studies were worked out to find out the influence of abiotic factors (maximum and minimum temperatures, morning and evening RH and rainfall) on the population dynamics of aphids on strawberry at experimental site during 2018 and 2019 (Table 3). A highly significant negative correlation existed between weekly mean relative humidity evening (-0.600**), significant negative correlation with relative humidity morning (-0.473*) and rainfall (-0.398*), and significant positive correlation with maximum (0.431*) and minimum temperature (0.397*), respectively. However, during 2019, the correlation studies showed that aphid population was found highly significant but negatively correlated with morning (-0.503**) and evening relative humidity (-0.794**) and rainfall (-0.534**) while it was found as highly significant and positively correlated with maximum (0.577**) and minimum (0.518**) temperature. Perusal of the literature reveals that information on weather parameters influencing strawberry aphid (*Chaetosiphon fragaefolii*) is not available from India or elsewhere except studies conducted by Zemfirov (1973) who found that aphid population was drastically reduced if weather turned cool in Bulgaria.

Table 3: Correlation matrix of aphid of strawberry in relation to abiotic factors during 2018 and 2019.

Insect pest	Year	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
		Maximum	Minimum	Morning	Evening	
Aphid	2018	0.431*	0.397*	-0.473*	-0.600**	-0.398*
	2019	0.577**	0.518**	-0.503**	-0.794**	-0.534**

** Correlation is significant at the 0.05 level (2-tailed)

* Correlation is significant at the 0.01 level (2-tailed)

3.2 Regression analysis

Regression analysis was done to find out the influence of abiotic factors (maximum and minimum temperatures, morning and evening RH and rainfall) on the population dynamics of aphids on strawberry at experimental site during 2018 and 2019 (Table 4). The value of linear regression equation for population dynamics of aphids at experimental site during 2018 was calculated to be Y^1 = 1956.054 - 2.489X1 - 7.994X2 - 9.521X3 - 21.043X4 - 15.497X5. The equation showed the increasing trend of populations of aphids due to gradual increase in temperature, preferably up to a certain extent. The corresponding correlation co-efficient of multiple determination (R^2) was worked out to be 0.544 and was found statistically significant at 5% level of significance. The overall impact of weather factors on population buildup of aphids on strawberry was 54.40%. The data on linear regression equations for aphid population during 2019 was calculated to be $Y^1 = -464.775 + 3.529X_1 + 3.220X_2 + 6.496X_3 - 3.206X_4 + 1.587X_5$. The corresponding correlation co-efficient of multiple determination (R^2) value for aphid was worked out to be 0.754.

Table 4: Regression equation & coefficient of multiple determination (R) of aphids on Strawberry in relation to abiotic factors during 2018 and 2019.

Insect pest	Year	Regression equation	Correlation coefficient (r)	Coefficient of determination (r2)	Coefficient of variation (%)
Aphid	2018	$Y = 1956.054 - 2.489X_1 - 7.994X_2 - 9.521X3 - 21.043X4 - 15.497X_5$	0.738	0.544	54.40
	2019	$Y^1 = -464.775 + 3.529X_1 + 3.220X_2 + 6.496X_3 - 3.206X_4 + 1.587X_5$	0.868	0.754	75.40

Where, X_1 = Maximum temperature, X_2 = Minimum temperature, X_3 = Relative humidity morning, X_4 = Relative humidity evening, X_5 = Rainfall

4. Conclusion

Aphids are the major pests on strawberry under field conditions and their population was observed from 3rd to 22nd standard weeks. Thus, this crop needs strong and careful vigilance during this period, especially when the pest is above threshold level to check for the severity of this pest on strawberry and devise appropriate measures for its careful and effective management.

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