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Population dynamics of fennel aphid, *Hyadaphis coriandri* das and occurrence of coccinellid predators on aphid in fennel

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Abstract
Population dynamics of aphids have been studied under field condition at Instructional Farm, Department of Agronomy, College of Agriculture, JAU, Junagadh during Rabi season, 2015-16 in fennel crop. The activity of aphid, *H. coriandri* was commenced from 2nd week of February and remained up to 3rd week of March having peak during 4th week of February in fennel crop. Simultaneously, higher population of coccinellids was observed during 4th week of January to 3rd week of March and showed significantly highly positive correlation with aphid population in fennel crop.

Keywords: Population dynamics, aphid, *Hyadaphis coriandri*, occurrence of *coccinellid*, fennel

Introduction
Fennel, *Foeniculum vulgare* (Miller) is believed to be native of Southern Europe, North America and coastal Mediterranean area of India. It is commonly known as *'Variali /Variari'* in Gujarati, where *'Saunf'* in Hindi and considered as an important spices crop. India is the leader producer of fennel as the crop is grown in about 38,660 hectares and produces 59,750 tonnes (T) of seeds during 2014-15 (Anon., 2015) [1]. Fennel is mainly grown in India for the states of Gujarat and Rajasthan and to some extent in Uttar Pradesh, Karnataka, Andhra Pradesh, Punjab, Madhya Pradesh, Bihar, Haryana and Jammu & Kashmir but Gujarat is the "heart" of India for the production of fennel. In Gujarat, the total area under Fennel is 45,400 hectares with annual production of 96,773 tonnes (T) of seeds during 2015-16 with the highest productivity of 1440 kg ha^{-1} (Meena *et al.*, 2010; Anon., 2016) [10, 2].
There are many insect-pests which are causing damage to the fennel crop. Among the different pests there are some sucking insect which causes economic loss to the crop *viz.*, Aphids, *Hyadaphis coriandri* Das and *Aphis gossypii* (Glover); Jassids, *Empoasca kerri* (Das); Thrips, *Thrips tabaci* (Lindeman), *Thrips flavus* (Schrank), S*cirtothrips dorsalis* (Hood); Pentatomid bugs, *Calcoris noregicus* (Gml); fennel flower bug, *Otinotus spp.*; Lygus bugs, *Lygus spp.* and Seed midges, *Systole coriandri* (Nikol) and *Systole albipennis* (Walkar). Among the different pests, aphid, *H. coriandri* causes maximum damage to the fennel crop as both nymph and adults suck the cell sap from leaves, stem and umbels and as a result plant becomes weak and stunted. In addition, it exudes copious quantity of honeydew, which favour the growth of sooty mould and results into retarded growth of the plant. Mittal and Butani (1989) recorded the losses of fennel seeds caused by aphid up to 903 kg/ha, which means 50 per cent of the crop losses in Gujarat and it is considered as a major or key pest of fennel which poses a threat to seed spices under Gujarat condition.

Materials and methods
In order to determine the population dynamics of fennel aphids, the crop was grown in November, 2015 at the instructional farm, Department of Agronomy, College of Agriculture, JAU, Junagadh having plot area 20 square meter. Randomly, the experimental plot was divided into four equal quadrates (1 x 1 square meter.) and number of aphid (nymph and adults) and coccinellids were recorded from five randomly selected plants from each quadrate. The fennel crop under experimentation was kept free from application of any insecticides. The observation on population of aphids was recorded at weekly interval, starting from germination to the harvest of crop. The population of aphid was estimated by adopting zero to four index through the observation made on 10 cm terminal twigs.

The following indices were fixed for estimation of population.
Indices Description

1. Plant free from aphids.
2. Aphids present but colonies builds up. No injury due to pest apparent on the plant.
3. Small colonies of aphids presents.
4. Large colonies of aphids presents on tender parts [Counting of the aphid colonies is possible and tender plant parts shows the damage symptoms due to aphids].
5. Entire plants were covered by aphids [Counts of aphids in colonies is impossible and plants shows the damage symptoms due to aphids] and finally plant dies.
6. The average aphid index was worked out by the following formula.

$$\text{Average aphid index per plant} = \frac{0N+1N+2N+3N+4N}{\text{Total number of plants observed}}$$

Where,
0, 1, 2, 3 and 4 are aphid index.
N = Number of plant showing respective aphid index. (Patel *et al*., 2011) [9]
The weekly meteorological observations on maximum (MaxT) and minimum temperature (MinT), morning (RH1) & evening relative humidity (RH2), wind velocity (WV), bright sunshine hours (BSS) were obtained from the meteorological observatory of Instructional farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during the course of investigation.

Correlation study
In order to study the influence of different meteorological parameters on pest incidence, simple correlation between periodical mean values of aphid with various abiotic parameters was calculated. Similarly, simple correlation between periodical mean values of aphid with coccinellid predators was also calculated.

Result and discussion
Infestation of aphids, *H. coriandri* on fennel plants
To know the effect of weather parameter on occurrence and abundance of aphid, *H. coriandri* the data showed in Column 4 in Table 1. The occurrence of aphid was commenced from 4th week of December i.e. 52nd Standard Meteorological Week (SMW) and continued till 4th week of March (13th SMW) which ranged from 0.15 to 3.05 [aphid index (A.I.) /plant]. The population of *H. coriandri* was fluctuated during the crop period. The infestation (0.15 A.I. /plant) was started from 4th week of December (52nd SMW) and showed first peak (3.05 A. I. /plant) during 4th week of February (9th SMW). In subsequent weeks, the incidence was decreased and reached to 0.45 A.I. /plant during 4th week of March (13th SMW). Starting from the infestation to the harvest of the crop pest showed continuous trend of increasing and after reaching its first peak aphids were continuously decreased.
A close perusal of this pest indicated that relatively higher (1.30 to 3.05 A. I. /plant) infestation of aphid was observed during 2nd week of February to 3rd week of March with a peak on 4th week of February. According to Hirpara (2000) [3], the aphids, *H. coriandri* remained active during January to March. However, the highest activity of this pest was observed in the first week of March in fennel crop. The peak population of fennel aphid on fennel was recorded during February and March (Patel *et al.*, 2011) [9]. In case of coriander, the aphid incidence was started in the first week of February and increased with the advancement of the season while the peak incidence of the pest was recorded during the end of February and 1st week of March (average of 31.5 aphids /umbel) (Kalra *et al.*, 2006) [4]. The same results was recorded by Meena *et al.* (2009) [5] as the aphid infestation was began in the second week of January that gradually increased in numbers and reaching to the maximum (584.16 /3 plants) in the first week of February. Pareek *et al.* (2013) [8] recorded peak population of aphid in fourth week of February in coriander crop. Overall, the results of the investigation follow more or less similar trend with earlier reports.

Occurrence of coccinellid predators on aphid infestation
An attempt was also made to understand the role of coccinellid predators on population fluctuation of the aphids on fennel crop. The coccinellid predator *viz.*, *Coccinella septempunctata* L., *C. transverselis* L., *Cheilomenes sexmaculatus* (F) and *Hippodamia convergens* were found to appear after third week from the incidence of *H. coriandri* on fennel crop. Out of these *Coccinella septempunctata* L. was found to be dominant one.
The data (Column 5 in Table 1) indicated that the population of coccinellids commenced from 3rd week of January i.e. 3rd Standard Meteorological Week (SMW) and continued till 4th week of March (13th SMW) which ranged from 0.25 to 15.00 coccinellids /plant. The population of coccinellids was fluctuated during the crop period based on aphid population.
The population (0.50 coccinellids /plant) was started from 3rd week of January (3rd SMW) and showed its first peak (15.00 coccinellids /plant) during 4th week of February (9th SMW). In subsequent weeks, the population was decreased and reached to 0.25 coccinellids /plant during 4th week of March (13th SMW). Starting from the population to the harvest of the crop coccinellids showed continuous trend of increasing and after reaching its first peak they were continuously decreased.
Thus, it is clear from the data (Table 1) that relatively higher (1.75 to 15.00 coccinellids/plant) population was observed during 4th week of January to 3rd week of March having highest peak on 4th week of February.

Effect of weather parameters on aphid, H. coriandri population
The data (Column 2 in Table 2) on association between aphid infestation and weather factors indicted that there was positive significant impact on the incidence of aphid due to MinT [0.522*]. There was no any significant linear correlation either negative or positive between incidences of aphid population for rest of the physical factors. However, MaxT [0.410], wind speed (WS) [0.226] and relative humidity (RH1 [0.198], RH2 [0.181]) were positively whereas bright sun shine hours (BSS) [-0.165] were negatively correlated with the incidence of aphid population but the relationship was non-significant.
According to Hirpara (2000) [3] both relative humidity and minimum temperature showed the negative correlation, whereas, maximum temperature and sunshine hours showed the positive correlation with fennel aphid. In the context, it was also found that H. coriandri have negative correlation with mean atmospheric temperature and relative humidity (Meena *et al*., 2009) [5]. The population of aphid have positive correlation with maximum temperature (MaxT), minimum temperature (MinT) and bright sun shine hours (BSS) and have negative correlation with atmospheric temperature and

relative humidity (RH) (Patel *et al*., 2011) [9]. The more or less same results were obtained by Pareek *et al*., (2013) [8] who reported positive significant correlation between aphid population and maximum temperature (MaxT), whereas, minimum temperature (MinT), relative humidity (RH) and rainfall (RF) exhibited non–significant correlation with the population. In the present investigation the results are nearer to the earlier findings but not the same which is might be due to the variation in the sowing periods or environmental conditions during the experimentation.

Effect of biotic and abiotic factors on coccinellids

The data (Column 3 in Table 2) on association between coccinellids and biotic (aphid infestation) as well as abiotic factors (weather parameters) indicted that there was negative significant impact on the population of coccinellids due to bright sunshine hours (BSS) [-0.535*] while highly positive significant impact on the population of coccinellids due to aphid population [0.888**]. There was no any significant linear correlation either negative or positive between incidences of aphid population for rest of the physical factors. However MaxT [0.274], MinT [0.376], wind speed (WS) [0.150] and relative humidity (RH1 [0.043], RH2 [0.099]) were positively correlated with the population of coccinellids but the relationship was non-significant.

Overall the pest, H. coriandri was highly active during 2nd week of February to 3rd week of March having highest peak on 4th week of February in fennel crop while, relatively higher population of coccinellids was observed during 4th week of January to 3rd week of March. Among the different abiotic factors, MinT and coccinellids exerted their positive relationship with the aphid population while rests of the abiotic factors were positively or negatively correlated with aphid population but the relationship was non-significant. Coccinellids have significant negative correlation with bright sunshine hours (BSS) while highly positive significant relationship with aphid population.

Table 1: Population of aphid, *H. coriandri* and coccinellids in fennel

Sr. No.	SMW	Month	Mean A.I. /plant	No. of coccinellids /plant
1	**2**	**3**	**4**	**5**
1	51	December	0.00	0.00
2	52		0.15	0.00
3	1	January	0.25	0.00
4	2		0.40	0.00
5	3		0.55	0.50
6	4		0.70	1.75
7	5		0.85	2.25
8	6	February	0.95	4.25
9	7		1.30	8.00
10	8		2.15	13.25
11	9		3.05	15.00
12	10	March	2.85	9.50
13	11		2.50	6.00
14	12		1.90	3.75
15	13		0.45	0.25
16	14	April	0.00	0.00

Table 2: Correlation of *H. coriandri* with biotic and abiotic factors in fennel

Factors	Aphid	Coccinelids
1	**2**	**3**
Bright Sunshine Hours, hrday-1 (BSS)	-0.165	-0.535*
Maximum Temperature, ^{0}C (MaxT)	0.410	0.274
Minimum Temperature, ^{0}C (MinT)	0.522*	0.376
Morning Relative Humidity, % (RH1)	0.198	0.043
Evening Relative Humidity, % (RH2)	0.181	0.099
Wind Speed, kmhr-1 (WS)	0.226	0.150
Coccinelids	0.888*	1

*Significant at 5% level, **Significant at 1% level

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