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Population dynamics of major insect pests infesting fennel (*Foeniculum vulgare* L.)

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Abstract
Fennel (*Foeniculum vulgare* L.) is major seed spice crop grown in India. Insect- pests are one of the major limiting factors for higher production of fennel. The fennel crop was grown for two consecutive years during *rabi*, 2017-18 and 2018-19. During the course of study, five different insect pests *viz*., thrips, *Scirtthrips dorasalis* Hood; cow bug, *Oxyrachis* spp., gram pod borer, *Helicoverpa armigera* (Hunbner) Hardwick; aphid, *Hyadaphis coriandri* Das and seed midge, *Systole albipenis* Walker were recorded on fennel at various stages of the crop.

Keywords: Aphid, seed midge, aphid index, standard meteorological week, week after germination

Introduction
India is the largest producer, consumer and exporter of spices and spices products. It produces a wide variety of spices like black pepper, cardamom, ginger, garlic, turmeric, chili, coriander, cumin, fennel, fenugreek, dill, ajwain *etc*. Among seed spices fennel (*Foeniculum vulgare* L.) is major seed spice crop commonly known as '*Variyali'* in Gujarat. The estimated area under fennel in Gujarat was 56416 ha with production of 117340 tonne in 2018-19. Gujarat occupies first rank having 38130 ha area with production of 79240 tonne and productivity of 2078 kg ha^{-1} in 2017-18 which was 82 per cent of its total production in India (Anonymous, 2019) [1].
The production of fennel is affected by various insect- pests like aphid: *Hyadaphis coriandri* (Das), thrips: *Thrips flavus* (Schrank); *Thrips tabaci* (Lindeman); *Scirtothrips dorsalis* (Hood), whitefly: *Bemisia tabaci* (Genn.), leaf eating caterpillar/gram pod borer: *Helicoverpa armigera* (Hubner) Hardwick, seed midge: *Systole albipennis* (Walker); *Systole coriandri* (Gussakovsky), cutworm: *Agrotis ipsilon* (Hufnagel) & *Agrotis segetum* (Denis), brown wheat mite: *Pterobia latens* (Muller), pentatomid bugs: *Calcoris noregicus* (Fabricius), lygus bugs: *Lygus spp*., cigarette beetle: *Lasioderma serricorne* (Fabricius), and drug store beetle: *Stegobium paniceum* (Motschulsky). Among the insect pests of fennel, aphid, *H. coriandri* has reported to be regular in Rajasthan and other parts of the country (Kalra, 2006) [5]. Seed midge, *S. albipennis* and *S. coriandri* has been reported as other major insect pests which damage the fennel seeds (Kalra, 2007) [6].

Materials and Methods:
Fennel, *var*. GF-12 was sown for two successive *rabi* seasons *i.e.*, 2017-18 and 2018-19 in 20 x 30 meter area at a distance of 90 x 30 cm at Entomology Farm, B. A. College of Agriculture, Anand Agricultural University, Anand and raised by adopting standard recommended agronomical practices. The plot was kept free from insecticidal spray during both the years. For recording observations, plot was divided into 6 different sectors (each of 10 x 10 m) to record the incidence of insect pests. From each sector, 5 plants were selected randomly to count the insect pests population. The data thus obtained were correlated with biotic and abiotic factors. Observations were recorded at weekly interval starting from one week after germination till the crop maturity.

Thrips
Thrips was recorded by counting the number of thrips from three leaves of five randomly selected plants.

Aphid
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 indexes through the observation made on 10 cm terminal twigs of five randomly selected plants. The following indices were suggested by Patel *et al*. (2011) [13] for estimation of aphid population.

Indices Description

0. Plant free from aphids
1. Aphids present but colonies are not building up
2. Small colonies of aphids presents
3. 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)
4. 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

The average aphid index was worked out by the following formula.

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

Where,
0, 1, 2, 3 and 4 are aphid index
N = Number of plants showing respective aphid index

Seed midge

Seed midge was recorded from seed setting to harvest of fennel umbels. Seed damage due to seed midge was recorded by selecting five plants randomly in each sector. After seed setting at weekly interval, five umbels were selected randomly from each sector and 100 seeds from those umbels were randomly collected and stored for 15 days and allow for emergence of midge from the seeds. All the seeds were thoroughly checked with the help of magnifying glass. The seed with appearance of black spot or insect exit hole was considered as damaged seed and per cent infestation was calculated accordingly.

Other insect pests

Observations of larvae of gram pod borer, *Helicoverpa armigera* and cow bugs were recorded by counting the numbers from five randomly selected plants from each sector.

In order to study the instantaneous effect of weather parameters on population fluctuation of various insect pests, the data of physical factors of environment *viz.*, bright sunshine (BSS), wind speed (WS), maximum (MaxT) and minimum (MinT) temperature, morning (RH_1) and evening (RH_2) relative humidity were correlated. Week-wise data on various parameters recorded by Department of Agricultural Meteorology, B. A. College of Agriculture, AAU, Anand during *rabi*, 2017-18 and 2018-19 were used to work out the association with incidence of insect pests on fennel. In order to determine the succession of insect pests, the periodic mean incidence of the major insect pests was worked out. Simple correlation was worked out using their weekly mean incidence by adopting a standard statistical procedure (Steel and Torrie, 1980) [16].

Results and Discussion

During the course of study, activity of thrips, *S. dorsalis*; aphid, *H. coriandri*; gram pod borer, *H. armigera* and seed midge, *S. albipenis* were recorded on fennel during the years and cow bug, *Oxyrachis* spp at various stages of crop in *rabi*, 2017-18 (Table 1).

During the first year thrips was the first pest noticed on fennel during early stage of crop growth on 3rd WAG *i.e*. 2nd week of November (45th SMW of the year 2017) and continued up to 3rd week of December. The population of cow bug was observed following the thrips population from 7th WAG (49th SMW) and observed during entire cropping season in more or less numbers. Gram pod borer, *H. armigera* followed the cow bug by appearing first time during 3rd week of December (51th SMW) and continued till 3rd week of February. The occurrence of the major and key pest aphid, *H. coriandri* was observed first time on crop after 2nd week of January (2nd SMW of the year 2018). The population of aphid was continued up to harvesting of crop *i.e.* 4th week of March (13th SMW). Seed midge, *S. albipenis* was observed at last. Activity of seed midge was considered as damaged seeds having exit hole, which was first time noticed from the seeds harvested during 2nd week of March (11th SMW) and continued up to last harvested seeds *i.e.* 1st week of April (14th SMW)

During the year, 2018-19 thrips recorded first on fennel crop during 4th WAG (46th SMW of the year 2018) and disappeared from 9th WAG (51th SMW). Gram pod borer population was observed on fennel first time after 1st week of December (49th SMW) and continued up to 1st week of February (6th SMW of the year 2019). Aphid population was noticed from 3rd week of January (3rd SMW of the year 2019) till harvesting of crop up to 1st week of April (15th SMW). Simultaneously, seed midge damage was observed during 2nd week of March and continued up to harvesting of crop, 2nd week of April (15th SMW).

Based on the results of correlation studies among the arthropods, there was considerable association among the arthropod activity in fennel ecosystem. During first year (Table 2), the population of thrips showed significant negative association with aphid (r = -0.46*) and gram pod borer (r = -0.41*). There was negative but non-significant association of thrips with cow bug (r = -0.17) and seed midge (r = -0.26), whereas non-significant positive (r = 0.15) and negative (r = -0.02) association of aphid with seed midge and pod borer, respectively in fennel. Cow bug population showed positive companionship with gram pod borer population (r = 0.40), whereas negative association with seed midge (r = -0.20) and aphid (r = -0.03) but non-significant. The association between seed midge and pod borer was non-significant and negative (r = -0.34) in fennel. In the year 2018-19 (Table 2), thrips population had negative association with aphid (r = -0.38), seed midge (r = -0.24) and *H. armigera* (r = -0.08) but non-significant. Aphid had significant negative association (r = -0.40*) with gram pod borer. Further, aphid exhibited non-significant positive association with seed midge (r = 0.30) during cropping season. Gram pod borer showed non-significant negative (r = -0.37) relationship with seed midge.

The present findings are in line with the reports of Meena *et al*. (2019) [10] who mentioned that population of thrips was observed on fennel crop during early growth stage (25-30 days after germination) at Ajmer, Rajasthan. Patel *et al*. (2011) [14] stated that the activity of aphid on fennel was started from January and continued up to last week of March. The infestation of seed midge was starts from 13th SMW and continued up to 19th SMW (Neema Ram, 2014). Patel and Patel (2003) [12] observed the intensity of seed midge in fennel

crop and found that the seed midge infestation commenced with the initiation of seed setting in the umbel and continued up to harvest.

Thrips, *S. dorsalis*

During *rabi* 2017-18, the activity of thrips (1.60 thrips/3 leaves) was started after 3rd week of germination *i.e.* 2nd week of November (45th SMW) on fennel crop and continued till 9th week of germination *i.e.* 51th SMW (3rd week of December). After appearance, its population gradually increased and reached at peak level (3.2 thrips/3 leaves) on 6th week of germination *i.e.* 5th week of germination (48th SMW). After reaching to the peak level it started decreasing gradually and disappeared after 4th week of December (Table 1). This may be due to fluctuation in the morning and evening relative humidity during this period. The morning and evening relative humidity ranges from 91 to 71.1 and 25 to 41 per cent, respectively during 44 to 51th SMW. During 2018-19, more or less similar trend of fluctuation in thrips population was observed as recorded in first year. The thrips incidence begin with 1.5 thrips/3 leaves on 46th SMW (3rd week of November) when crop was four weeks old. The population of thrips fluctuated between 0.8 and 3.1 thrips/3 leaves during early growth stage of fennel (4 to 9 WAG) and reached its peak with 3.1 thrips/3 leaves on 6th WAG *i.e.* 5th week November (48th SMW). Morning and evening relative humidity were recorded 82 and 40 per cent, respectively on 48th SMW.

Looking to the pest activity recorded during both the years, it can be exposed that the thrips population commenced from 3rd week after germination and continued up to 9th week of germination in vegetative stage of the crop. The peak activity of *S. dorsalis* on fennel crop was found during 6th week after germination (48th SMW). Meena *et al*. (2018) [9] found the thrips (*Thrips tabaci*, *Frankliniella schultzei* and *Caliothrips indicus*) population on cumin in Rajasthan during first week of November (44th SMW) and after that it reached to its peak level with 2.8 thrips per plant during 47th SMW. In contrast to this, Ghulam *et al*. (2016) [2] reported that thrips, *T. tabaci* attacking fennel crop from 21st January to 5th April. The highest population (28.789 thrips/ plant) was recorded on 8th February.

Cow bug, *Oxyrachis* spp.

Activity of cow bug on fennel crop during the first year of experimentation observed first time (0.4 bug/plant) during 7th WAG (1st week of December, 49th SMW). The population was negligible and fluctuated during entire cropping season. The incidence of cow bug was noticed in 1st and 2nd week of December, 1st to 3rd and 5th week of January, 2nd and 3rd week of February as well as 3rd week of March. It was maximum (0.8 bug/plant) in 3rd week of January (3rd SMW) and 3rd week of February (8th SMW) (Table 1). Cow bug population was not found during second year of experimentation. Also, the activity of this pest on fennel was not mentioned by any researcher earlier.

Pod borer, *H. armigera*

The population of pod borer was first time noticed on (0.5 larva/ plant) fennel crop on 9th WAG *i.e.* 3rd week of December (51th SMW of the year 2017) during *rabi* 2017-18. The incidence of this pest increased slowly and reached to a peak level (1.07 larvae/ plant) on 6th SMW of the year 2018 (1st week of February). After attending the peak level, the larval population started decreasing and disappears after 3rd week of February (8th SMW). Gram pod borer population on fennel crop during *rabi* season of 2018-19 is presented in Table 1. Larval population was first time noticed on 7th WAG *i.e.* 1st week of December (49th SMW). The pest fluctuated between 0.47 and 1.13 larvae per plant during 7th week after germination (49th SMW) to 16th week after germination (6th SMW). The activity of pest gradually increased and reached to maximum level (1.13 larvae/ plant) on 2nd week of January *i.e*. 12th week after germination (2nd SMW). The pest disappeared from fennel crop after 1st week of February (6th SMW). The activity of the pest observed on vegetative as well as reproductive stages of crop. The larvae damaged the foliage and the umbels of fennel by direct feeding. The activity of *H. armigera* on fennel crop was not studied in past.

Aphid, *H. coriandri*

During first year the *H. coriandri* activity (0.67 A.I.) commenced from 12th WAG *i.e.* 2nd week of January (2nd SMW) and continued till harvesting of fennel crop. After appearance, its population was drastically deceased (0.13 A.I.) in next week (3rd SMW). Later on, the population of aphid was increased and reached its peak (3.23 A.I.) during 1st week of March (10th SMW). After attending the peak population, the pest started declining during maturity of crop and disappeared or migrated on alternate host at the time of harvesting of fennel. The heavy infestation of aphids resulted in to withering and drying of plant and poor seed yield of fennel. During the year 2018-19, population of aphid, *H. coriandri* begin (0.73 A.I.) on 13th WAG *i.e.* 3rd week January (3rd SMW). From 4th SMW to 6th SMW population of aphid decreased up to 0.60 aphid index due to fluctuation in maximum temperature (29.7 to 25.5 ^{0}C) during this period (3rd and 4th SMW). The pest reached its peak activity (3.23 A.I.) during 2nd week of March (11th SMW). During 3rd week of March (12th SMW) incidence of aphid decreased drastically up to 1.13 A.I. due to sudden fall in the maximum temperature from 34 to 20 ^{0}C during 3rd week of March (12th SMW). Similarly, the aphid population was again started to build up (1.93 A.I.) from 4th week of March as the temperature was suitable for growth but due to the crop maturity the population started decreasing in subsequent weeks and disappeared at the time of harvesting *i.e.* 2nd week of April (15th SMW).

The activity of aphid, *H. coriandri* on fennel crop can be easily understood from the above results. The aphid population was started from beginning of January (1st SMW) and persisted till harvesting of crop in first week of April (14th SMW). The peak activity (3.23 A.I.) was observed on first to second week of March (10th to 11th SMW) during both the years. Fluctuation in the population of this pest was mainly due to fluctuation in maximum temperature. Hirpara (2000) [3] reported that the aphids, *H. coriandri* remained active during January to March on fennel. However, the highest activity of this pest was observed in the first week of March. Kanjiya *et al.* (2018) [8], reported that the infestation of aphid, *H. coriandri* (0.15 A.I.) on fennel was started from 4th week of December (52nd SMW) and showed its peak (3.05 A. I.) during 4th week of February (9th SMW). In subsequent weeks, the incidence was decreased and reached to 0.45 A.I. during 4th week of March (13th SMW).

Seed midge

The data on per cent damage of seed midge of the year 2017-

18 are presented in Table 1 exhibited that seed damage caused by *S. albipenis* was found from 2nd week of March (11th SMW, 21st WAG) with 3.9 per cent and noticed till 1st week of April (14th SMW, last harvesting of umbels). After appearance, the damage gradually increased and showed its peak level (9.7%) on 1st week of April. The damage of seed midge during second year of experimentation follows same trend as noticed in first year. The seed midge damage started with 3.2 per cent on 2nd week of March (11th SMW). By gradually increasing it reached to the peak level (9.5%) on 2nd week of April (15th SMW). There was no more fluctuation observed in seed midge damage, but every week it found increasing trends.

Neema Ram (2014) reported that seed damage due to midge on fennel was started with 0.50 per cent on last week of March (13th SMW) which increased gradually and reached to maximum 15.50 per cent on first week of May (18th SMW). Purti (2015) [15] reported that incidence of seed midge, *S. albipenis* on coriander *var*. DH-2 was started from 18th March with 2.66 per cent seed damage and continued up to 2nd April with 12.62 per cent seed damage.

Correlation of insect pest with weather parameters

Thrips

Thrips exhibited highly significant positive association (r = 0.52** and 0.67**, respectively) with evening relative humidity during both the years, whereas significant positive (r = 0.67**) with evaporation during first year. Bright sunshine had non-significant negative association (r = -0.42 and -0.36, respectively) with thrips during both the years. Janu *et al*. (2017) [4] mentioned that evening relative humidity had highly significant positive association (r = 0.75**) with thrips incidence while bright sunshine exhibited non-significant negative (r = -0.56) association with thrips on cotton.

Cow bug

Population of cow bug was more or less negatively fluctuated with weather parameters as maximum (r = -0.24), minimum temperature (r = -0.29), morning (r = -0.21), evening vapor pressure (r = -0.03), wind speed (r = -0.13) and evaporation (r = -0.24), but non-significant. The morning (r = 0.20) and evening (r = 0.30) relative humidity and bright sunshine (r = 0.01) exhibited non-significant positive association.

Gram pod borer

Larval population of *H. armigera* showed highly significant negative association with maximum (r = -0.52** and -0.58**, respectively) and minimum temperature (r = -0.71** and -0.73**, respectively) and morning vapor pressure (r = -0.66** and – 0.55**, respectively) during both the years. The highly significant negative (r = -0.54**) and significant negative (r = -0.40*) correlation with evaporation and evening vapor pressure was recorded during 2018-19. population but non-significant. The findings of present investigation are in close conformity with Patel and Koshiya (1999) [13] who reported negative association of maximum and minimum temperature as well as vapor pressure with *H. armigera* on chick pea.

Aphid

The aphid population exhibited highly significant positive association with evaporation (r = 0.53**) and significant negative association with evening relative humidity (r = -0.46*) in fennel crop during 2017-18. Whereas the weather parameters like maximum (r = 0.40 and minimum (r =0.22 and 0.08) temperature, bright sunshine (r = 0.28 and 0.38) were positively associated with aphid during first and second year, respectively. The remaining weather parameters showed positive or negative correlation with aphids, but non-significant. Patel *et al*. (2011) [14] reported that *H. coriandri* on fennel crop had positive association with maximum (r = 0.25), minimum (r = 0.08) temperature and bright sunshine (r = 0.38), while negative relation with morning (r = -0.26) and evening (r= -0.16) relative humidity. Swami *et al*. (2018) noticed that aphid, *H. coroiandri* had positive association with maximum (r = 0.31) and minimum temperature (r = 0.03) while, negative association with relative humidity (r = -0.44) on coriander *var*. RCr-436.

Seed midge

The incidence of seed midge highly significant positively associated with minimum temperature (r = 0.65** and 0.62**) and evaporation (r = 0.86** and 0.92**) during both the years, respectively whereas significantly positive with morning vapor pressure (r = 0.43*) and highly significant positively associated with maximum temperature (r = 0.63**) during first year while significantly positive with maximum temperature (r = 0.45*) during second year of experiment. Morning (r = -0.69**) and evening (r = -0.55**) relative humidity had highly significant negative relationship with midge during first year and significant negative (r = -0.56* and -0.46*, respectively) during second year of experiment. Purti (2015) [15] mentioned the highly significant positive association of seed midge with maximum (r = 0.94**) and minimum (r = 0.95**) temperature, while highly significant negative association with morning (r = -0.78**) and evening (r = -0.86**) relative humidity on coriander crop in Rajasthan. Further, they reported non-significant positive association with bright sunshine (r = 0.48) and wind speed (r = 0.33). Neema Ram (2014) reported that the maximum (r = 0.89*) and minimum temperatures (r = 0.91*) had significant positive correlation with seed midge infestation, while relative humidity had negative significant correlation (r= -0.87*) on fennel.

Table 1: Abundance of insect pests on fennel

SMW	Month & week		WAG	No. of thrips/ 3 leaves		No. of cowbug/ plant	No. of *H. armigera* larva(e)/ plant		Aphid index (0-4)		Seed midge Damage (%)	
				2017-18	2018-19	2017-18	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
44	November	1	2	0.0	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0
45		2	3	1.6	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0
46		3	4	2.2	1.5	0.0	0.0	0.00	0.0	0.00	0.0	0.0
47		4	5	2.3	2.5	0.0	0.0	0.00	0.0	0.00	0.0	0.0
48		5	6	3.2	3.1	0.0	0.0	0.00	0.0	0.00	0.0	0.0
49	December	1	7	2.7	2.9	0.4	0.0	0.53	0.0	0.00	0.0	0.0
50		2	8	1.5	1.5	0.2	0.0	0.47	0.0	0.00	0.0	0.0

51		3	9	1.3	0.8	0.0	0.5	0.67	0.0	0.00	0.0	0.0
52		4	10	0.0	0.0	0.0	0.5	0.77	0.0	0.00	0.0	0.0
1	January	1	11	0.0	0.0	0.6	0.6	0.83	0.0	0.00	0.0	0.0
2		2	12	0.0	0.0	0.2	0.67	1.13	0.67	0.00	0.0	0.0
3		3	13	0.0	0.0	0.8	0.8	1.00	0.13	0.73	0.0	0.0
4		4	14	0.0	0.0	0.0	0.87	0.73	0.68	0.33	0.0	0.0
5		5	15	0.0	0.0	0.6	0.87	0.53	0.57	0.45	0.0	0.0
6	February	1	16	0.0	0.0	0.0	1.07	0.47	1.34	0.60	0.0	0.0
7		2	17	0.0	0.0	0.2	0.83	0.00	1.57	1.54	0.0	0.0
8		3	18	0.0	0.0	0.8	0.4	0.00	2.60	1.68	0.0	0.0
9		4	19	0.0	0.0	0.0	0.0	0.00	2.43	2.31	0.0	0.0
10	March	1	20	0.0	0.0	0.0	0.0	0.00	3.23	2.60	0.0	0.0
11		2	21	0.0	0.0	0.0	0.0	0.00	2.57	3.23	3.9	3.2
12		3	22	0.0	0.0	0.2	0.0	0.00	1.78	1.13	4.8	4.6
13		4	23	0.0	0.0	0.0	0.0	0.00	1.13	1.93	6.8	6.8
14	April	1	24	0.0	0.0	0.0	0.0	0.00	0.0	1.53	9.2	7.4
15		2	25	-	0.0	-	-	0.00	-	0.00	-	9.5

SMW – Standard Meteorological Week
WAG – Week After Germination

Table 2: Correlation coefficient (r) between insect pests as well as weather parameters in fennel

Biotic and abiotic factors	Thrips		Cow bug	*H. armigera*		Aphids		Seed midge	
	2017-18	2018-19	2017-18	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Maximum temperature (^{0}C) (Max T)	-0.29	0.11	-0.24	-0.52**	-0.58**	0.40	0.15	0.63**	0.45*
Minimum temperature (^{0}C) (Min T)	0.02	0.02	-0.29	-0.71**	-0.73**	0.22	0.26	0.65**	0.62**
Morning relative humidity (%) (RH_1)	0.24	0.28	0.20	0.24	0.25	-0.32	-0.35	-0.69**	-0.56*
Evening relative humidity (%) (RH_2)	0.52**	0.67**	0.30	0.22	0.15	-0.46*	-0.28	-0.55**	-0.46*
Bright Sunshine (hrs/day) (BSS)	-0.42	-0.36	0.01	-0.05	-0.13	0.28	0.09	0.26	0.09
Morning vapour pressure (mm) (VP_1)	0.02	0.14	-0.21	-0.66**	-0.55**	0.17	-0.03	0.43*	0.35
Evening vapour pressure (mm) (VP_2)	-0.04	0.30	-0.03	-0.23	-0.40*	0.15	0.02	-0.18	0.22
Wind Speed (km/hr) (WS)	0.26	-0.30	-0.13	-0.24	0.07	-0.05	0.44*	0.31	0.24
Evaporation (mm) (EP)	-0.43*	-0.39	-0.24	-0.37	-0.54**	0.53**	0.28	0.86**	0.92**
Aphids	-0.46*	-0.38	-0.03	-0.02	-0.40*	1.0**	1.0**	-	-
Thrips	1.0**	1.0**	-0.17	-0.41*	-0.08	-0.46*	-0.38	-	-
Cow bug	-0.17	-	1.0**	0.40	-	-0.03	-	-	-
H. armigera	-0.41*	-0.08	0.40	1.0**	1.0**	-	-	-	-
Seed midge	-0.26	-0.24	-0.20	-0.34	-0.37	0.15	0.30	1.0**	1.0**

*Correlation is significant at the 0.05 level
**Correlation is significant at the 0.01 level

Conclusion

Thrips was appeared first on fennel crop from 3rd week after germination *i.e.* 2nd week of November (45th SMW) and remained active during early growth stages of crop up to 3rd week of December (51th SMW). The negligible population of cow bug was found following thrips population during first year of experimentation and active during entire season. Gram pod borer population was noticed during January and February month *i.e.* vegetative and reproductive stages of crop. The activity of major and key pest aphid, *H. coriandri* was recorded on fennel from 2nd week of January (2nd SMW, 12th WAG) to removal of crop *i.e.* 1st week of April with maximum (3.23 A.I.) aphid incidence during 1st and 2nd week of March during first and second year, respectively.

The activity of insect pests on fennel crop was greatly influenced by weather parameters. Thrips showed highly significant positive association with evening relative humidity, while significant negative association with evaporation. Gram pod borer exhibited highly significant negative association with maximum temperature, minimum temperature and morning vapor pressure. Aphid incidence was positively correlated with maximum temperature, minimum temperature and bright sunshine, whereas negatively correlated with morning and evening relative humidity but nonsignificant. Seed midge population showed highly significant negative association with morning and evening relative humidity.

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