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Study on the Insect Pest-Complex and its Correlations with Environmental Factors on Fenugreek Trigonella foenum graecum L

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Abstract

The present investigation was carried out during November 2022 to February 2023. The field experiment was conducted in Randomized block design with eight treatments and three replications at Experimental farm, Department of Entomology, SAS, Medziphema. The outcomes of the experiments revealed that, during period of investigation, ten insect pests and two natural enemies were observed. The activity of aphid (*Aphis craccivora*) infestation on fenugreek started in the 45th SMW (1.5 aphids/ three leaves) and reached its peak during 52nd SMW (23.36 aphids/ three leaves). The thrips (*Scirtothrips dorsalis*) was observed from 46th SMW (0.8 thrips/ three leaves) and reached its peak during 2nd SMW (9.32 thrips/ three leaves). The population of *Spodoptera litura* on fenugreek started appearing from 47th SMW (0.1caterpilar/ plant) and the highest incidence was recorded during 1st SMW (2 caterpillar/ plant). The serpentine leaf miner was observed from 49th SMW (0.56 maggot/ plant) and reached its peak during 2nd SMW (2.3 maggot/ plant). The population of flea beetle on fenugreek started appearing from 48th SMW (0.8 adult/ plant) and the highest incidence was recorded during 1st SMW (2.03 adult/ plant). The correlation studies with weather parameters revealed that aphid, thrips, *Spodoptera litura*, serpentine leaf miner and flea beetle population had significant negative correlation with maximum temperature, minimum temperature but non-significant with other remaining weather parameters.

Keywords: Fenugreek, Insect pest complex, correlation Studies, Environment Factors.

Abbreviations: % - Percentage, / - Per, ^{0}C- Degree Centigrade, cm - Centimetre, DAS - Days after spraying, *et al*.- and others, g- Gram, i.e - That is, ICAR- Indian Council of Agricultural Research, Kg – Kilogram, L- Litre/Linnaeus, MSL - Mean Sea Level, m- Meter, No. – Number, NU - Nagaland University, RBD - Randomized Block Design, SAS - School of Agricultural Sciences, SMW - Standard Meteorological Week, *Viz*., - Namely, **According to the rule of ICZN all scientific names must have to write on *Italic*.**

1. Introduction

Fenugreek, scientifically known as *Trigonella foenum-graecum* (L.), is a plant that reproduces through self-pollination. It falls under the category of an annual dicotyledonous leguminous crop and is part of the subfamily Papilionaceae within the Fabaceae family (Leguminosae). Its chromosome number is identified as 2n=2x=16. Within the genus *Trigonella*, there are two main cultivated species: *foenum-graecum*, commonly referred to as common fenugreek, and *corniculata*, known as the Kasuri type fenugreek. Fenugreek, known for its small, deeply furrowed seeds, serves multiple purposes as both a vegetable and a flavoring agent. Its seeds, in particular, are used extensively for their distinctive taste and are employed as a spice to enhance the flavor and nutritional content of various dishes. This annual herb, commonly referred to as Methi, is cultivated for both its seeds and its leaves, whether used fresh or dried. The seeds, with their strong flavor profile and slightly bitter taste, hold a significant place as a seasoning component in pickles and vegetable curries. Moreover, beyond its culinary uses, fenugreek possesses medicinal properties attributed to its leaves and seeds. They are known to aid in reducing blood sugar and cholesterol levels, contributing to its value in promoting health and wellness.

Fenugreek seeds contain 0.2-0.3% essential oil, little amount of starch (1.6%), sugar (0.4%) and protein (3.6%) but a large amount of dietary fibres (45%). Fenugreek seeds also contain in small quantity (< 2%) coumarin, diosgenin, saponins and other steroids. These compounds and other constituents give fenugreek products an undesirable taste for some uses [14]. Fenugreek, a crop with major global production, finds its primary cultivation hubs in countries such as India, Morocco, Spain, Turkey, China, and Pakistan. Its origins trace back to South-Eastern Europe and Western Asia.Within India, fenugreek cultivation is particularly prevalent in regions like Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh, Arunachal Pradesh, and to a smaller extent in the North-eastern regions. These areas are known for their conducive climatic conditions and agricultural practices that support the growth of fenugreek plants. [27]. Insect pests which caused infestation to fenugreek crop are Aphid, *Aphis craccivora* Koch, Leaf hopper, *Empoasca kerri* Pruthi; Whitefly, *Bemisia tabaci* Gennadius; Leaf miner *Liriomyza congesta* Becker; Leaf eating caterpillar, *Spodoptera litura* Fabricius; Weevil, *Hypera branneipennis* Boh.; Mite, *Petrobia lateens* Muller and Thrips, *Thrips tabaci* [15].

As agricultural systems face increasing pressures due to climate change and evolving pest dynamics, the insights gleaned from this study serve as a crucial foundation for further research and the development of adaptive strategies. By continuously exploring the complex interplay between insect pests and their environment on Fenugreek crops, the agricultural community can strive towards sustainable and resilient cultivation practices, ensuring food security while preserving the natural equilibrium of ecosystems.

2. Objectives

The present research "Study on the Insect Pest-Complex and its Correlations with Environmental Factors on Fenugreek (*Trigonella foenum graecum* L.)" was undertaken with the following objectives:

1. To study the insect pests complex and their natural enemies on fenugreek
2. To study incidence of insect pest and its correlation with environmental factors
3.

3. Literature Review

3.1 To study the insect pests complex and their natural enemies on fenugreek

Joshi and Mathur (1967) reported that *Acyrthosiphon pisum* (Harris) and *Aphis craccivora* (Koch.)

damaged pea and fenugreek crops during January-February.

Garcia (1974) reported that *A. pisum* first caused heavy damage to fenugreek in Peru during 1971-72.

Kumar (1976) studied insect pest infestation especially pea aphid, *A. pisum* on fenugreek crop which deteriorated the quality of leaves by sucking cell sap and secreting honeydew.

Lal (1976) reported that *A. pisum* caused serious damage to the fenugreek crop at Jobner. Pea aphid, *A. pisum* and *A. craccivora* were found causing serious damage to fenugreek crop every year in fenugreek growing areas of the state of Rajasthan.

Boiko (1982) observed Lygus bugs and pea aphid, *A. pisum* causing damage to the fenugreek crop, particularly during the budding stage.

Manohar (1988) reported *A. pisum* as major pest of fenugreek at Jobner and caused considerable reduction in grain yield. The peak activity of the pest was observed in first week of March. The surface grasshopper, *Chrotogonus tachypterus* Blanch., jassid, *Creontiades pallidifer* Walker, whitefly, *Bemisia tabaci* Genn., cowpea aphid, *A. craccivora*, bug, *Ratbura nagourensis* Distant and thrips, *Thrips tabaci* Lind were also recorded as a minor pests of fenugreek.

Singh (1996) reported *A. pisum* as a major pest of fenugreek in semi-arid region. The pest remained active during January-February and resulted in reduction both in quality and quantity of fenugreek seed.

Meena (1998) reported *A. pisum* as major pest of fenugreek crop during January-February months and sucked the cell sap from leaves and pods and ultimately resulted in lowering the yield as well as production of poor quality seeds.

Kalra *et al.* (2002) conducted a survey in Haryana during *rabi*, 1998-99 to identify the insect pests associated with fenugreek. They found that alfalfa weevil, *Hypera postica* caused significant damage to fenugreek crop besides aphid, *A. craccivora* and *Liriomyza* sp.

Yadav (2004) reported *A. pisum* as key pest of fenugreek in semi-arid climatic conditions of Rajasthan. The pest also attacked other crops of family Leguminosae and brought a reduction in seed yield with poor quality of seed.

Manjula *et al.* (2015) report that insect pests attacking the fenugreek crop are aphid, *Aphis craccivora*; Koch, leaf hopper, *Empoasca kerri* Pruthi; whitefly, *Bemisia tabaci* Gennadius; leaf miner *Liriomyza congesta* Becker, *Spodoptera*, *Spodoptera litura* Fabricius, weevil, *Hypera branneipennis* Boh.; mite, *Petrobia lateens* Muller and thrips, *Thrips tabaci*.

Gyaneswari *et al.* (2021) showed that the fenugreek field was rich in natural enemies and 6 species of spiders (*Distina* sp. (Archaeidae), *Marpissa* sp. (Salticidae), *Oxyopes* sp. (Oxyopidae), *Lycosa* sp. (Lycosidae), *Tetragnatha* sp. (Tetragnathidae), *Pardosa* sp. (Lycosidae); Araneae), 5 species of coccinellids (*Micraspis discolor* Fab., *Menochilus sexmaculatus* Fab., *Scymnus* sp., *Coccinella septumpunctata* L., *Coccinella transversalis* Fab.; Coccinellidae, Coleoptera), 3 species of praying mantids and one species of syrphid fly were recorded. High population of predatory coccinellids were recorded throughout January, February and first week of March, recording as high as 5.2 beetles/plant on 16th February. Three species of praying mantids (*Mantis religiosa inornata* (European Mantis)), *Hierodula membranacea* (Giant Asian Mantis), *Statilia maculata* (Asian Jumping Mantis; Mantidae, Mantodea) were also recorded from the fenugreek field but their population was quite low, the highest population density was on 2nd February (1.5 mantids/plant). One species each of syrphid fly (*Syrphus* sp.; Syrphidae, Diptera) and chrysopid (*Chrysoperla* sp.; Chrysopidae, Neuroptera) were also recorded from the fenugreek field but its population was quite low.

3.2 To study incidence of insect pest and its correlation with environmental factors

Dunn and Wright (1955) reported rain as one of the most consistent factor in population reduction of pea aphid, *A. pisum*.

Banerjee and Basu (1956) found that the weather factors could hardly affected the population of aphids, *Myzus persicae* (Sulz.) and *Aphis gossypii* (Glover).

Prasad *et al.* (1984) observed that the population buildup of *A. pisum* was closely related to weather conditions prevailed during their period of activity and the preceding period. A maximum ambient temperature of around 20º C, fairly high relative humidity, long hours of bright sun light (8h/day) and intermittent rainfall favoured the population buildup of insect pests on pea.

Chandra and Kushwaha (1986) reported that the most vulnerable period for population of *L. erysimi* varied from second week of January to last week of February. They also concluded that initial fluctuation in aphid population were negatively and positively correlated with temperature and relative humidity, respectively.

Ahuja (1990) observed that the incidence of mustard aphid, *L. erysimi* on fenugreek is commenced in late December or January in Rajasthan, gradually increased and reached peak towards the end of January to third week of February depending upon the prevailing weather conditions.

Singh and Malik (1998) reported that the population of *L. erysimi* initiated in the beginning of January and reached its peak in the middle of February and completely disappeared from the field in the beginning of March. The increase in temperature was significantly conducive for aphid multiplication but relative humidity had shown slightly negative response on its intensity without any remarkable response of mild rainfall, while wind velocity had negative effect on the pest. The extent of loss was as high as 59.3 percent in the yield of mustard.

Malik and Deen (1999) studied the seasonal incidence of *L. erysimi* on different varieties of fenugreek and reported that aphid appeared in third week of January with a mild intensity, increased gradually and reached to peak by the end of February. The aphid intensity decreased thereafter and wiped out by the mid of March.

Mishra (1999) recorded the incidence of mustard aphid, *L. erysimi* in semi-arid region of Rajasthan in late December. The population reached its peak in the first week of February when the temperature ranged between 6.7 to 21.4ºC. The aphid population disappeared after third week of January.

Meena and Bhargava (2001) observed maximum population of aphid, *A. pisum* on fenugreek in the first week of February when average temperature ranged between 20-25ºC coupled with a relative humidity of 57.5 percent. They found significantly negative correlation between aphid population and temperature whereas, such correlation was significantly positive with relative humidity.

Barma and Jha (2011) observed the peak incidence of insect pest was obtained in third week of May to first week of June during all the three years of study (i.e. 2007-08, 2008 09, 2009- 10). Correlation with individual weather factors revealed that each of maximum and minimum temperature had significant positive correlation (r = +0.386 and +0.501, respectively) on the population build-up of the pest. The relative humidity % of morning hours had significantly negative correlation (r = -0.451) and that of evening slightly positive (r = +0.284). Rainfall had insignificantly positive (r = +0.195), soil temperature significantly positive (r = +0.555) and the bright sun shine hours insignificantly positive (r = +0.103) effects on the population development.

4. Materials and Methods

The materials and methods followed for the studies are presented in this chapter as under.

4.1 Experimental site: The study was conduct at the Experimental farm, Department of Entomology, School of Agricultural Sciences (SAS), Medziphema. Geographically the experimental area is situated 25˚ 75' 24''latitude and 93˚85' 51'' longitude. It has an average elevation of 430 m from the mean sea level.

4.2 Soil condition: The soil type of the experimental area is sandy loam in texture, well drained with mean pH range of 4.5-6.5 and acidic in nature.

4.3 Climatic condition: The experimental site of the farm falls under subtropical climatic condition with a predominantly high humidity (70-85%), moderate temperature and medium to high rainfall 2000 mm-2500 mm. Mean summer temperature varies from 28˚C -32˚C and winter temperature varies from 10˚C -15˚C.

4.4 Meteorological data: The data on weather parameters *viz.*, minimum and maximum temperature, relative humidity and rainfall during the investigation period was obtained from ICAR–Research complex for NEH Region, Nagaland Center, Medziphema, Nagaland.

Table no. 1: Meteorological observations during the study period (November 2022 - February 2023)

Standard Meteorological Week (SMW)	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
	Maximum	Minimum	Maximum	Minimum	
44	29.8	17.1	96	60	41.0
45	29.3	16.7	96	57	0.0
46	27.9	14.6	98	56	0.0
47	27.7	12.8	96	52	0.0
48	27.8	14.3	96	67	0.0
49	27.6	12.0	95	49	0.0
50	26.4	11.3	96	50	0.0
51	25.7	11.0	96	51	0.2
52	22.7	11.2	97	60	15.2
1	23.2	9.2	97	50	0.0
2	25.4	8.8	96	55	0.0
3	22.8	7.0	94	45	0.0
4	24.9	6.9	93	45	0.0
5	27.0	10.4	93	46	0.0

Source: ICAR- Research Complex for NEH Region, Nagaland Center, Medziphema

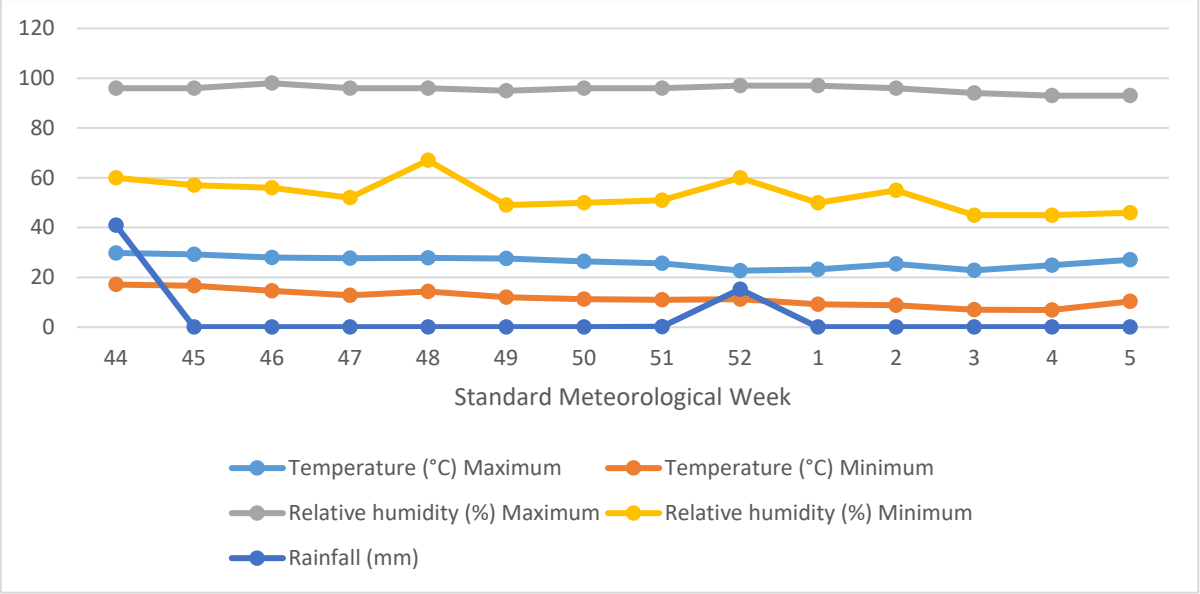

Fig.1: Meteorological observations during the study periods (Above table is interpreted on this figure)

4.5 Cultivation practices

4.5.1 Field preparation: The land was well prepared for the good germination and to ensuring the better growth of fenugreek. After ploughing the soil was mixed with well decomposed farm yard manure (FYM) and seed bed were prepared, 2 m × 1.5 m for the line sowing.

4.5.2 Sowing: Direct line sowing was adopted for good cultural practices. Seed was sown in the depth of 2-3 cm and 30 × 10 cm spacing in six rows per plot.

4.5.3 Irrigation: Light irrigation was followed immediately after the sowing. Initially, irrigation was done regularly at 3-5 days' interval to maintain the desired soil moisture level and after 20 days' irrigation was given only when moisture was required.

4.5.4 Weeding: Hand weeding was practiced at 15, 45 and 65 days after sowing to practice clean cultivation.

4.5.6 Harvesting: Harvesting was done when the fenugreek fruits were matured.

4.6 Methodology

4.6.1 Details of experiment

Crop	:	Fenugreek
Variety	:	Manohar
Spacing	:	30 cm × 10 cm
Experimental design	:	Randomized Block Design (RBD)
No. of treatments	:	8
No. of replication	:	3
No. of experimental plots	:	24
Treatment plot size	:	2 m × 1.5 m
Total number of plants	:	2160
Total length of field	:	20.5 m
Total width of field	:	10 m
Total area of field	:	205 m^2

4.7 Insect pest complex and natural enemies of insect on fenugreek

Observations: Observations on abundance of insect pest complex of fenugreek and their natural enemies were recorded at an interval of seven days during morning hours on five randomly selected plants. The population of insect pest complex of fenugreek was counted on three leaves per plant from the upper, middle and lower positions as per the method suggested by Satpathy (1973). The population of natural enemies were counted per plant.

4.8 Incidence of insect pest and its correlation with environmental factors

Observations: The ecological plots were maintained five meters away from the treated plots in which the insect pest complex of fenugreek and their natural enemies and correlation of major pests of fenugreek with environmental factor and natural enemies was studied under natural conditions.

5. Results and Discussion

The data observed during the investigation period are tabulated, statistically analysed and the findings are systematically presented under the following headings.

5.1 Insect pest complex and their natural enemies on fenugreek

The data on the insect pest complex and their natural enemies on fenugreek were recorded at weekly interval from the ecological plots to maintain and study their occurrence at natural condition. A number of insect pests were observed feeding on different stages of the crop. Five insect pests were identified as major insect pests to carry out on their incidence. The results obtained are presented and discussed below.

During the period of investigation, ten insect pests and two natural enemies were observed (Table 2) in the field during November 2022 to February 2023 Out of these, five insects *viz*., aphid (*Aphis craccivora* Koch; Aphididae, Hemiptera), thrips (*Scirtothrips dorsalis* Hood; Thripidae, Thysanoptera), *Spodoptera* (*Spodoptera litura* F.; Noctuidae, Lepidoptera), flea beetle (*Phyllotreta* sp.; Chrysomelidae, Coleoptera) and serpentine leaf miner (*Liriomyza trifolii* Burgess; Agromyzidae, Diptera), were considered as major insect pests as they were found in large numbers and injured the crop.

The other insect pests such as jassid (*Ambrasca* sp.; Cicadellidae, Hemiptera), White fly (*Bemisia tabaci* Genn.; Aleyrodidae, Hemiptera), painted bug, (*Bagrada hilaris* (Burmeister); Pentatomidae, Hemiptera), aphid (*Acyrthosiphon pisum* Harris; Aphididae, Hemiptera), termite (*Odontotermes obesus* (Rambur); Termitidae, Isoptera) were also observed feeding on fenugreek but considered as a minor importance as they were not in large numbers and neither consistently present in the field for longer period. During the investigation period two natural enemies were observed *viz.*, lady bird beetle (*Coccinella* sp.; Coccinellidae, Coleoptera) and spider (*Oxyopes* sp.; Oxyopidae, class- Class- Arachnida).

The present finding is in the line with the work of Manjula *et al.* (2015) who reported that eight insect pests were observed attacking fenugreek *i.e.* aphid, *Aphis craccivora* Koch, leaf hopper, *Empoasca kerri* Pruthi; whitefly, *Bemisia tabaci* Gennadius; leaf miner *Liriomyza congesta* Becker, leaf eating caterpillar, *Spodoptera litura* (Fabricius), weevil, *Hypera branneipennis* Boh.; Mite, *Petrobia latens* Muller and thrips, *Thrips tabaci*. Gyaneswari *et al.* (2021) also reported that the fenugreek field was rich in natural enemies and 6 species of spiders (*Distina* sp. (Archaeidae), *Marpissa* sp. (Salticidae), *Oxyopes* sp. (Oxyopidae), *Lycosa* sp. (Lycosidae), *Tetragnatha* sp. (Tetragnathidae), *Pardosa* sp. (Lycosidae); Araneae), 5 species of coccinellids (*Micraspis discolor* Fab., *Menochilus sexmaculatus* Fab., *Scymnus* sp.,

Coccinella septumpunctata L., *Coccinella transversalis* Fab.; Coccinellidae, Coleoptera), 3 species of praying mantids and one species of syrphid fly were recorded during their time of investigation.

Table no. 2: Insect pest complex and their natural enemies found on fenugreek

SL. No.	Species/Common name	Scientific name	Family	Order	Damaging stage	Site of Damage
1.	Aphid	*Aphis craccivora* Koch	Aphididae	Hemiptera	Nymph, Adult	Yong stem, Leaf, Fruit
2.	Thrips	*Scirtothrips dorsalis* Hood	Thripidae	Thysanoptera	Nymph, Adult	Yong stem, Leaf, Fruit
3.	Tobacco caterpillar	*Spodoptera litura* Fabricius	Noctuidae	Lepidoptera	Caterpillar	Leaf
4.	Serpentine leaf miner	*Liriomyza trifolii* Burgess	Agromyzidae	Diptera	Larvae	Leaf
5.	Flea beetle	*Phyllotreta* sp.	Chrysomelidae	Coleoptera	Grub, Adult	Leaf, Stems
6.	Jassid	*Ambrasca* sp	Cicadellidae	Hemiptera	Nymph, Adult	Yong stem, Leaf, Fruit
7.	White fly	*Bemisia tabaci* Genn.	Aleyrodidae	Hemiptera	Nymph, Adult	Yong stem, Leaf
8.	Painted bug	*Bagrada hilaris* Burmeister	Pentatomidae	Hemiptera	Nymph, Adult	Yong stem, Leaf, Fruit
9.	Aphid	*Acyrthosiphon pisum* Harris	Aphididae	Hemiptera	Nymph, Adult	Yong stem, Leaf, Fruit
10	Termite	*Odontotermes obesus* Rambur	Termitidae	Isoptera	Worker caste	All parts of plant
11	Lady bird beetle	*Coccinella* sp.	Coccinellidae	Coleoptera	Grub, Adult	Predator
12	Spider	*Oxyopes* sp.	Oxyopidae	Class-Arachnida	Adult	Predator

5.2 Incidence of insect pest and its correlation with environmental factors

The data on the incidence of insect pest and its correlation with environmental factors were collected from ten randomly selected plants and weekly average data on different weather parameters were correlated with the mean population of insect pests.

5.2.1 Aphids, *Aphis craccivora* Koch (Aphididae, Hemiptera)

The aphid infestation on fenugreek started in the 45th Standard Meteorological Week (SMW) with the mean population of 1.5 aphids/ three leaves **(**Table 3**)**. It was observed that the aphid population had significant increase until 50th SMW. Peak activity of aphids was observed in the 52nd SMW (23.36 aphids/ three leaves) when the corresponding minimum and maximum temperature, relative humidity and rainfall were 11.2°C, 22.7°C, 60-97% and 15.2 mm respectively (Table 1). After sudden decrease in aphid population was recorded which may be due to negative effect of rainfall and relative humidity on aphid population. This result is in line with the findings of Mishra and Pandey (2023).

The results of correlation studies (Table 4) revealed that the aphid population showed significant negative correlation with minimum (r = -0.595) and maximum temperature (r = -0.871). This shows that aphid population decreases when temperature increases. On the contrary non-significant correlation was observed with maximum relative humidity and non- significant negative correlation was observed with minimum relative humidity (r = -0.142, -0.077) and rainfall (r = -0.140). The results are in the line with the work of Mishra and Pandey (2023) who reported that maximum temperature exhibited significant negative correlation with aphid population while relative humidity and rainfall showed a negative correlation.

5.2.2 Thrips, *Scirtothrips dorsalis* Hood (Thripidae, Thysanoptera)

The data presented in the table 3 revealed that the activity of thrips initiated from 46th Standard Meteorological Week (SMW) *i.e.* 0.80 thrips/ three leaves. There was no thrips activity found in the initial stage of crop growth (until 2 weeks after sowing). The thrips population gradually started increasing when the crop was at fruiting stage and attained its peak (9.32 thrips/ three leaves) during 2nd SMW (2023) when the minimum and maximum temperature, minimum and maximum relative humidity and rainfall were 8.8°C, 25.4°C, 55-96% and 00 mm respectively (Table1). Thereafter, drastic decline in thrips population was observed until crop maturity.

Correlation coefficient was worked out between thrips population and the weather parameters *viz.*, minimum and maximum temperature, relative relative humidity and rainfall **(**Table 4**)**. The result indicated that thrips population exhibited significant negative correlation with minimum (r = - 0.728) and maximum temperature (r = - 0.829) and non- significant correlation with maximum relative humidity (r = - 0.219 to 0.044) and rainfall (r = -0.220). The present findings are in partial agreement with the work of Subhashree Priyadarshini *et al.* (2017) who reported that correlation studies between thrips population and weather parameters showed significant negative with maximum relative humidity while non-significant positive correlation with temperature and non-significant negative correlation was observed with relative humidity (minimum and average) and rainfall.

5.2.3 *Spodoptera litura* F. (Noctuidae, Lepidoptera)

The population of *Spodoptera litura* on fenugreek started appearing from 47th Standard Meteorological Week (SMW) with the mean population of 0.1/plant (Table 3). The highest incidence was recorded during 1st SMW (2023) (2 caterpillars/plants) when the corresponding minimum and maximum temperature, relative humidity and rainfall were 9.2°C, 23.2°C, 50-90% and 0.0 mm respectively (Table 1).

Correlation studies (Table 4) revealed that significant negative correlation was found between *S. litura* population and maximum temperature (r = -0.874), minimum temperature (r = -0.736) and negative

non-significant correlation with maximum relative humidity (r = 0.044). Non-significant negative correlation was observed with minimum relative humidity (r = -0.219) and negative correlation was observed with rainfall (r = -0.214). Murthy (1994) also reported that the population of *Spodoptera litura* (Fabricius) was at its peak level during December and declined to minimum by last week of January. He also stated maximum and minimum temperatures and relative humidity showed negative relation.

Table no. 3: Incidence of insect pest of fenugreek and their natural enemies

Standard Meteorological Week (SMW)	Date Of Observation	Mean population of pests per three leaves/plant					Mean population of predators per plant	
		Aphids	Thrips	*Spodoptera*	Serpentine leaf miner	Flea beetle	Coccinellids	Spiders
44	29-Oct-22	0	0	0	0	0	0	0
45	05-Nov-22	1.5	0	0	0	0	0	0
46	12-Nov-22	2.16	0.8	0	0	0	0.1	0
47	19-Nov-22	4.52	1.23	0.1	0	0	0.3	0.2
48	26-Nov-22	6.61	1.7	0.5	0	0.8	0.4	0.1
49	03-Dec-22	7.87	2.43	0.8	0.56	0.9	0.7	0.3
50	10-Dec-22	9.51	3.56	1.2	0.9	1	1.2	0.6
51	17-Dec-22	12.3	4.26	1.7	1.35	1.2	0.8	1.2
52	24-Dec-22	23.36	6.84	1.9	1.7	1.46	2.6	0.9
1	31-Dec-22	15.91	7.84	2	1.95	1.68	1.9	1.5
2	07-Jan-23	12.62	9.32	1.5	2.3	2.03	1.4	2.3
3	14-Jan-23	10.52	5.2	1.3	2.1	1.86	2.2	1.9
4	21-Jan-23	8.12	3.22	1.01	1.8	1.5	1.3	2.8
5	28-Jan-23	5.62	3.02	0.9	1.56	1.24	1.1	1.6

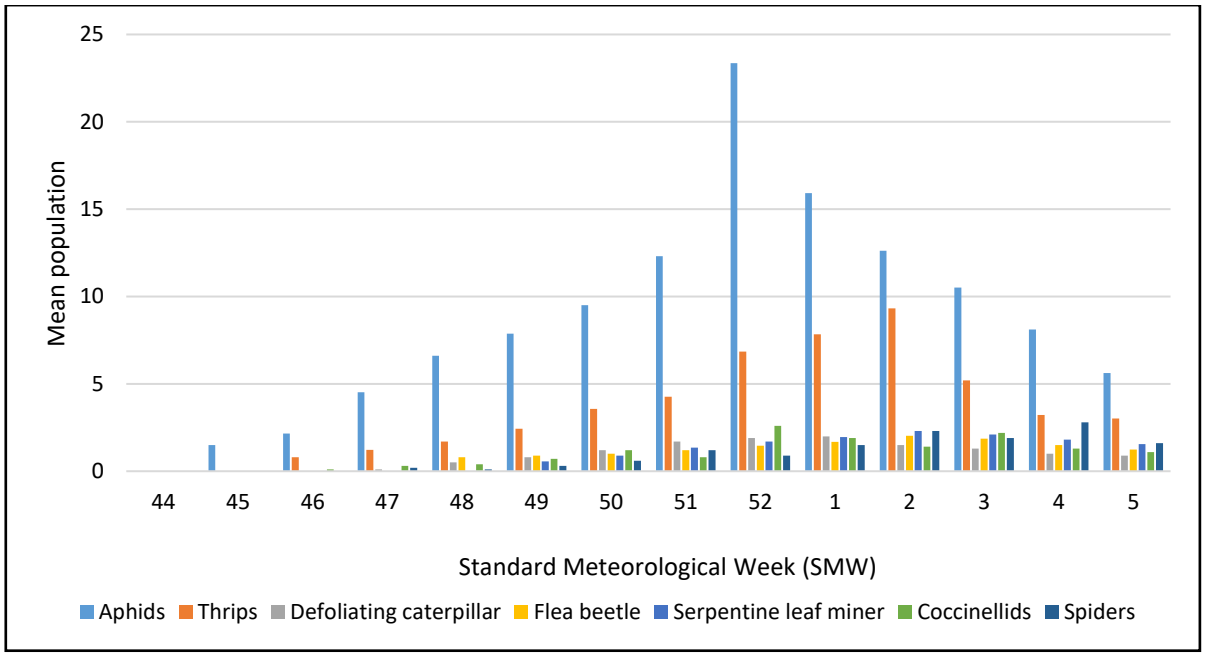

Fig. 2: Incidence of insect pest of fenugreek and their natural enemies (Representation of above table)

5.2.4 Serpentine leaf miner, *Liriomyza trifolii* Burgess (Agromyzidae, Diptera)

The population of serpentine leaf miner on fenugreek started appearing from 49th Standard Meteorological Week (SMW) with the mean population of 0.56/plant (Table 3). The highest incidence was recorded during 2nd SMW (2023) (2.3 leaf miner /plants) when the corresponding minimum and maximum temperature, relative relative humidity and rainfall were 8.8°C, 25.4°C, 55-96% and 0.0 mm respectively (Table 1).

Correlation studies (Table 4) revealed that significant negative correlation was found between serpentine leaf miner population and maximum temperature (r = -0.857) and minimum temperature (r = -0.895). Negative non-significant correlation was observed with maximum relative humidity (r = -0.360), minimum relative humidity (r = -0.532) and rainfall (r = -0.234). Sharma *et al.* (1997) reported that the correlations of weather parameters (temperature and rainfall) with the population build-up of *Liriomyza trifolii* (Burgess) were non-significant on soybean crop in Jabalpur.

5.2.5 Flea beetle, *Phyllotreta* sp. (Chrysomelidae, Coleoptera)

The population of flea beetle on fenugreek started appearing from 48th Standard Meteorological Week (SMW) with the mean population of 0.8/plant (Table 3). The highest incidence was recorded during 2nd SMW (2023) (2.03 flea beetle/plants) when the corresponding minimum and maximum temperature, relative humidity and rainfall were 8.8°C, 25.4°C, 55-96% and 0.0 mm respectively (Table 1).

Correlation studies (Table 4) revealed that significant negative correlation was observed between flea beetle population, maximum temperature (r = -0.845) and minimum temperature (r = -0.886). Negative non-significant correlation with maximum relative humidity (r = -0.352), minimum relative humidity (r = -0.413) and rainfall (r = -0.303). In connection to the present finding workers like Mani and Pal (2013) report that the meteorological parameters exerted immense influence on the infestation of flea beetle. Together all the abiotic factors were responsible for 94% variation in the flea beetle population.

Table no. 4: Insect pest, natural enemies and its correlation coefficient (r) with environmental factors

Insect Pest Complex	Environmental factors				
	Temperature		Relative humidity		Rainfall (mm)
	Max.	Min.	Max.	Min.	
Aphids	-0.871**	-0.595*	0.142NS	-0.077NS	-0.140NS
Thrips	-0.829**	-0.728**	0.044NS	-0.219NS	-0.220NS
S. litura	-0.874**	-0.736**	-0.046NS	-0.311NS	-0.214NS
Serpentine leaf miner	-0.857**	-0.895**	-0.360NS	-0.532NS	-0.234NS
Flea beetle	-0.845**	-0.886**	-0.352NS	-0.413NS	-0.303NS
Natural enemies					
Coccinellids	-0.955**	-0.779**	-0.167NS	-0.344NS	-0.137NS
Spiders	-0.688**	-0.905**	-0.572*	-0.605*	-0.288NS

Note: *- Correlation is significant at 0.05 % level
**- Correlation is significant at 0.01 % level
NS- Correlation is Non Significant

6. Conclusion

The comprehensive investigation into the insect pest-complex and its intricate relationship with environmental factors on Fenugreek (*Trigonella foenum graecum* L.) underscores the nuanced interplay between biological organisms and their surrounding environment. Through this study, a deeper understanding has emerged regarding the multifaceted dynamics governing insect pest populations and their impact on Fenugreek cultivation. The research illuminated the diverse array of insect pests that afflict Fenugreek crops, shedding light on their varying life cycles, feeding habits, and susceptibility to environmental stimuli. Moreover, the study underscored the pivotal role played by environmental factors such as temperature, humidity, precipitation, and soil conditions in modulating the population dynamics and behaviour of these pests. This nuanced understanding is pivotal in devising effective pest management strategies that minimize crop damage and optimize yields sustainably. Furthermore, the findings underscore the necessity of adopting holistic and integrated approaches in pest management, incorporating both traditional and innovative methods. Employing eco-friendly practices, such as biological control measures, crop rotation, and the use of resistant varieties, holds promise in mitigating the impact of insect pests while minimizing adverse effects on the ecosystem and human health.

In conclusion, the study on the insect pest-complex and its correlations with environmental factors on Fenugreek represents a significant contribution to agricultural science. Its findings pave the way for informed decision-making, innovative pest management strategies, and the cultivation of Fenugreek in a manner that balances productivity, environmental conservation, and food safety in a rapidly changing world.

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