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Succession and Seasonal Incidence of Major Insect Pests of Indian Gooseberry and their Relation with Meteorological Parameters

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ABSTRACT: The investigation entitled 'Succession and seasonal incidence of major insect pests of Indian gooseberry and their relation with meteorological parameters' was conducted at Asalpur Farm, SKN College of Agriculture, Jobner (Rajasthan) during the year 2019 and 2020. The study on the succession and incidence of insect pests revealed that the leaf roller, *Caloptilia (=Gracillaria) acidula* (Meyr.); shoot gall maker, *Hypolamprus* (=*Betousa*) *stylophora* (Swinhoe); bark eating caterpillar, *Indarbela tetraonis* Moore, *I. quadrinotata* (Walker) and fruit borer, *Deudorix* (=*Virachola*) *isocrates* (Fab.) were recorded as major insect pests quantitatively at different phenology of Indian gooseberry. The peak population (46.60 and 44.80/ 5 shoots) of leaf roller was recorded in the last week of September (39th SMW), 2019 and 2020. The leaf roller population had positive significant correlation (r=0.44, 0.39, respectively during 2019 and 2020) with the minimum temperature. The maximum shoot gall maker damage of 6.60-7.40 per cent was observed in last week of August (35th SMW) to first week of September (36th SMW). The mean relative humidity had significantly positive correlation (r=0.57, 0.65) during both the years of investigation. The damage of bark eating caterpillar was observed at its peak (4.0-5.0/ 5 plants in 2019 and 2020) in first week of September. The bark eating caterpillar had significantly positive correlation (r=0.54, 0.61) during both the years with the mean relative humidity. The peak infestation of fruit borer was recorded to be 16.00 and 15.00 per cent in 2019 and 2020, respectively in the 38th SMW (3rd week of September). Due to the seasonal changes in any area the incidence of insect-pest also affects with availability of their suitable environmental conditions.

Keywords: Succession, incidence, leaf roller, shoot gall maker, bark eating caterpillar, fruit borer Indian gooseberry, natural enemies, preying mantid and ladybird beetle.

INTRODUCTION

Aonla or Indian gooseberry, *Phyllanthus emblica* L. (=*Emblica officinalis* Gaertn), belonging to family Euphorbiaceae is one of the traditional fruits grown in India and enjoys the status of king of arid fruits. It is indigenous to India and has great medicinal and nutritional value which is gaining popularity among farmers due to its immense potential of cultivation in arid and wastelands (Hiwale, 2015). Dried fruits of Gooseberry find use in rectifying various health complications such as hemorrhages, diarrhea, dysentery, anaemia, jaundice and cough besides being used as a major constituent of *Chyavanprash* and *Trifla*. Owing to its hardy nature, suitability to various wastelands, gooseberry can be grown successfully in semi-arid climate and in soils with higher pH (up to 9.5) and poor fertility status (Pathak and Pathak 2001). Because of being one of the richest sources of vitamin C, possessing high productivity per unit area, and nutritive and therapeutic value, gooseberry fruit has arisen a good deal of interest among the scientific workers. Gallic acid, ellagic acid, chebulic acid, chebulagic acid, chebulinic acid, gallotannins (amlic acid), alkaloids, phyllatidine and phyllantine are reported to be present in gooseberry tree leaves (Khanna and Bansal 1975; Asmawi *et al.,* 1992). Gooseberry is one of the richest sources of ascorbic acid (500-700 mg ascorbic acid/ 100 g of pulp) which is being extensively used in Indian system of medicine such as *Ayurveda, Siddha* and *Unani*. It is also used in Indian system of medicine as an ingredient in more than 175 Ayurvedic formulations. Apart from this, the fruit of gooseberry is also used in pickle, *Murabba*, jam and sauce preparation.

In view of therapeutic properties, gooseberry has gained prominence as a crop of economic importance in recent past (Scartezzini *et al.,* 2006). Its cultivation increased manifold and has become a choice among the orchardists. Though, it is widely grown indifferent states such as Uttar Pradesh, Maharashtra, Gujarat, Haryana,

Punjab, Tamil Nadu, Andhra Pradesh and Karnataka. The climate ranging from hot tropical plains to humid subtropical mid elevation hills is suitable for its cultivation. It can even be raised in arid, semi-arid coastal and warm temperate conditions successfully. India ranks first in production of gooseberry, the total area under cultivation is 92 thousand ha with a total production to the tune of 1046 thousand MT (Anonymous, 2018-19). In Rajasthan, the crop is grown in 1565 ha area with the production of 11,187 MT and average productivity to the tune of 7,146 kg/ ha (Anonymous, 2018). Though, considered to be a hardy fruit crop, not less than 30 insect pests and mite species have been recorded feeding on this scared tree from different places, mostly from India (Lakra, 1996). The major constraints in its fruit production are ravages caused by the insect pests, diseases and some physiological problems throughout the world. Among the insect pests, the *Aonla* shoot gall maker, *Hypolamprus* (=*Betousa*) *stylophora* (Swinhoe); leaf rolling caterpillar, *Caloptilla* (=*Gracillaria*) *acidula* (Mery.); bark eating caterpillar, *Indarbela quardinatata* Walker, *I. tetraonis* Moore; fruit borer, *Deudorix* (=*Virachola*) *isocrates* (Fab.); fruits sucking moths, *Othreis fullonica* (Clerk), *O. materna* (L.) and mealy bug, *Ferrisia virgata* Cockerell have been reported to be of major importance (Chadha, 2003; FAO, 2013). The present study is thus proposed to investigate the succession and seasonal incidence of insect pests and to evaluate the available cultivars of gooseberry for their reaction to important pests. Since, the incidence and development of all the insect pests are very much dependent upon the prevailing weather conditions, such as temperature, relative humidity and precipitation, it is imperative to generate a baseline data and to fill the existing information gaps.

MATERIALS AND METHODS

To study the succession and incidence of major insect pest of Indian gooseberry and their natural enemies, five trees of Indian gooseberry variety, NA-7 were observed at weekly interval. The recommended agronomic package of practices was adopted for raising the crop excluding plant protection measures. The crop was allowed to have natural infestation.

The observations on the succession and seasonal incidence of insect pests of Indian gooseberry were recorded on five plants of eight years age and of equal vigour and size. The observations were recorded when the insect pest population appeared in the orchard at weekly interval in the field conditions starting from the first week of July at different stages of plant growth throughout the year. The incidence of various insect pests along with the nature of damage was studied.

(i) Leaf roller, *Caloptilia (=Gracillaria) acidula* (Meyr.) population: Five terminal shoots measuring 30 cm from every four directions were earmarked from the tree canopy and number of leaf roller larvae per terminal shoot were recorded at weekly interval.

(ii) Shoot gall maker, *Hypolamprus* (=*Betousa*) *stylophora* (Swinhoe): In order to record the observations on infestation of shoot gall maker, number of healthy and damaged shoots were recorded from twenty randomly selected shoots per plant and per cent shoot damage was calculated.

(iii) Bark eating caterpillar, *Indarbela tetraonis* Moore: Observations on infestation due to bark eating caterpillar was recorded by observing branches and stems of five ear marked trees. The damaged branches/ stems were observed and the number of holes were counted.

(iv) Fruit borer, *Deudorix* (=*Virachola*) *isocrates* (Fab.): The observations were initiated to register as soon as the fruit borer appeared in the orchard and infested the fruits of Indian gooseberry. The observations on fruit borer were recorded at weekly interval. Total healthy and infested fruits were counted from one hundred fruits taken randomly from each of the earmarked trees for recording fruit infestation. Weekly records of fruit borer were registered from the experimental field.

The weekly data on temperature (maximum and minimum °C), mean relative humidity (%) and rainfall (mm) were obtained from Meteorological Observatory of the Department of Agronomy, SKN College of Agriculture, Jobner. The simple correlation was worked out between insect pest population, damage indices and the meteorological parameters. Following formula was used for calculating correlation coefficient (Panse and Sukhatme 1967).

$$r = \frac{\breve{N} \sum xy - (\sum x)(\sum y)}{\sqrt{N\sum x^2 - (\sum x)^2 . N\sum y^2 - (\sum y)^2}}$$

Where,

r = Simple correlation coefficient

x = Independent variables, *i.e.,* abiotic components

y = Dependent variables, *i.e.,* insect pests

N = Number of observations

For recording natural parasitization by the biocontrol agents in the field, the infected insects were collected and brought to the laboratory for further emergence of parasitoid, their identification and per cent parasitization. The manually collected infested insects were kept in glass jars (10x 15x 20 cm) and were provided with their preferred host food along with the streak of honey through cotton swabs and were examined for emergence of parasites. The infested leaves were brought to the laboratory and counted numbers of infested leaf roller (20) was kept in glass jars for emergence of parasitoids and their per cent parasitization**.** Predators preying upon the different immature stages of leaf roller and borers observed in the field conditions were also collected and brought to laboratory to confirm their predation. The observation of predatory beetles, mantids and spiders were also

recorded by counting number of adults from five randomly selected twigs from each direction from five selected trees. The individual damaged twigs of gooseberry were enclosed on tree itself with a specially prepared cage with (20 x 5cm) to collect the parasitoids. For the purpose, pupae formed on the twigs were brought to the laboratory and counted the number of emerged parasitoids. Based on these data, per cent parasitism was worked out.

RESULTS AND DISCUSSION

The infestation of leaf roller commenced in the first week of July (27th standard meteorological week, SMW) and persisted upto the last week of December, 2019 and 2020 (52nd SMW). Initially, the population of leaf roller was 3.20 and 3.40 per five shoots (30 cm each) during 2019 and 2020, respectively. The shoot gall maker damage commenced in the first week of July (27th SMW), *viz.* 1.0 per cent in 2019 and second week of July (28th SMW), *viz*. 1.20 per cent in 2020. The damage due to bark eating caterpillar was commenced the second week of July 2019 (28th SMW) (1.00 holes/ 5 plants) and third week of July (29th SMW) in 2020 with the same level of infestation with that of previous year. The fruit borer damage in 2019 was commenced in the 30th SMW (6.00%) and in 31st SMW of 2020 (5.00%).

The peak population (46.60 and 44.80/ 5 shoots) of leaf roller was recorded in the last week of September (39th SMW) 2019 and 2020. Thereafter, the population of leaf roller was at a decreasing trend. The meteorological parameters during the peak population of the leaf roller exhibited 24.30°C minimum temperature, 32.80°C maximum temperature, 75.00 per cent mean relative humidity and 12.20 mm rainfall in 2019 and 20.80°C minimum temperature, 36.90°C maximum temperature, 59.00 per cent mean relative humidity and 3.20 mm rainfall in 2020. The maximum shoot gall maker damage of 7.40 per cent in last week of August (35th SMW) and 6.60 per cent in first week of September (36th SMW) was registered in 2019 and 2020, respectively when minimum temperature of 19.50°C, maximum temperature of 33.90°C, mean relative humidity of 83.00 per cent and rainfall of 44.20 mm in first year and minimum temperature of 21.30°C, maximum temperature of 31.70°C, mean relative humidity 84.00 per cent and rainfall of 24.40 mm in second consecutive year was experienced. The infestation of shoot gall maker was at diminishing pattern thereafter.

With a view to provide sound base of pest management, the pest populations and its damage indices in relation to key abiotic factors, *viz.,* maximum and minimum temperature, relative humidity and rainfall under the prevailing set of agro-climatic conditions were studied. During the field experimentation of two consecutive years, the leaf roller, *Caloptilia (=Gracillaria) acidula* (Meyr.); shoot gall maker, *Hypolamprus* (=*Betousa*) *stylophora* (Swinhoe); bark eating caterpillar, *Indarbela tetraonis* Moore, *I. quadrinotata* (Walker) and fruit borer, *Deudorix* (=*Virachola*) *isocrates* (Fab.) were recorded as major insect pests quantitatively at different stages of plant growth of Indian gooseberry. The results corroborated with the findings of Beeson (1941); Lal (1950); Wadhi and Batra (1964); Srivastava and Jain (1975); Sen Sharma (1987); Chundawat (1990); Lal *et. al*. (1996); Dadmal and Pawar (2002). Nair and Mathew (1988); Kaushik (2005); Arpitha *et al.* (2022) observed leaf eating caterpillar, and Pawar (2002) observed shoot gall maker and bark eating caterpillar as serious enemies of Indian gooseberry. Bharpoda *et. al.* (2009); FAO (2013) observed shoot gall maker, leaf roller, fruit borer and bark eating caterpillar as major insect pests of Indian gooseberry.

The infestation of leaf roller commenced in the first week of July (27th standard meteorological week, SMW) and persisted upto the last week of December, 2019 and 2020 (52nd SMW). Initially, the population of leaf roller was 3.20 and 3.40 per five shoots (30 cm each) during 2019 and 2020, respectively. The shoot gall maker damage commenced in the first week of July (27th SMW), *viz.,* 1.0 per cent in 2019 and second week of July (28th SMW), *viz*., 1.20 per cent in 2020. The damage due to bark eating caterpillar was commenced the second week of July 2019 (28th SMW) (1.00 holes/ 5 plants) and third week of July (29th SMW) in 2020 with the same level of infestation with that of previous year. The fruit borer damage in 2019 was commenced in the 30th SMW (6.00%) and in 31st SMW of 2020 (5.00%). The commencement period of these pests got support from the findings of Singh (1990); Patel *et. al*. (1999); Singh and Singh (2002).

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The damage of bark eating caterpillar was observed at its peak (4.00 and 5.00 holes/ 5 plants in 2019 and 2020, respectively) in first week of September both the years. During first year, the minimum temperature, maximum temperature, mean relative humidity and rainfall at peak period of infestation were registered to be 22.90°C, 33.80°C, 83.00 per cent and 6.60 mm, respectively; the same parameters during the second year were 21.30°C, 31.70°C, 84.00 per cent and 24.40 mm, respectively. The damage indices were at decreasing trend after this period.

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The peak infestation of fruit borer was recorded to be 16.00 and 15.00 per cent in 2019 and 2020, respectively in the 38th SMW (3rd week of September). During first year, the minimum temperature, maximum temperature and mean relative humidity at peak period of infestation were registered to be 23.30°C, 35.20°C and 63.00 per cent, respectively; the same parameters during the second year were 21.50°C, 37.30°C and 63.00 per cent, respectively.

The peak infestation of fruit borer was recorded to be 16.00 and 15.00 per cent in 2019 and 2020, respectively in the 38th SMW (3rd week of September). During first year, the minimum temperature, maximum temperature and mean relative humidity at peak period of infestation were registered to be 23.30°C, 35.20°C and 63.00 per cent, respectively; the same parameters during the second year were 21.50°C, 37.30°C and 63.00 per cent, respectively. Srivastava and Jain (1975) reported the occurrence of *D. isocrates* during August to September which corroborated with the present result.

Few minor insect pests recorded in traces were: cow bug or tree hopper, *Tricentrus congestus* Walkar; aphid, *Schoutedenia* (=*Cerciaphis*) *emblica* (Patel & Kulkarni); Aonla shoot borer, *Zeuzera coffea* Nietner*;* mealy bug, *Nipaecoccus vastator* (Maskell) and hairy caterpillar, *Selepa celtis* Moore. The present findings are in agreement with Beeson (1941); Ali (1961);Shrivastava and Butani (1998); Kaushik (2005); Malsia (2006).

For recording natural parasitization by the biocontrol agents in the field, the infected insects were collected and brought to the laboratory for further emergence of parasitoids and parasitization of the host. Traces of *Trichogrmma chilonis* from eggs of fruit borer, *D. Isocrates* and *Tetrastichus* sp. from leaf roller infested leaflets. Further, the populations of green lacewing, *Chrysoperala zastrowi Arabica (*Henry *et al.)*; preying mantid, *Mantis religiosa* (L.); ladybird beetle, *Adalia bipunctata* (L.); yellow wasp, *Polistes hebraeus* (F.); assassin bug, *Harpactor costalis* (Stal); spider and black ant, *Camponotus compressus* (Fab.), though prevalent but meagre in numbers.

The natural enemies (parasites and predators) recorded were traces of *Trichogrmma chilonis* from eggs of fruit borer, *D. Isocrates* and *Tetrastichus* sp. from leaf roller infested leaflets. Further, the populations of green lacewing, *Chrysoperala zastrowi arabica* (Henry *et al.*); preying mantid, *Mantis religiosa* (L.); ladybird beetle, *Adalia bipunctata* (L.); yellow wasp, *Polistes hebraeus* (F.); assassin bug, *Harpactor costalis* (Stal); spider and black ant, *Camponotus compressus* (Fab.), though prevalent but meagre in numbers. The results got support from the findings of Mani *et.al.* (2005); Malsia (2006); Mahor (2007).

Effect of environmental factors on incidence of major insect pests. The maximum leaf roller population (46.60/ 5 shoots) was recorded at 32.80°C and 24.30°C maximum and minimum temperature and 75.00 per cent mean relative humidity in the first year, *i.e.* 2019. In the second year (2020), its population was recorded maximum (44.80/ 5 shoots) at 36.90°C maximum temperature, 20.80°C minimum temperature and 59.00 per cent mean relative humidity and rainfall 3.20 mm. The minimum temperature had positive significant correlation (r=0.44, 0.39, respectively during 2019 and 2020). The other meteorological variables differed non significantly with the population of leaf roller.

The shoot gall maker damage was at its peak (7.40%) when the maximum temperature was 33.90°C, minimum temperature 19.50°C, mean relative humidity 83.00 per cent and rainfall 44.20 mm during 2019 and peak of 6.60 per cent damage when the maximum temperature was 31.70°C, minimum temperature 21.30°C, mean relative humidity 84.00 per cent and rainfall 24.40 mm during 2020. The mean relative humidity had significantly positive correlation (r=0.57, 0.65) during both the years of investigation.

Table 1: Succession and seasonal incidence of major insect pests of Indian gooseberry and their relation with meteorological parameters during 2019.

SMW	Date of observations	Meteorological parameters				Leaf roller/ 5 shoots (30 cm each)	Shoot gall maker damage (%)	No. of holes caused by bark eating caterpillar /5 plants	Fruit borer damage (%)
		Temperature (^{O}C)		Relative humidity (%)	Rainfall (mm)				
		Minimum	Maximum						
27	02.07.2019	22.50	38.10	62.00	14.80	3.20	1.00	0.00	0.00
28	09.07.2019	22.90	36.80	53.00	5.00	11.20	1.00	1.00	0.00
29	16.07.2019	22.00	36.30	63.00	6.40	15.80	1.00	1.00	0.00
30	23.07.2019	20.40	32.50	89.00	141.50	17.60	2.00	2.00	6.00
31	30-07.2019	21.50	33.20	83.00	22.40	19.20	1.60	2.00	8.00
32	06.08.2019	20.00	32.00	82.00	95.60	25.40	2.40	2.00	9.00
33	13.08.2019	19.80	30.50	87.00	43.00	28.20	2.60	2.00	10.00
34	20.08.2019	20.00	34.00	75.00	0.80	33.60	2.00	3.00	10.00
35	27.08.2019	19.50	33.90	83.00	44.20	36.60	7.40	2.00	12.00
36	03.09.2019	22.90	33.80	83.00	6.60	38.20	3.00	4.00	15.00
37	10.09.2019	24.90	36.30	70.00	0.00	40.00	3.00	3.00	14.00
38	17.09.2019	23.30	35.20	63.00	0.00	42.60	2.60	2.00	16.00
39	24.09.2019	24.30	32.80	75.00	12.20	46.60	3.00	2.00	13.00
40	01.10.2019	22.70	33.30	67.00	0.60	40.80	2.40	0.00	14.00
41	08.10.2019	17.60	33.70	53.00	0.00	37.80	1.00	-	9.00
42	15.10.2019	17.70	34.70	55.00	1.90	32.20	1.00	-	8.00
43	22.10.2019	13.00	32.80	57.00	1.40	30.80	0.60	-	7.00
44	29.10.2019	15.10	32.00	61.00	1.40	28.80	0.00	-	6.00
45	05.11.2019	13.10	29.30	73.00	2.10	25.40	-	-	0.00
46	12.11.2019	10.60	30.40	63.00	1.90	21.80	-	-	-
47	19.11.2019	11.00	28.30	63.00	0.00	18.40	-	-	-
48	26.11.2019	5.10	25.70	71.00	0.00	16.20	-	-	-
49	03.12.2019	6.00	25.00	59.00	0.00	13.00	-	-	-
50	10.12-2019	3.50	21.30	76.00	3.10	11.60	-	-	-
51	17.12.2019	0.60	20.40	70.00	0.00	9.20	-	-	-
52	24.12.2019	1.00	21.70	65.00	0.00	6.60	-	-	-
	Correlation Maximum Temperature (°C)					0.29 (NS)	-0.11 (NS)	-0.32(NS)	-0.12 (NS)
	Correlation Minimum Temperature (°C)					0.44*	0.32 (NS)	-0.03(NS)	0.35 (NS)
	Correlation Relative humidity (%)					0.10 (NS)	0.57*	0.54*	0.37 (NS)
	Correlation Rainfall (mm)					-0.12 (NS)	0.23 (NS)	0.05(NS)	-0.02 (NS)

SMW- Standard meteorological week ; *Significant at 5% level

Table 2: Succession and seasonal incidence of major insect pests of Indian gooseberry and their relation with meteorological parameters during 2020.

SMW	Date of observations	Meteorological parameters				Leaf roller/ 5 shoots (30 cm each)	Shoot gall maker damage (%)	No. of holes caused by bark eating caterpillar /5 plants	Fruit borer damage (%)
		Temperature (^{O}C)		Relative humidity (%)	Rainfall (mm)				
		Minimum	Maximum						
27	01.07.2020	24.40	40.90	59.00	13.80	3.40	0.00	0.00	0.00
28	08.07.2020	24.20	35.50	74.00	28.80	11.60	1.20	0.00	0.00
29	15.07.2020	25.40	37.60	63.00	0.00	16.00	2.00	1.00	0.00
30	22.07.2020	23.10	34.00	77.00	13.20	17.80	2.40	1.00	0.00
31	29.07.2020	24.20	36.00	69.00	0.00	19.20	3.00	2.00	5.00
32	05.08.2020	23.00	32.90	83.00	47.40	25.60	3.00	3.00	6.00
33	12.08.2020	23.50	33.10	86.00	57.40	28.40	3.60	3.00	8.00
34	19.08.2020	22.00	30.20	87.00	39.40	33.80	3.40	3.00	9.00
35	26.08.2020	21.50	31.10	86.00	27.80	37.00	4.20	4.00	11.00
36	02.09.2020	21.30	31.70	84.00	24.40	38.40	6.60	5.00	13.00
37	09.09.2020	21.10	36.30	67.00	0.00	40.20	4.00	4.00	14.00
38	16.09.2020	21.50	37.30	63.00	1.30	43.80	3.60	3.00	15.00
39	23.09.2020	20.80	36.90	59.00	3.20	44.80	2.20	2.00	12.00
40	30.09.2020	14.30	37.00	47.00	0.00	41.00	2.00	0.00	11.00
41	07.10.2020	16.50	36.60	43.00	0.00	35.00	1.80	-	10.00
42	14.10.2020	20.30	35.00	44.00	0.00	31.40	1.20	-	7.00
43	21.10.2020	17.60	33.30	43.00	0.00	28.00	0.60	-	6.00
44	28.10.2020	10.50	31.00	48.00	0.00	26.00	0.40	-	4.00
45	04.11.2020	8.90	30.90	65.00	0.00	25.60	0.00	-	0.00
46	11.11.2020	12.70	27.40	71.00	0.00	24.00	-	-	-
47	18.11.2020	7.70	25.20	72.00	0.00	23.00	-	-	-
48	25.11.2020	7.70	25.80	77.00	1.00	12.60	-	-	-
49	02.12.2020	7.10	30.20	79.00	0.00	9.00	-	-	-
50	09.12-2020	9.80	24.70	81.00	2.00	8.40	-	-	-
51	16.12.2020	5.40	28.60	70.00	0.00	5.60	-	-	-
52	23.12.2020	2.70	25.20	65.00	0.00	5.00	-	-	-
	Maximum Temperature (^{O}C)					0.36(NS)	-0.24(NS)	-0.64*	-0.03(NS)
	Correlation Minimum Temperature (^{O}C)					0.39*	0.42(NS)	-0.03(NS)	-0.03(NS)
	Correlation Relative humidity (%)					-0.19(NS)	0.65*	0.61*	0.03(NS)
	Correlation Rainfall (mm)					0.12(NS)	0.41(NS)	0.29(NS)	-0.01(NS)

SMW- Standard meteorological week; *Significant at 5% level

The bark eating caterpillar infestation was registered at its peak (4.00 holes/ 5 plants) when the maximum temperature was 33.80°C, minimum temperature 22.90°C, mean relative humidity 83.00 per cent and rainfall 6.60 mm during 2019 and peak of 5.00 holes/ 5 plants when the maximum temperature was 31.70°C, minimum temperature 21.30°C, mean relative humidity 84.00 per cent and rainfall 24.40 mm during 2020. The mean relative humidity had significantly positive correlation (r=0.54, 0.61) during both the years of study. Though the maximum temperature showed negative significant correlation during second year investigation (r=-0.64).

The fruit borer damage differed non significantly with all the meteorological variables during both the years of study. The results could not be discussed and supported due to lack of suitable information available on the aspect.

CONCLUSIONS

The leaf roller, *Caloptilia (=Gracillaria) acidula* (Meyr.); shoot gall maker, *Hypolamprus* (=*Betousa*) *stylophora* (Swinhoe); bark eating caterpillar, *Indarbela tetraonis* Moore and *I. quadrinotata (*Walker) fruit borer, *Deudorix* (=*Virachola*) *isocrates* (Fab.) were recorded as major insect pests quantitatively at different phenology of Indian gooseberry.

The peak population (46.60 and 44.80/ 5 shoots) of leaf roller was recorded in the last week of September (39th SMW) 2019 and 2020. The meteorological parameters during the peak population of the leaf roller exhibited 20.80-24.30°C minimum temperature, 32.80-36.90°C maximum temperature and 59.00-75.00 per cent mean relative humidity. The leaf roller population had positive significant correlation (r=0.44, 0.39, respectively during 2019 and 2020) with the minimum temperature.

The maximum shoot gall maker damage of 6.60-7.40 per cent in last week of August (35th SMW) to first week of September (36th SMW) when minimum temperature of 19.50-21.30°C, maximum temperature of 31.70-33.90°C and mean relative humidity of 83.00-84.00 per cent. The mean relative humidity had significantly positive correlation (r=0.57, 0.65) during both the years of investigation.

The damage of bark eating caterpillar was observed at its peak (4.0-5.0/ 5 plants in 2019 and 2020, respectively) in first week of September. The minimum temperature, maximum temperature, mean relative humidity and rainfall at peak period of infestation were registered to be 21.30-22.90°C, 31.70-33.80°C, 83.00-84.00 per cent, respectively. The bark eating caterpillar had significantly positive correlation (r=0.54, 0.61) during both the years with the mean relative humidity.

The peak infestation of fruit borer was recorded to be 16.00 and 15.00 per cent in 2019 and 2020, respectively in the 38th SMW (3rd week of September). The minimum temperature, maximum temperature and mean relative humidity at peak period of infestation were registered to be 21.50-23.30°C, 35.20-37.30°C and 63.00 per cent, respectively.

The natural enemies (parasites and predators) associated with the insect pests on Indian gooseberry were *Trichogrmma chilonis; Tetrastichus* sp.; green lacewing, *Chrysoperala zastrowi arabica* (Henry *et al.)*; preying mantid, *Mantis religiosa* (L.); ladybird beetle, *Adalia bipunctata* (L.); yellow wasp, *Polistes hebraeus* (F.); assassin bug, *Harpactor costalis* (Stal); spider and black ant, *Camponotus compressus* (Fab.) but meagre in numbers.

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