Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(5): 1277-1282
Received: 07-07-2020
Accepted: 14-08-2020

Mahesh Keshabhai Katesiya
Chimanbhai Patel College of Agriculture, Department of Agriculture Entomology, Sardarkrushinagar Dantiwada Agriculture University, Sardarkrushinagar, Gujarat, India

Dr. Babubhai Gobarbhai Prajapati
Associate Research Scientist, Seed Spices Research Center, Jagudan, Gujarat, India

Pritam Dineshbhai Vora
Chimanbhai Patel College of Agriculture, Department of Agriculture Entomology, Sardarkrushinagar Dantiwada Agriculture University, Sardarkrushinagar, Gujarat, India

Vijaykumar Bhikhabhai Prajapati
B. A. College of Agriculture, Anand Agriculture University, Anand, Gujarat, India

Chandreshbhai Balavantbhai Solanki
Chimanbhai Patel College of Agriculture, Department of Agriculture Entomology, Sardarkrushinagar Dantiwada Agriculture University, Sardarkrushinagar, Gujarat, India

Corresponding Author:
Mahesh Keshabhai Katesiya
Chimanbhai Patel College of Agriculture, Department of Agriculture. Entomology, Sardarkrushinagar Dantiwada Agriculture University, Sardarkrushinagar, Gujarat, India

Population dynamics of aphid, *Aphis gossypii* Glover infesting isabgul under north Gujarat Agro-climatic conditions

Dr. Babubhai Gobarbhai Prajapati, Pritam Dineshbhai Vora, Vijaykumar Bhikhabhai Prajapati and Chandreshbhai Balavantbhai Solanki

Abstract
A field experiment was conducted on the population dynamics of *Aphis gossypii* Glover during *rabi* 2017-18 at Chimanbhai Patel College of Agriculture, Sardarkrushinagar. The results showed that the aphid infestation was started from 1st week of January (1st Standard Meteorological Week) and gradually increased up to 4th week of February (8th Standard Meteorological Week) with a peak population of 2.40 aphid index. During the peak period, the minimum and maximum temperatures and morning and evening Relative Humidity (R.H.) were recorded 33.6 ºC and 13.8 ºC and 65.9 and 37.0 per cent, respectively. Among the natural enemies, the lady bird beetle larva was found active between 4th week of January and 3rd week of March. Lady bird beetle adult found active between 4th week of January and 4th week of March, whereas, larval population of syrphid fly was recorded during 1st week of January to 2nd week of March, 2018. The larval population of lady bird beetle and syrphid fly had highly significant positive correlation with aphid, whereas, ladybird beetle adult had significant positive correlation.

Keywords: Isabgul, population dynamics, isbgul aphid, *Aphis gossypii* Glover, predators, abiotic factors, lady bird beetle, syrphid fly, correlaton

Introduction
Isabgul (*Plantago ovata* Forsk.), a medicinal plant, is widely used in traditional and industrial pharmacology. India holds monopoly in the production and export of Isabgul to the world market. About 80 to 90% produce is mainly exported to U.S.A., West Germany, U.K. and France. The most important component of Isabgul is husk obtained from its seed. Isabgul husk is popularly known as "Sat Isabgol" in Indian market. It is an important medicine for intestinal and stomach disorders. Isabgul is commercially grown as a winter crop cultivated in North Gujarat, Saurashtra and Kachchh region of Gujarat state. Isabgul is ravaged by number of insect pests. Among them, Isabgul aphid, *Aphis gossypii* Glover, seed beetle, *Lasioderma serricorne* Fabricius, termite, *Odontotermes obesus* Rambur and white grub, *Holotrichia consanguinea* Blanchard are major insect pests attacking in Isabgul crop (Reddy, 2009) [7]. Out of which Isabgul aphid, *Aphis gossypii* Glover (Homoptera: Aphididae) has been reported as a major pest of Isabgul (Sagar and Jindla, 1984) [9]. It is a polyphagous pest which infesting number of field crops. It has been reported to attack 220 host plants belonging to 46 families throughout the world (Roy and Behura, 1983) [8]. Regular occurrence of *A. gossypii* on Isabgul crop in North Gujarat and South Rajasthan regions causing enormous economic yield losses. Very few research work on the population dynamics of Isabgul aphid in general and particularly from North Gujarat Agro- Climatic Zone. Keeping these points in view, the population dynamics of aphid, *Aphis gossypii* Glover in isabgul was conducted during *rabi* 2017-18.

Materials and methods
A field experiment was conducted at Agronomy Instuctional Farm of Chimanbhai Patel College of Agriculture, Sardarkrushinagar during *rabi* 2017-18 to study the population dynamics of *Aphis gossypii* Glover. The isabgul variety Gujarat Isabgul 4 was spaced at 30cm × 10cm and kept unsprayed during the crop season.
For the purpose, whole experimental plot (25m × 20m) of isabgul crop was divided into five quadrates (1 m × 1 m). Ten plants were randomly selected from each quadrate and were tagged for recording the observations. Number of aphids present on tagged plant were recorded at weekly interval.

Thus, the aphid population was recorded from 50 plants and mean aphid index was calculated. The observations were started from one week after germination till harvest of the crop at weekly interval. Population of natural enemies were also recorded on five plants and mean population of natural enemies were also worked per plant.

Aphid index

Following aphid index given by Bank (1954) [1] was fixed for estimating the population of aphid and the average aphid index was worked out by adopting following formula.

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

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

Aphid index		Particulars
0	**:**	Plant free from aphid
1	**:**	Aphid present, but colonies did not build up. No injury due to pest apparent on the plant
2	**:**	Small colonies of aphid were present
3	**:**	Large colonies of aphid was present on tender parts and show damage symptoms due to aphids
4	**:**	Entire plant was covered by aphids

Correlation study

In order to find out the specific impact of different weather parameters on *A. gossypii* in isabgul, the data on aphid index was correlated with the different meteorological parameters recorded at Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. Correlation values were worked out by standard statistical procedure.

Results and discussion

Population dynamics of isabgul aphid, *A. gossypii*

It is clearly evident from the results presented in table 1 and depicted graphically in fig. 1 that the aphid population was initiated during the first week of January (1st SMW-Standard Meteorological Week *i.e.*, 6 WAS-Weeks after Sowing) (0.04 aphid index). The aphid population was increased up to 1.48 aphid index during the fourth week of January (4th SMW *i.e.*, 9WAS). Thereafter, the aphid population was increased gradually throughout the crop season and reached at its peak (2.40 aphid index) during the fourth week of February (8th SMW *i.e.*, 13 WAS). During the first week of February (5th SMW *i.e.*, 10 WAS) population reached to 1.72 aphid index and it increased up to 2.14 aphid index in the second week of February (6th SMW, *i.e.*, 11 WAS), 2.22 aphid index during the third week of February (7th SMW, *i.e.* 12 WAS) and 2.40 aphid index during the fourth week of February (8th SMW, *i.e.*, 13WAS). Overall, during the month of February, the aphid population was ranged between 1.72 and 2.40 aphid index. Further, the aphid population reached up to 1.56 aphid index during the first week of March (9th SMW *i.e.*, 14 WAS) and it was declined gradually. During the second week of March (10th SMW *i.e.*, 15 WAS), it was 1.08 aphid index and reached to 0.16 aphid index during the fourth week of March (12th SMW *i.e.*, 17 WAS). Overall, the aphid population was ranged between 0.16 and 1.56 aphid index during the month of March.

From the results, it can be inferred that the incidence of aphid occurred between the first week of January to fourth week of March and population of aphid was varied from 0.04 to 0.16 aphid index. Maximum aphid population was observed during the fourth week of February (8th SMW *i.e.*, 13WAS) and it was 2.40 aphid index. Isabgul crop was harvested during the fourth week of March, 2018.

The results are in close accordance with the findings of Sagar *et al.* (1987) [10] who reported that the population dynamics of *A. gossypii* Glover on three promising cultivars of isabgul in Punjab and found that the aphid was first appeared in the second week of February and increased gradually up to sixth march. There was a substantial increase in the population of the pest on sixth March 30.8, 31.8 and 30.1 aphids/tiller on P-79-1-7, S-8-1-5 and progeny 27-1-9, respectively. Maximum population of aphids was registered on thirteenth March and almost disappeared on twentieth March. As per the report of Kandoria *et al.* (1989) [3] from Punjab, *A. gossypii* found during February and was very active on melon and tomato in March. Patel (2002) [5] from Gujarat reported that *A. gossypii* on isabgul was found during the first week of March. Rajput *et al.* (2010) [6] found that low temperature and high humidity during the months of January and February favored high build up population of *A. gossypii* on cotton. Selvaraj *et al.* (2010) [11] reported that the aphid population started from the fourth week of February on fourth week old crop and acquired its peak in the fourth week of March on sixth week old cotton crop. Kataria and Kumar (2015) [4] observed that the aphid population is higher in the months of January to March on cotton, whereas, maximum populations of aphid were seen during the month of February on cotton host plants. Thus, present findings are in accordance with the reports made by earlier workers.

Natural enemies of isabgul aphid

The lady bird beetle, *Coccinella septempunctata* as well as syrphid fly, *Xanthogramma scutellare* are known to be effective predators of aphid. Therefore, periodic incidence of these natural enemies was also studied simultaneously so as to know their role in checking the population of aphid in isabgul.

Table 1: Population dynamics of isabgul aphid, *Aphis gossypii* Glover infesting in relation to abiotic factors during *rabi* 2017-18

SMW	Month and weeks		Mean aphid index	Abiotic factors						
				Temperature (ºC)		Relative Humidity (%)		Wind velocity (km/hrs)	Bright sunshine (hours/day)	Rainfall (mm)
				Max.	Min.	Morn.	Even.			
50	December, 2017	III	0.00	23.8	10.7	69.3	56.7	4.2	6.7	1.0
51		IV	0.00	29.6	9.9	65.7	52.9	2.7	8.6	0.0
52		V	0.00	28.7	9.4	64.9	50.1	2.3	9.1	0.0
01	January, 2018	I	0.04	26.6	6.6	66.9	47.0	2.6	9.6	0.0
02		II	0.40	28.6	10.1	62.9	50.7	2.4	8.8	0.0
03		III	1.28	30.7	9.7	62.5	45.8	6.6	9.8	0.0
04		IV	1.48	29.1	6.2	55.8	40.3	2.0	9.5	0.0

05	February, 2018	I	1.72	30.3	9.3	62.9	34.0	1.9	9.7	0.0
06		II	2.14	29.9	9.8	62.1	50.0	3.5	8.7	0.0
07		III	2.22	30.5	11.2	61.3	42.5	3.0	9.4	0.0
08		IV	2.40	33.6	13.8	65.9	37.0	2.8	9.7	0.0
09	March, 2018	I	1.56	36.3	15.0	66.2	35.0	3.4	9.5	0.0
10		II	1.08	36.6	13.7	63.6	32.5	3.9	10.3	0.0
11		III	0.40	35.7	14.9	69.3	39.1	4.4	8.7	0.0
12		IV	0.16	35.4	16.9	71.7	46.2	4.8	9.6	0.0

SMW: Standard Meteorological Weeks

Table 2: Population dynamics of isabgul aphid, *Aphis gossypii* Glover and natural enemies during *rabi* 2017-18

Month and weeks		SMW	WAS	Mean aphid index	Mean number of natural enemies/plant		
					Ladybird beetle		Syrphid fly (Larva)
					Larva	Adult	
December, 2017	III	50	3	0.00	0.00	0.00	0.00
	IV	51	4	0.00	0.00	0.00	0.00
	V	52	5	0.00	0.00	0.00	0.00
January, 2018	I	01	6	0.04	0.00	0.00	0.09
	II	02	7	0.40	0.00	0.00	0.40
	III	03	8	1.28	0.00	0.00	1.25
	IV	04	9	1.48	0.20	0.06	2.30
February, 2018	I	05	10	1.72	0.52	0.40	2.95
	II	06	11	2.14	1.04	1.24	3.10
	III	07	12	2.22	1.38	1.40	2.20
	IV	08	13	2.40	1.70	1.64	2.14
March, 2018	I	09	14	1.56	2.34	2.30	1.04
	II	10	15	1.08	1.44	2.56	0.44
	III	11	16	0.40	0.72	1.22	0.00
	IV	12	17	0.16	0.00	0.44	0.00

SMW : Standard Meteorological Weeks; WAS : Weeks After Sowing

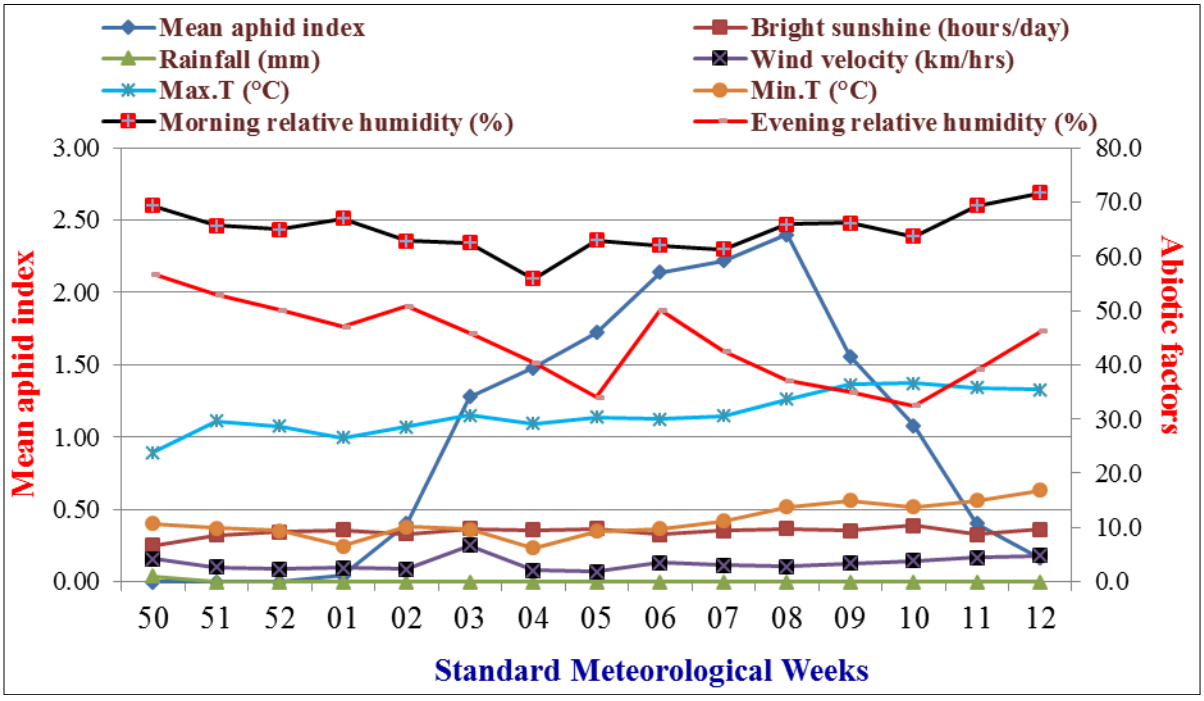

Fig. 1. Population dynamics of isabgul aphid, *Aphis gossypii* Glover in relation to abiotic factors

Predators

Lady bird beetle (Larva)

Perusal of the results presented in table 2 and depicted in fig. 2 revealed that the larval activity of lady bird beetle was increased gradually throughout the season and reached at peak during the first week of March (9th SMW *i.e.*, 14 WAS) and it was 2.34 larvae per plant. As far as larval population of lady bird beetle is concerned, the population was commenced during the fourth week of January (4th SMW *i.e.*, 9 WAS) and it was 0.20 larva per plant. The larval population was increased up to 1.70 larva per plant during the fourth of February (8th SMW *i.e.*, 12 WAS) and similar trend was continued in the first week of March (9th SMW *i.e.*, 14 WAS) (2.34 larva/plant). Afterwards, the larval population of lady bird beetle was declined and reached to 1.44 larva per plant during the second week of March (10th SMW *i.e.*, 15 WAS), 0.72 larva per plant during the third week of March (11th SMW *i.e.*, 16 WAS), whereas, it was disappeared during the fourth week of March (12th SMW *i.e.*, 17 WAS). Overall in

the month of March, the larval population was ranged between 0.72 and 2.34 larva per plant.

Based on these results, the larval activity of lady bird beetle commenced from the fourth week of January and lasted up to the third week of March. The larval population was varied from 0.20 to 0.72 larva per plant. The larval population of lady bird beetle showed gradual increase during the first week of March and then after, decreased till the harvesting of the crop. The maximum larval population of lady bird beetle (2.34 larva/plant) was observed during the first week of March, 2018 (9th SMW *i.e.*, 14 WAS).

Lady bird beetle (Adult)

The data presented in table 2 and depicted in fig. 2 revealed that the adult population of lady bird beetle was increased gradually throughout the crop season and reached at peak (2.56 adults/plant) during the second week of March (10th SMW *i.e.*, 15 WAS). As far as adult population of lady bird beetle is concerned, it was started gradually (0.06 adult/plant) during the fourth week of January (4th SMW *i.e.*, 9 WAS). It was increased up to 1.64 adults per plant during the fourth week of February (8th SMW *i.e.*, 13 WAS) and similar trend was continued during the first week of March, 2018 also. During the first week of March (9th SMW *i.e.*, 14WAS), it was observed to 2.30 adults per plant and it was increased at its peak (2.56 adults/plant) during the second week of March (10th SMW *i.e.*, 15 WAS). During the third week of March (11th SMW *i.e.*, 16 WAS), the adult population was declined (1.22 adults/plant) and finally, the population of lady bird beetle was noticed 0.44 adults per plant during the fourth week of March (12th SMW *i.e.*, 17 WAS).

Overall in the month of March, the adult population of lady bird beetle was ranged between 0.44 and 2.30 adults per plant. From these results, it can be inferred that the activity of lady bird beetle commenced from the fourth week of January to fourth week of March and adult population of lady bird beetle was varied from 0.06 to 0.44 adults per plant. The population of lady bird beetle adult gradually increased during the second week of March and later on, it was declined till the harvesting of the crop. The maximum adult population of lady bird beetle (2.56 adults/ plant) was observed during the second week of March (10th SMW *i.e.*, 15 WAS).

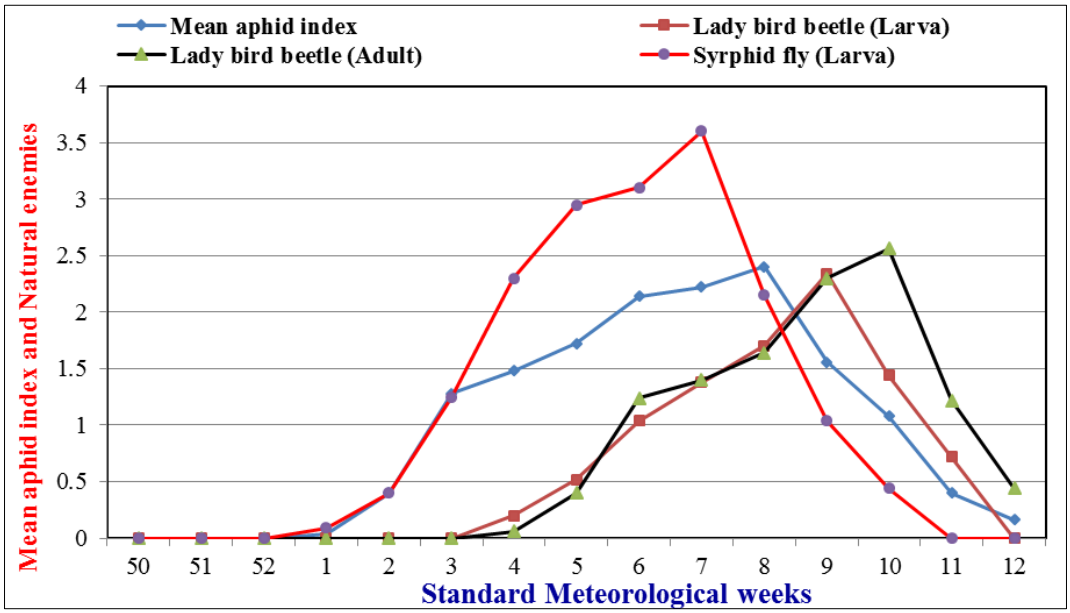

Fig. 2. Population dynamics of isabgul aphid, *Aphis gossypii* Glover and natural enemies

Syrphid fly (Larva)

The data presented in table 2 and depicted in fig. 2 revealed that the larval activity of syrphid fly was increased gradually and reached at its peak during the second week of February (6th SMW *i.e.*, 11 WAS) and it was 3.10 larva per plant. Larval population of syrphid fly was initiated (0.09 larvae/plant) during the first week of January (1st SMW *i.e.*, 6 WAS). It was increased up to 0.40 larva per plant during the second week of January (2nd SMW *i.e.*, 7 WAS) and it was attained at 1.25 larva per plant during the third week of January (3rd SMW *i.e.*, 8 WAS) and 2.30 larva per plant in fourth week of January (4th SMW *i.e.*, 9 WAS). Overall, the larval population was ranged between 0.09 and 2.30 larva per plant during the month of January. During the first week of February (5th SMW *i.e.*, 10 WAS), the larval population reached up to 2.95 larva per plant. It was increased up to 3.10 larva per plant during the second week of February (6th SMW *i.e.*, 11 WAS). Thereafter, larval population decreased to 2.20 larva per plant during the third week of February (7th SMW *i.e.*, 12 WAS). Overall, the larval population was ranged between 2.14 and 2.95 larva per plant during the month of February. Thereafter, the larval population decreased to 1.04 larva per plant during the first week of March (9th SMW *i.e.*, 14 WAS). During the second week of March (10th SMW *i.e.*, 15 WAS), the larval population of syrphid fly was 0.44 larva per plant and thereafter, the population of syrphid fly was disappeared due to lack of aphid.

It can be inferred from these results that the larval population of syrphid fly was started from the first week of January, 2018 to the second week of March, 2018. The maximum larval population of syrphid fly was observed during the second week of February (6th SMW *i.e.*, 11 WAS).

Correlation between isabgul aphid and its natural enemies with abiotic factors

To know the effect of various abiotic factors *viz.*, maximum temperature (ºC), minimum temperature (ºC), morning relative humidity, evening relative humidity, wind velocity (km/hrs), bright sunshine (hours/day) and rainfall (mm) on the fluctuation of population of isabgul aphid and its natural enemies, correlation were worked out and presented in table 3.

Table 3: Correlation of isabgul aphid and their natural enemies with different abiotic factors

Particulars	Temperature (ºC)		Relative Humidity (%)		Wind velocity (km/hrs)	Bright sun-shine (hours/day)	Rain-fall (mm)
	Max.	Min.	Mor.	Eve.			
Aphid	0.292	0.048	-0.541*	-0.564*	-0.091	0.410	-0.306
Ladybird beetle (larvae)	0.623*	0.495	-0.075	-0.675**	0.057	0.333	-0.222
Lady bird beetle (adult)	0.763**	0.631*	0.047	-0.712	0.087	0.388	-0.227
Syrphid fly (Larvae)	0.007	-0.251	0.653**	-0.383	-0.253	0.281	-0.251
* Significant at 5 per cent level ('r' = 0.514); ** Significant at 1 per cent level ('r' = 0.641)							

Isabgul aphid, *A. gossypii*

The correlation between aphid index and weather parameters are presented in table 3. The aphid population had non-significant and negative correlation with evening relative humidity (r = -564*), wind velocity (r = -0.091) and rainfall (r = -0.306). It had positive, but non-significant correlation with maximum temperature (r = 0.292), bright sunshine (r = 0.410) and minimum temperature (r = 0.048). The aphid population showed negative and significant relationship with morning relative humidity (r = -0.541*).

The results are in close accordance with the findings of Patel (2002) [5] observed that the temperature had significantly positive correlation with aphid, *A. gossypii* population while, relative humidity exhibited negative association with aphid population on isabgul. Singh *et al.* (2015) [12] observed that the maximum temperature, minimum temperature and evening relative humidity showed a positive correlation with the population of aphid during the years and negative correlation with morning relative humidity and rainfall during the year, however, morning humidity and rainfall showed positive correlation during the year.

Natural enemies

Predators

Lady bird beetle (Larva)

The correlation between lady bird beetle (larva) and weather parameters are presented in table 3 indicated that very few parameters had significant effect on lady bird beetle (larva). Maximum temperature (r = 0.623*) significant positively correlated, whereas, minimum temperature (r = 0.495), wind velocity (r = 0.057) and bright sunshine hours (r = 0.333) found positively, but non-significantly correlated with the activity of lady bird beetle (larva). Evening relative humidity (r = -0.675**) was highly and negatively as well significantly correlated with the activity of lady bird beetle (larva), while morning relative humidity (r = -0.075) and rainfall (r = -0.222) showed negative and non-significant correlation with the larval activity of lady bird beetle.

Lady bird beetle (Adult)

The correlation between lady bird beetle (Adult) and weather parameters are presented in table 3 indicated that none of the parameters had significant effect on lady bird beetle (Adult) except evening relative humidity. However, maximum temperature (r = 0.763**) highly significant positively correlated, whereas, minimum temperature (r = 0.631*) significant positive correlation. Morning relative humidity (r = 0.047), wind velocity (r = 0.087) and bright sunshine hours (r = 0.388) found positively and non- significantly correlated with the activity of lady bird beetle (Adult). Evening relative humidity (r = -0.712) and rainfall (r = -0.227) showed non-significant negative correlation with the activity of lady bird beetle (Adult).

Syrphid fly (Larva)

The data on correlation of larval population of syrphid fly with weather parameters are presented in table 3. Morning relative humidity (r = 0.653**) showed highly significant positive correlation with the larval activity of syrphid fly and maximum temperature (r = 0.007) and bright sunshine (r = 0.281) showed non-significant positive correlation with activity of syrphid fly larva, whereas, wind velocity (r = -0.253), minimum temperature (r = -0.251), evening relative humidity (r = -0.383), rainfall (r = -0.251) had negative correlation with the larval population of syrphid fly, but were found non-significant.

Correlation between isabgul aphid and its natural enemies

Isabgul aphid and larva of ladybird beetle

The correlation of population of aphid with lady bird beetle (Larva) was also worked out and presented in table 4. The larval population of lady bird beetle showed highly significant and positive correlation (r = 0.697**) with aphid population.

Table 4: Correlation between isabgul aphid, *A. gossypii* and natural enemies

S. No.	Natural enemies	Aphid index
1.	Lady bird beetle (Larva)	0.697**
2.	Lady bird beetle (Adult)	0.548*
3.	Syrphid fly (Larva)	0.900**
*Significant at 5 per cent level ('r' = 0.514); ** Significant at 1 per cent level ('r' = 0.641)		

Isabgul aphid and ladybird beetle (Adult)

The correlation of population of aphid with adult of lady bird beetle was also worked out and presented in table 4. The adult population of lady bird beetle showed significant and positive correlation (r = 0.548*) with aphid population. Thus, can be clearly indicated that as the aphid population increased, the *C. septempunctata* (Adult and Larva) population was also increased.

Isabgul aphid and syrphid fly (Larva)

The correlation of larval population of aphid with syrphid fly was also worked out and presented in table 4. The larval population of syrphid fly showed highly significant and positive correlation (r = 0.900**).

Basit *et al.* (2009) [2] recorded that the natural enemies, correlation study indicated that ladybird beetles and syrphid fly had a significant positive correlation with *A. gossypii*. Surwase (2017) [13] observed that the population of lady bird beetle presented was ranged between 0.20 and 2.40 per plant.The lady bird beetle activity started from 31st SMW (0.20/plant) with the first peak (1.00/plant), (1.20/plant) and (1.10/plant) during 33rd, 34th and 39th SMW, respectively. Surwase (2017) [13] observed that the population of syrphid maggot ranged between 0.10 and 2.10 per plant. The syrphid maggot observed during 31st SMW. The peak activity of syrphid maggots was observed from 36th to 44th SMW with a peak (2.10/plant) during 41th SMW.

References

1. Bank. A method for estimating population and counting large number of aphid, *Aphis fabae* Scop. Bulletin of Entomological Research. 1954; 45(4):751-756.

2. Basit M, Saeed S, Saleem MA, Zulfiqar R. Population dynamics of sunflower insect pests and their natural enemies. Sarhad Journal of Agriculture. 2009; 32(4):417-423.
3. Kandoria JL, Jamwal AJ, Singh G. Seasonal activity and host range of *Aphis gossypii* Glover in the Punjab. Journal of Insect Science. 1989; 2(1):68-70.
4. Kataria R, Kumar D. Population dynamics, biology of cotton aphid, *Aphis gossypii* (Glover) and its associated natural enemies in Vadodara, Gujarat. International Journal of Science and Nature. 2015; 6(3):411-420.
5. Patel HM. Bio-ecology and management of *Aphis gossypii* Glover infesting medicinal crop isabgul, *Plantago ovata* Forskel. M.Sc. (Agri.) Thesis, submitted to Gujarat Agricultural University, Sardarkrushinagar, 2002.
6. Rajput KP, Mutkule DS, Jagtap PK. Seasonal incidence of sucking pests and their correlation with weather parameters in cotton crop. *Pestology.* 2010; 34(3):44-51.
7. Reddy P. Advances in integrated pest management in horticultural crops. Ornamental, Medicinal, Aromatic and Tuber Crops. 2009; 3:124-128.
8. Roy S, Behura BK. Effect of temperature on the fecundity of five species of aphids. Crop protection. 1983; 2(3):739-755.
9. Sagar P, Jindla LN. An outbreak of the aphid, *Aphis gossypii* Glover on isabgul, (*Plantago ovata* L.) and its chemical control. International Pest Control. 1984; 26(3):76-77.
10. Sagar P, Jindla LN, Mehta SK. Field screening of isabgul (*Plantago ovata* Linn.) against aphid, *Aphis gossypii* Glover in Punjab. Journal of Entomological Research. 1987; 24(3):441-444.
11. Selvaraj S, Anandhi D, Ramesh V. Effect of abiotic factors on incidence and development of aphid, *Aphis gossypii* (Glover) in different varieties of cotton under unsprayed conditions. Journal of Cotton Research and Development. 2010; 24(2):245-249.
12. Singh AB, Sachan SK, Singh R. Population build-up of Aphid (*A. gossypii* Glover) on brinjal in relative to weather factors. Annals of Horticulture. 2015; 8(2):202-204.
13. Surwase SR. Seasonal activity of major insect pests and bio-efficacy of newer insecticides against sucking pest complex of transgenic cotton. Ph.D. Thesis, submitted to Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra State), 2017.