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Population dynamics of major insect pest of safflower and their correlation with abiotic factors

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Abstract
The investigations on seasonal incidence of Aphid, Jassids, Head borer, Safflower Caterpillar on safflower were conducted on research farm of Department of Agricultural Entomology, College of Agriculture, Latur during *rabi*, 2020. The aphid incidence was first noticed in first week of December and reached to peak of 140.2 aphids / 5 cm apical twig during first fortnight of February. The pest infestation found active from December to March. Jassid incidence started in last week of November and reached to the peak of 6.6 per plant in first week of January while *H. armigera* incidence started in second week of December and reached a peak of 3.8 larvae per plant in first week of February. It was observed that the incidence of safflower caterpillar was very low throughout the season and a maximum of only 0.3 larvae per plant were recorded from last week of December to second week of January.

Keywords: Safflower, aphid, jassids, *H. armigera*, safflower caterpillar

Introduction
Safflower (*Carthamus tinctorius* L.) belongs to family Compositae found in many parts of world namely Asia, Africa, Mediterrian region, out of these only (C. *tinctorious* L.) (2n=24) is cultivated in India. Safflower (*Carthamus tinctorius* L.) is commonly known as Karadayee and grown in *rabi* seasons of the country and well adopted to dry region. Safflower oil which is sold as saffola, is considered to be more preferred oil due to rich poly unsaturated fatty acid (73-79% lenoleic), which help in reducing the blood cholesterol level. The oil is mainly used as edible oil. It is also used in manufacture of paints, varnishes and linoleum. Safflower is under threat from a variety of insects pests which is a main cause for its low yield Singh and Singh (1999) [14]. A total of 101 insect pests have been record on safflower. In India as many as 75 insect species have been reported Parlekar (1987) [11]. In Karnataka, 20 insect pests have been recorded on safflower along with 9 species of natural enemies. Population dynamics of four insect genera including jassid (A. *bigutella bigutella*), aphid (U. *carthami*), lygus bug (*Lygus Hesperus* K.), Safflower bud fly (*Acanthiophilus helianthi* Rossi) and pod borer (*H. armigera* Hub.); and two beneficial insect genera named green lace wing (*Chrysoperla carnea*) and lady bird beetle (*Coccinella septempunctata* Linn.) were monitored by Javed and its co-worker Javed *et al.*, (2013) [7]. Ghayal and its co-worker found that Dactyonotus jaceae (Linn.), *Macrosiphum sonchi* (H.R.L.), *Macrosiphum sonchi* (Linn.), *Macrosiphum compositae* (Theobold), *Macrosiphum spp.* (jaceae), *Myzus persicae* (Sulz), *Aphis fafia* (Scop), *Capitophorus eleagni* (Del. Guer), *Aphis gossypi*, *Aphis nerii*, *Pleotrichophorus glandolosus*, *Brachycaudus helichrysi* feeding on safflower Ghayal *et al.*, (2019) [6]. In nature, insect populations fluctuate depending on environmental factors. Broadly speaking, these environmental factors can be divided into biotic factors, such as natural enemies and plants, and abiotic factors, such as temperature, relative humidity and precipitation. From ecological studies, vital information can be obtained by monitoring changes in insect population numbers that result from changes in environmental factors. Considering this, the present study will be helpful to know the occurrence of major insect - pests of safflower with respect to weather parameter.

Material and Methods
The experiment was conducted at Department of Agricultural Entomology, College of Agriculture, Latur during *Rabi*, 2020 with Safflower variety PBNS-86. Field plot was prepared by applying well decomposed farm yard manure. Plot size 10 x 10 m with spacing 45 x 20 cm2 row to plant with recommended package of practices except the plant protection measures against insect pests.

After one week of germination, observations for the insect pests and their natural enemies were recorded on weekly basis till harvesting of the crop. Ten plants from the experimental plot were randomly selected and tagged. Sucking insect pests such as aphids was recorded from on 5 cm apical twig of the main branch (stem) of the plant. Chewing insect pests such as American bollworm and safflower caterpillar etc. were recorded on whole plant basis. Mean of sucking pests such as aphids was worked out as population per 5 cm apical twig while that of chewing insect pests was worked out as population per plant.

Results and Discussion

Population dynamics of major insect - pests of safflower

Aphids, *U. compositae*

The aphid, *U. compositae* were first observed during 48th SMW (26 Nov – 02 Dec.) by recording 10.3 aphids / 5 cm apical twig when the corresponding rainfall, maximum temperature, minimum temperature, morning, evening relative humidity and wind speed recorded were 0.00 mm, 29.4 °C, 17.5 °C, 79.04%, 64.05% and 22.3 km / h, respectively. Thereafter for two weeks, the aphid population increased slowly and recorded 22.7 per 5 cm apical twig in 50th SMW (10-16 December). Thereafter, the population increased fast and reached to a peak of 140.2 aphids / 5 cm apical twig in 5th SMW (29 Jan-04 Feb). When the corresponding rainfall, maximum temperature, minimum temperature, morning, evening relative humidity and wind speed recorded were 1.25 mm, 31.6 °C, 15.4 °C, 77.0%, 37.7% and 23.1 km / h, respectively. Then the aphid population showed slight reduction in the number but present throughout the season and at harvest 115.6 aphids / plant were recorded. Studies on the aphid incidence was first noticed in first week of December and reached to peak of 140.2 aphids per five-centimeter apical twig were observed during first fortnight of February. These results are in conformity with those of Upadhyay *et al*., (1980) [15] who reported that the aphid was first observed on leaf whorls during the 1st week of December, after which its numbers increased, reaching a peak between mid-January and mid-February. Its population then declined and the pest had disappeared by the end of March. Akashe *et al.,* (2010) [1]. found that the safflower aphid was active during 47th to 1st SMW on elongation and branching stages of safflower crop Akashe *et al.,* (2010) [1] while Kumbhar *et al*., (2018) [9] noted maximum incidence of *U. compositae* to the tune of 142 aphids / 5 cm twig during 3rd SMW in January Kumbhar *et al*., (2018) [9]. The pest was found active from January to February. More or less similar trend was observed in the present study and the peak aphid incidence was recorded in 5th SMW thereafter the population decreased naturally. The present results on aphid incidence are also similar to the findings of Darandale *et al.* who revealed that the incidence of sucking pests viz., aphid, *U. compositae* (Theobald) started from second week of December which reached peak (63.20 aphids / leaf) during first week of February Darandale *et al*., (2015) [4].

Table 1: Population infesting dynamics of aphid, *U. compositae* safflower

Sr. No.	Met. Week	Period	Rainfall (mm)	Temperature (^{0}C)		Humidity% (per cent)		Wind speed (km/h)	No of Aphid/5 cm apical twig
				Max.	Min.	AM	PM		
1	48	26-02Dec	0.0	29.4	17.5	79.4	64.5	22.3	10.3
2	49	03-09Dec	0.0	31.3	13.1	67.4	39.5	21.6	19.9
3	50	10-16Dec	0.0	31.2	15.6	67.7	45.2	21.4	22.7
4	51	17-23Dec	0.0	29.5	12.2	74.4	42.4	20.0	46.5
5	52	24-31Dec	0.0	30.5	12.8	75.4	43.6	18.4	58.9
6	1	01-07Jan	0.0	30.4	16.1	91.2	53.4	18.7	85.0
7	2	08-14Jan	1.0	31.9	16.9	82.6	51.5	19.9	111.4
8	3	15-21Jan	0.0	31.9	16.1	81.5	48.1	19.7	114.4
9	4	22-28Jan	0.0	32.8	16.1	75.9	43.5	20.0	119.5
10	5	29-04Feb	1.25	31.6	15.4	77.0	37.7	23.1	140.2
11	6	05-11Feb	0.5	30.9	12.0	60.3	32.5	21.7	136.6
12	7	12-18Feb	0.0	32.9	15.5	65.9	36.3	24.0	124.3
13	8	19-25Feb	6.25	30.8	14.6	72.9	39.6	23.7	124.2
14	9	26-04Mar	0.0	36.0	18.5	48.9	24.8	26.1	117.8
15	10	05-11Mar	0.0	37.0	23.4	42.5	25.8	26.1	115.6
Correlation			0.314	0.477	0.206	- 0.194	-0.515*	0.313	
R^2 (Regression Coefficient)			0.66						

*Significant at 5%; Max- Maximum temperature; Min.- Minimum temperature

Regression equation

Y= - 480.618+ (5.711) x B1 + (11.859) x B2 + (0.814) x B3 + (4.225) x B4 + (- 4.383) x B5 + (2.774) x B6 + 34.809

Where,

B1- Rainfall (mm), B2- Max. temperature (°C), B3- Min. temperature (°C), B4-Morning RH (%), B5- Evening RH (%), B6-Wind speed

Jassid, *A. biguttula biguttula*

The jassids, *A. biguttula biguttula* were first observed during 48*th* SMW (26 Nov - 02 Dec.) by recording 0.8 Jassid / plant, when the corresponding rainfall, maximum temperature, minimum temperature, morning and evening relative humidity and wind speed were 0.00 mm, 29.4 °C, 17.5 °C, 79.04%, 64.05% and 22.3 km / h, respectively. Thereafter, the Jassid population increased slowly and reached to the peak of 6.6 jassid / plant in 1st SMW when the corresponding rainfall, maximum temperature, minimum temperature, morning, evening relative humidity and wind speed were 0.00 mm, 30.4 °C, 16.1 °C, 91.2%, 53.4% and 18.7 km / h, respectively. From second week of February the jassids population disappears naturally till the harvest of the crop. In the present study jassids were found active from December to mid-February with maximum 6.6 jassid per plant were observed during first week of January. The literature on jassids incidence in safflower is scanty. However, similar trend with jassids incidence on niger was observed by Darandale *et al*.,

(2015) [4]. They mentioned that the incidence of jassid, *A. biguttula biguttula* (Ishida) started from second week of December with a peak (8.52 jassids / leaf) during fourth week of January and thereafter, steadily declined and finally disappeared. Bhatt and Karnatak (2018) [2] reported that the population of leaf hopper showed a gradual increase and attained its peak population (11.13 leaf hopper / 3 leaves) in okra at 70 DAS in the 40th SMW (1st week of October).

Table 2: Population dynamics of jassid, *A. biguttula biguttula* infesting safflower

Sr. No.	Met. Week	Period	Rainfall (mm)	Temperature (0C)		Humidity% (per cent)		Wind speed (km/h)	No of Jassid / Plant
				Max.	Min.	AM	PM		
1	48	26-02Dec	0.0	29.4	17.5	79.4	64.5	22.3	0.8
2	49	03-09Dec	0.0	31.3	13.1	67.4	39.5	21.6	1.4
3	50	10-16Dec	0.0	31.2	15.6	67.7	45.2	21.4	2.0
4	51	17-23Dec	0.0	29.5	12.2	74.4	42.4	20.0	2.8
5	52	24-31Dec	0.0	30.5	12.8	75.4	43.6	18.4	4.7
6	1	01-07Jan	0.0	30.4	16.1	91.2	53.4	18.7	6.6
7	2	08-14Jan	1.0	31.9	16.9	82.6	51.5	19.9	1.3
8	3	15-21Jan	0.0	31.9	16.1	81.5	48.1	19.7	1.3
9	4	22-28Jan	0.0	32.8	16.1	75.9	43.5	20.0	0.1
10	5	29-04Feb	1.25	31.6	15.4	77.0	37.7	23.1	1.3
11	6	05-11Feb	0.5	30.9	12.0	60.3	32.5	21.7	4.3
12	7	12-18Feb	0.0	32.9	15.5	65.9	36.3	24.0	1.1
13	8	19-25Feb	6.25	30.8	14.6	72.9	39.6	23.7	0.0
14	9	26-04Mar	0.0	36.0	18.5	48.9	24.8	26.1	0.0
15	10	05-11Mar	0.0	37.0	23.4	42.5	25.8	26.1	0.0
Correlation			- 0.261	- 0.515*	- 0.486	0.422	0.267	- 0.648*	
R^2 (Regression Coefficient)			0.96						

*Significant at 5%; Max- Maximum temperature; Min.- Minimum temperature

Regression equation
Y= 36.051 + (- 0.385) x B1 + (- 0.722) x B2 + (0.181) x B3 + (0.053) x B4 + (- 0.166) x B5 + (- 0.419) x B6 + 1.593

Where,
B1- Rainfall (mm), B2- Max. temperature (°C), B3- Min. temperature (°C), B4-Morning RH (%), B5- Evening RH (%), B6-Wind speed

Head borer, *H. armigera*

The *H. armigera* were first observed during 50th SMW (10 - 16 Dec.) by recording 1.0 *H. armigera* / plant. when the corresponding rainfall, maximum temperature, minimum temperature, morning, evening relative humidity and wind speed recorded were 0.00 mm, 31.2 °C, 15.6 °C, 67.7%, 42.2% and 21.4 km / h, respectively. Thereafter, the *H. armigera* population slowly increased and recorded its first peak of 2.4 larvae/ plant in 51st SMW when the corresponding rainfall, maximum temperature, minimum temperature, morning, evening relative humidity and wind speed recorded were 0.00 mm, 29.5 °C, 12.2 °C, 74.4%, 42.4% and 20.0 km / h, respectively. Thereafter their population decreased slowly up to 3rd SMW (1.8 larvae / plant). In next two weeks ups and down in the population were recorded and in 6th SMW it recorded season's highest population of 3.8 larvae / plant when the corresponding rainfall, maximum temperature, minimum temperature, morning, evening relative humidity and wind speed recorded were 0.50 mm, 30.9 °C, 12.0 °C, 60.3%, 32.5% and 21.7 km / h, respectively. In next two weeks the population decreases and recorded 2.4 larvae / plant in 8th SMW. From 9th SMW, the population disappears naturally from the safflower and no larvae were found at the time of harvesting of the crop. In present study *H. armigera* incidence on safflower started in second fortnight of December and reached to a peak of 3.8 larvae per plant during second week of February. Javed *et al.*, (2013) [7] reported that the population of *H. armigera* on five different varieties of safflower differed significantly on different dates of observations. Maximum population of *H. armigera* was observed on SAF-38 (0.6 larvae) as against (0.3 larvae) on SAF-3. The *H. armigera* population observed in present study was much more than that observed by Javed *et al.*, (2013) [7]. However, the population of *H. armigera* in chickpea, which is also a *rabi* crop, was earlier studied by Chatar *et al*., (2010) [3] who reported that the pest appeared from 2nd week of December and attained a peak of 3.12 larvae per plant during 2nd week of January Chatar *et al*., (2010) [3]. The pest was active during the last week of December to 3rd week of January. Also, Gautam *et al*., (2018) [5] noticed *H. armigera* population in chickpea for the first time during 46th SMW of 2016 and respective mean population were 0.33 larvae / plant. Further, Kumar *et al*., (2018) [8] reported that the larval population in chickpea was initially recorded in 7th standard week (third week of February) (2.33 larva / plant) with a peak in 13th standard week (2nd week of April) (5.33 larva / plant).

Table 3: Population dynamics of *H. armigera* infesting safflower

Sr. No.	Met. Week	Period	Rainfall (mm)	Temperature (0C)		Humidity% (per cent)		Wind speed (km/h)	No of *H. armigera* / plant
				Max.	Min.	AM	PM		
1	48	26-02Dec	0.0	29.4	17.5	79.4	64.5	22.3	0.0
2	49	03-09Dec	0.0	31.3	13.1	67.4	39.5	21.6	0.0
3	50	10-16Dec	0.0	31.2	15.6	67.7	45.2	21.4	1.0
4	51	17-23Dec	0.0	29.5	12.2	74.4	42.4	20.0	2.4
5	52	24-31Dec	0.0	30.5	12.8	75.4	43.6	18.4	2.1
6	1	01-07Jan	0.0	30.4	16.1	91.2	53.4	18.7	1.6
7	2	08-14Jan	1.0	31.9	16.9	82.6	51.5	19.9	1.6
8	3	15-21Jan	0.0	31.9	16.1	81.5	48.1	19.7	1.8
9	4	22-28Jan	0.0	32.8	16.1	75.9	43.5	20.0	2.6
10	5	29-04Feb	1.25	31.6	15.4	77.0	37.7	23.1	1.8
11	6	05-11Feb	0.5	30.9	12.0	60.3	32.5	21.7	3.8
12	7	12-18Feb	0.0	32.9	15.5	65.9	36.3	24.0	3.4
13	8	19-25Feb	6.25	30.8	14.6	72.9	39.6	23.7	2.4
14	9	26-04Mar	0.0	36.0	18.5	48.9	24.8	26.1	0.0
15	10	05-11Mar	0.0	37.0	23.4	42.5	25.8	26.1	0.0
Correlation			0.217	- 0.336	- 0.580*	0.260	-0.059	- 0.329	
R^2 (Regression Coefficient)			0.46						

*Significant at 5%; Max- Maximum temperature; Min.- Minimum temperature

Regression equation
Y= 6.027 + (0.088) x B1 + (- 0.010) x B2 + (-0.155) x B3 + (0.049) x B4 + (- 0.079) x B5 + (- 0.084) x B6 + 1.191

Where,
B1- Rainfall (mm), B2- Max. temperature (°C), B3- Min. temperature (°C), B4-Morning RH (%), B5- Evening RH (%), B6-Wind speed

Safflower caterpillar, *P. capensis*

Population of P. capensis was observed very low throughout the season. The larvae of *P. capensis* were first observed during 49th SMW (03-09 Dec.) by recording 0.1 larvae / plant when the corresponding rainfall, maximum temperature, minimum temperature, morning, evening relative humidity and wind speed recorded were 0.00 mm, 31.3 °C, 13.1°C, 67.4%, 39.5% and 21.6 km / h, respectively. Thereafter, though stable, the larval population was observed throughout the season up to mid-February when 0.1 larvae / plant were noted. Comparatively more larval population was observed from end – December to End-January. A maximum of 0.3 larvae / plant were recorded in 52nd, 1st and 2nd SMWs.

Table 4: Population dynamics of safflower caterpillar, *P. capensis* infesting safflower

Sr. No.	Met. Week	Period	Rainfa ll (mm)	Temperature (0C)		Humidity% (per cent)		Wind speed (km/h)	No of *P. capensis*/ Plant
				Max.	Min.	AM	PM		
1	48	26-02Dec	0.0	29.4	17.5	79.4	64.5	22.3	0.0
2	49	03-09Dec	0.0	31.3	13.1	67.4	39.5	21.6	0.1
3	50	10-16Dec	0.0	31.2	15.6	67.7	45.2	21.4	0.1
4	51	17-23Dec	0.0	29.5	12.2	74.4	42.4	20.0	0.1
5	52	24-31Dec	0.0	30.5	12.8	75.4	43.6	18.4	0.3
6	1	01-07Jan	0.0	30.4	16.1	91.2	53.4	18.7	0.3
7	2	08-14Jan	1.0	31.9	16.9	82.6	51.5	19.9	0.3
8	3	15-21Jan	0.0	31.9	16.1	81.5	48.1	19.7	0.1
9	4	22-28Jan	0.0	32.8	16.1	75.9	43.5	20.0	0.1
10	5	29-04Feb	1.25	31.6	15.4	77.0	37.7	23.1	0.1
11	6	05-11Feb	0.5	30.9	12.0	60.3	32.5	21.7	0.1
12	7	12-18Feb	0.0	32.9	15.5	65.9	36.3	24.0	0.1
13	8	19-25Feb	6.25	30.8	14.6	72.9	39.6	23.7	0.0
14	9	26-04Mar	0.0	36.0	18.5	48.9	24.8	26.1	0.0
15	10	05-11Mar	0.0	37.0	23.4	42.5	25.8	26.1	0.0
Correlation			- 0.228	- 0.358	- 0.326	0.596*	-0.382	- 0.676*	
R^2(Regression Coefficient)			0.68						

*Significant at 5%; Max- Maximum temperature; Min.- Minimum temperature

Regression equation
Y= 0.549 + (- 0.005) x B1 + (0.006) x B2 + (0.007) x B3 + (0.004) x B4 + (- 0.005) x B5 + (- 0.037) x B6 + 0.079

Where,
B1- Rainfall (mm), B2- Max. temperature (°C), B3- Min. temperature (°C), B4-Morning RH (%), B5- Evening RH (%), B6-Wind speed

Correlation and regression of insect - pests of Safflower with abiotic factors

***U. Compositae*, Theobold**

In the present study aphid population showed positive but non-significant correlation with rainfall, maximum, minimum temperature and wind speed while it was negative and non-significant with morning relative humidity and only evening relative humidity showed significant but negative correlation. Similar to these findings, Rawat *et al*., (2020) [12] studied correlation of okra aphid population with weather parameters and found non-significant positive correlation with maximum and minimum temperature (r = 0.527 and r = 0.096, respectively), wind velocity (r = 0.291). Further, he reported that evening relative-humidity (r = - 0.397) showed non-significant negative correlation, however in the present study the correlation with evening relative humidity was observed significant and negative. Further, Lal *et al*., (2020) [10] also observed significantly positive correlation between aphid population and maximum temperature in okra, confirming the findings of present study.

A. biguttula biguttula

In the present study, all the abiotic factors except morning and evening relative humidity showed negative correlation with jassids population. Among these, maximum temperature and wind speed showed negative but significant correlation with jassids population. Earlier, Darandale *et al.*, (2015) [4] reported that the correlation co-efficient existed between jassid population on niger and weather parameters revealed that maximum temperature (r= - 0.733), minimum temperature (r= - 0.646) had highly significant negative influence on jassid population. While, evening relative humidity (r= 0.518) exhibited significant positive correlation with jassid population, partially supporting the findings of present study. Also, Rawat *et al*., (2020) [12] correlated hopper population on okra with weathers parameters and found significant negative correlation with rainfall (r = - 0.602) and also non-significant negative correlation with minimum temperature (r = - 0.291) and significant negative correlation with evening relative humidity (r = - 0.682*), respectively, supporting the findings of present study.

H. armigera

H. armigera population in present study showed positive non-significant correlation with rainfall and morning relative humidity while only minimum temperature showed significant negative correlation. Earlier, reported positive but non-significant correlation (r = 0.03) of rainfall against larval population of *H. armigera* in chickpea. While Chatar *et al*., (2010) [3] reported significant negative correlation with minimum temperature (r = - 0.5771*) and highly significant positive correlation with morning relative humidity (r = 0.7098**) with larvae *of H. armigera* in chickpea, In case of tomato, Vikram *et al*., (2018) [16] reported that evening relative humidity (r= -0.388) had non-significant negative correlation while, rainfall had non-significant positive correlation (r=0.091) with larval population of *H. armigera* as observed in the present study. Also, Sharma *et al.*, (2020) [13] reported that the larval population of *H. armigera* on chickpea showed non-significant negative correlation with minimum temperature (r= - 0.050), confirming the results of present study.

Conclusion

Thus, from the population dynamics study it was clear that aphid, *U. compositae* is the major pest of safflower. Other pests include jassids, *A. bigutulla bigutulla*, head bore *H. armigera* and Safflower caterpillar, *P. capensis* but their population on safflower was found comparatively less. In the present study aphid (*U. compositae*) population showed positive but non-significant correlation with rainfall, maximum and minimum temperature and wind speed while it was negative and non-significant with morning relative humidity and only evening relative humidity showed significant but negative correlation. Also, all the abiotic factors except morning and evening relative humidity showed negative correlation with jassids (*A. biguttula biguttula)* population. Among these, maximum temperature and wind speed showed negative but significant correlation with jassids *(A. biguttula biguttula*) population. Head borer (*H. armigera*) population showed positive non-significant correlation with rainfall and morning relative humidity while only minimum temperature showed significant negative correlation.

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