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Studies on Succession and Population Dynamics of Sap Feeders as Influenced by Weather on Sesame

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A B S T R A C T

Population dynamics of sucking pests of sesame *viz.* thrips, whitefly, leaf hoppers and aphids were studied. Correlation between the pest population and weather parameters was analyzed and regression equations were developed. Incidence of aphids, leaf hoppers and thrips on sesame crop during *kharif* season has started on 25th SMW. Thrips (7.3/ plant) attained peak in the 30st SMW, whereas, whitefly population reached peak during 27th SMW with population of 1.7/ plant, whereas, leaf hopper (2.8/plant) and aphid population (12.1/plant) reached the peak in the 31st SMW. Thrips population exhibited significant positive correlation with mean temperature (r=0.501) and non-significant negative correlation with mean relative humidity(r=-0.312) and rainfall (r=-0.498). Whitefly population showed non-significant positive correlation with mean atmosphere temperature(r = 0.285) and mean relative humidity(r = 0.028) and non-significant negative correlative with rainfall (r = -0.452). Leaf hopper exhibited significant positive correlation with mean temperature (r = 0.667) while, non-significant negative correlation with mean relative humidity(r = -0.325) and rainfall(r = -0.296). Aphid population showed significant positive correlation with mean atmosphere temperature(r = 0.667) and non-significant negative correlative with mean relative humidity(r = -0.236) and rainfall (r = -0.444). Incidence of thrips, whitefly, leaf hoppers and aphids on sesame crop during *rabi-summer* season has started on3rd SMW. Thrips (3.22/plant), white flies (2.48/plant) leaf hoppers (10.1 /plant) and aphids (12.8/plant) reached the peak in the 10th SMW. The correlation between weather parameters and sucking pest population followed the pattern similar to *kharif* season. Regression analysis data of revealed that the multiple non-linear regression equations are sufficient to predict the pest population with prevailing weather parameters.

Keywords

Sesame, weather parameters, pest incidence, correlation, regression analysis

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Introduction

Sesame (*Sesamum indicum* L.) is an annual crop belonging to the family *Pedaliaceae* and is one of the world's oldest oil seed grown for its oil-rich seeds which have diverse uses. Due to the high oil content (38-54 percent), protein (18-25 percent), calcium, phosphorous and oxalic acid (Prasad *et al.,* 2002). India is the world's leading producer of sesame with largest cultivation area. The annual sesame cultivation area in India is about 1.79 mha (45% of the world cultivation area) and the total production is 8.02 lakh tones with the productivity of 448 kg/ha.

Within India sesame is cultivated in the states of Uttar Pradesh, Rajasthan, Madhya Pradesh, Andhra Pradesh, Maharashtra, Gujarat, Tamil Nadu and Orissa and Karnataka. Andhra Pradesh along with West Bengal, Madhya Pradesh, Rajasthan, Uttar Pradesh, Gujarat, and Telangana contributes to more than 85 percent production.

The acerage of sesame in Andhra Pradesh is 0.61 lakh hectares with production of 0.2 lakh tonnes and productivity of 321 kg/ha (Anonymous). The major reasons for low productivity of sesame are its rainfed cultivation in marginal and sub marginal lands and poor management of pests and diseases. Apart from input starved conditions, insect pests are one of the major factor for lower yields, especially sucking pests that harm the crop directly by sap sucking and indirectly by virus and mycoplasma transmission (Ahirwar *et al.*, 2010). Leaf hoppers and white flies act as vectors for incidence of phyllody and leaf curl disease in sesame (Ahirwar *et al.*, 2010).

In designing appropriate management schedules, the awareness of the seasonal occurrence of insect pests at various stages of development would be beneficial to understand the population dynamics of sucking pests. This would in turn provide an insight into the peak cycles which would be helpful in formulating appropriate timely management strategies Hence the present study was contemplated to observe the succession and population dynamics of sap feeders of sesame in relation to various weather parameters under unprotected field conditions.

Materials and Methods

The experiment was conducted at Agricultural Research Station, Yellamanchili, Visakhapatnam, Andhra Pradesh during *rabi-summer 2018* and *kharif 2018* to investigate the succession and population dynamics of sap feeders on sesame under unprotected field conditions.

Cultivation of sesame

Untreated sesame seed of variety YLM-66 was sown in the a bulk plot of size 0.2 ha, adopting 30 cm row to row and 15 cm plant spacing, during *rabi-summer* and *kharif* seasons. All recommended agronomical practices were adopted. The seed rate of 6 kg/ha was used and fertilizers applied were FYM @ 10 t/ha and NPK as 40:20:20 with N in two equal splits as basal and at 30 days after sowing (DAS). The *kharif* crop has been raised as rainfed while three life-saving irrigations have been provided during the *rabi-summer*. Manual weeding was done twice during each of the season. No plant protection measures were taken up during the entire crop growth period during both the seasons.

Data on population of sucking pests

Data was recorded in the early hours between 7:00 am and 9:00 am on randomly selected plants in the plot using standard sampling methods. Population data for thrips, leaf hoppers, aphids in the sesame crop were recorded at three plant canopy levels (lower, middle and top). Ten plants were selected randomly per spot from five random spots in the plot of 0.2 ha and data on sucking pest population was collected and calculated the mean population. The recorded populations of sap feeders were presented standard week-wise from initial appearance till crop maturity.

Weather data

Weather data pertaining to maximum and minimum temperature ($^{\circ}$C); maximum and minimum relative humidity (%) and rainfall (mm) were collected for the standard weeks from the observatory located at Agricultural Research Station, Yellamanchili.

Statistical analysis

Using Microsoft Excel software, data on insect species and weather parameters were statistically analysed for correlation. The data collected on sucking pests were correlated with the weather parameters following the standard weather week (SMW) [Steel and Torry, 1980].

$$r_{xy} = \frac{\sum XY - \sum X \sum Y}{\sqrt{\left[\sum X^2 - \frac{\sum X^2}{n}\right] - \left[\sum Y^2 - \frac{\sum Y^2}{n}\right]}}$$

Where,

$r_{xy} = Simple\ corelation\ coefficient$

X = Variable (abiotic component.)

Y = Variable(No. of Insects per plant)

n = Number of observations

The correlation coefficient (r) values were subjected to the test of significance using t-test

$$t = \frac{r}{\sqrt{1-r^2}} X\sqrt{n-2} \sim t_{n-2} d.f$$

The calculated t-value obtained was compared with tabulated t-value at 5% level of significance

Regression analysis

The data on insect populations and weather parameters was subjected to nonlinear regression analysis was carried out using microsoft excel software and developed the regression equations (Steel and Torry, 1980).

Results and Discussion

The mean population of aphids, whitefly, leaf hoppers & thrips and the standard week wise along with weather parameters are presented in Table 1(*kharif*) and Table 2 (*rabi-summer*). The findings of the current investigation and the related discussion are outlined hereunder.

Population dynamics of thrips

The thrips incidence reported during 25th standard meteorological week (SMW) in the *kharif* season with an average population of 1.10 /plant. The population increased and peaked during 30st SMW with mean population of 7.3 thrips/plant. The population then decreased by the 34th SMW with average population of 2.2 thrips/ plant at the time of maturity as reported in Fig.1. The thrips population exhibited significant positive correlation with minimum temperature (r=0.662), mean temperature (r=0.501), relative humidity (r=0.809) while, non-significant positive correlation with maximum temperature(r=0.416) and negative correlation minimum relative humidity(r=-0.468), mean relative humidity(r=-0.312) and rainfall(r=-0.497) as shown in Table 3.

During *rabi-summer* season, the thrips population observed on 3rd SMW with an average population of 0.3 thrips/plant and increased till 11th SMW and peaked with 3.22 thrips/plant, thereafter population decreased and finally reported 1.72 thrips on 12th SMW at crop maturity as shown in Fig.5. The maximum temperature(r=0.11) had positive insignificant correlation with thrips population, whereas significant negative correlation with minimum temperature (-0.576), mean relative humidity (r=-0.642) and non-significant negative correlative with mean temperature (r=-0.311), maximum relative humidity(r = -0.206). It was indicated that the mean temperature and relative humidity favored the pest population. These results are in accordance with the Ahirwar, *et al.*, 2009.

Population dynamics of whitefly

The whitefly incidence reported during 27th standard meteorological week (SMW) in the *kharif* season with an average population of 1.5 /plant.

The population peaked during 28th SMW with an average population of 1.7 /plant, then decreased till the 34th SMW with average population of 1.0/plant as reported in Fig.2. Correlation studies carried out between meteorological parameters and whitefly population showed a positive correlation maximum temperature (r=0.181), minimum temperature (r=0.0.53), mean temperature (r=0.284), minimum relative humidity (r=0.029) and mean relative humidity (r=0.028), while with non-significant negative correlation was observed with maximum relative humidity (r=-0.018) and rainfall (r=-0.452).

During *rabi-summer* season, the whitefly population observed on 3rd SMW with an average population of 0.3 /plant and increased till 12th SMW and peaked with 2.28 whitefly/plant as shown in Fig.5. The maximum temperature(r=0.11) had positive insignificant correlation with whitefly population, whereas significant negative correlation with minimum temperature (-0.733), and non-significant negative correlative with mean temperature (r=-0.366), maximum relative humidity(r = -0.437), minimum relative humidity (-0.074) and mean relative humidity (-0.174)). It was indicated that the Maximum temperature and rainfall were significantly positively correlated with the population of pest whereas the minimum temperature and relative humidity were showed significant negative correlation. Similar results reported by Bondre *et al.,* 2016; Ba Angood *et al.,* 2000 and Ahirwar *et al.,* 2009.

Population dynamics of leaf hoppers

Incidence of leaf hoppers during *kharif* season reported during 25th standard meteorological week (SMW) with an average population of 0.9 /plant. The population steadily increased and peaked during 31st SMW with an average population was 2.8/ plant, the mean temperature and relative humidity of 30.8 °C and 70%, respectively observed during the week. Later, the population then decreased till the 34th SMW with average population of 2.1 leaf hopper/plant as shown in Fig.3. The leaf hopper population exhibited significant positive correlation with mean temperature (r =0.667) while, non-significant negative correlation with mean relative humidity(r = -0.325) and rainfall (r =-0.296). Leaf hopper population shown positive correlation with maximum relative humidity (r = 0.866) and negative with minimum relative humidity(r = -0.493).

Similar trend was also observed during *rabi-summer* season; the leaf hopper population observed on 3rd SMW with an average population of 2.0/ plant and steadily increased till 11th SMW and peaked with 10.4 / plant and at crop maturity the population recorded was 9.6/plant on 12th SME as shown in Fig.6.

The mean temperature(r=0.016), maximum temperature(r=0.435) and mean relative humidity (r = 0.267) had positive insignificant correlation with leaf hopper population and shown non-significant negative correlative with maximum relative humidity(r=-0.397) and minimum temperature (r=-0.331). Shukla *et al.,* 2014; Mishra *et al.,* 2015 have also reported similar trends in population dynamics of leaf hoppers in sesame.

Population dynamics of aphids

Incidence of aphids during *kharif* season was 5.0/plant on 28th standard meteorological week (SMW). The population later increased and peaked during 31st SMW with an average population of 10.8/plant. The population then decreased till the 33rd SMW with average population of 3.5 aphids/plant and finally reported 6.6 aphids/plant on 34th SMW depicted in Fig.4.

Table.1 Succession and population dynamics of sap feeders as influenced by weather on Sesame (*kharif*)

Std. Week	Pests Observed (population per plant)				Weather parameters						
	Thrips	White flies	Leaf hoppers	Aphids	Max. Temp. (0 C)	Min. Temp. (0 C)	Mean Temp. (0 C)	RH Max (%)	RH Min (%)	Mean RH (%)	Rainfall (mm)
25	1.1	0.0	0.9	0.0	31.1	24.2	27.7	86	66	76	17.4
26	1.0	0.0	0.5	0.0	32.7	24.8	28.8	87	64	76	54.3
27	0.6	1.5	0.7	0.0	33.2	25.3	29.3	85	64	75	29.9
28	1.9	1.7	1.0	5.0	31.2	25.1	28.2	87	73	80	5.0
29	5.2	0.7	1.6	3.8	31.9	25.3	28.6	88	68	78	20.4
30	7.3	0.6	2.2	3.7	33.8	25.6	29.7	90	60	75	11.7
31	4.6	1.0	2.8	10.8	35.6	26.0	30.8	91	49	70	10.4
32	2.3	0.8	1.6	7.5	33.8	25.1	29.5	88	68	78	16.7
33	1.1	0.0	3.2	3.5	31.6	24.5	28.1	87	75	81	62.9

Table.2 Succession and population dynamics of sap feeders as influenced by weather on Sesame (*rabi-summer*)

Std. Week	Pests Observed (population per plant)				Weather parameters					
	Thrips	White flies	Leaf hopper	Aphids	Max. Temp. (^{0}C)	Min. Temp. (^{0}C)	Mean Temp. (^{0}C)	RH Max (%)	RH Min (%)	Mean RH (%)
3	0.3	0.5	2.0	3.3	33.7	17.8	25.8	93	43	68
4	0.22	0.4	3.1	2.1	33.2	17.2	25.2	90	44	67
5	2.5	0.9	4.2	4.8	34.3	17.7	26.0	92	32	62
6	1.82	0.7	1.26	5.48	31.7	16.2	24.0	90	39	65
7	1.7	0.88	1.14	3.3	31	15.4	23.2	88	36	62
8	2.04	1.2	1.4	9.26	31.6	14.3	23.0	90	27	59
9	2.98	1.86	2.1	11.54	33	15.7	24.4	91	28	60
10	3.12	2.22	3.92	12.8	33.5	14.8	24.2	90	38	64
11	3.22	2.48	10.1	9.42	33.6	14.7	24.2	89	34	62
12	1.72	2.28	9.6	8.62	32.8	14.8	23.8	88	50	69

Table.3 Correlation coefficient of sap feeders of sesame with respect to weather parameters

Parameter	Thrips	Whitefly	Leaf hoppers	Aphids
Kharif				
Temperature(Max)	0.416	0.181	0.646	0.639
Temperature(Min)	0.662	0.530	0.624	0.642
Temperature(Mean)	0.501	0.285	0.667	0.667
Relative Humidity(Max)	0.809	-0.018	0.866	0.768
Relative Humidity(Min)	-0.468	0.029	-0.493	-0.392
Relative Humidity(Mean)	-0.312	0.028	-0.325	-0.236
Rain fall	-0.498	-0.452	-0.296	-0.444
Rabi-summer				
Temperature(Max)	0.114	0.202	0.436	0.448
Temperature(Min)	-0.577	-0.733	-0.331	0.459
Temperature(Mean)	-0.311	-0.366	0.017	0.451
Relative Humidity(Max)	-0.206	-0.438	-0.398	-0.173
Relative Humidity(Min)	-0.583	-0.074	0.349	-0.362
Relative Humidity(Mean)	-0.643	-0.174	0.267	-0.410

Table.4 Regression analysis of sap feeders of sesame with respect to weather parameters

Pest	Regression equation	Regression coefficient
Kharif		
Thrips	X_k=-103.7-0.98(T_{max}) +2.13(T_{min}) +1.0(RH_{max})-0.004(RH_{min})+ 0.007(Rain)	R^2=0.79
White fly	X_k=-17.16+0.06(T_{max}) +1.12(T_{min}) -0.2(RH_{max})+0.005(RH_{min})-0.009(Rain)	R^2=0.81
Leaf hopper	Y_k=-35.7+0.19(T_{max})-0.11(T_{min})+0.36(RH_{max})-0.03(RH_{min}) - 0.001(Rain)	R^2=0.79
Aphids	Z_k=-173.2+1.94(T_{max}) -0.79(T_{min}) +1.28(RH_{max})+0.34(RH_{min})+0.06(Rain)	R^2=0.78
Rabi-summer		
Thrips	Xr=12.4.+0.59(T_{max})-0.38(T_{min}) -0.22(RH_{max})-0.09($RH_{min.}$)	R^2 = 0.77
Whitefly	Xr=0.042+0.53(T_{max})-0.57(T_{min}) -0.08(RH_{max})-0.0009($RH_{min.}$)	R^2 = 0.9
Leaf hopper	Yr=45.5+2.91(T_{max}) -0.74(T_{min})-1.41 (RH_{max})+0.07(RH_{min})	R^2 = 0.82
Aphids	Zr=-86.9+1.38(T_{max})-3.58 (T_{min})+1.18 (RH_{max})-0.017(RH_{min})	R^2 = 0.86

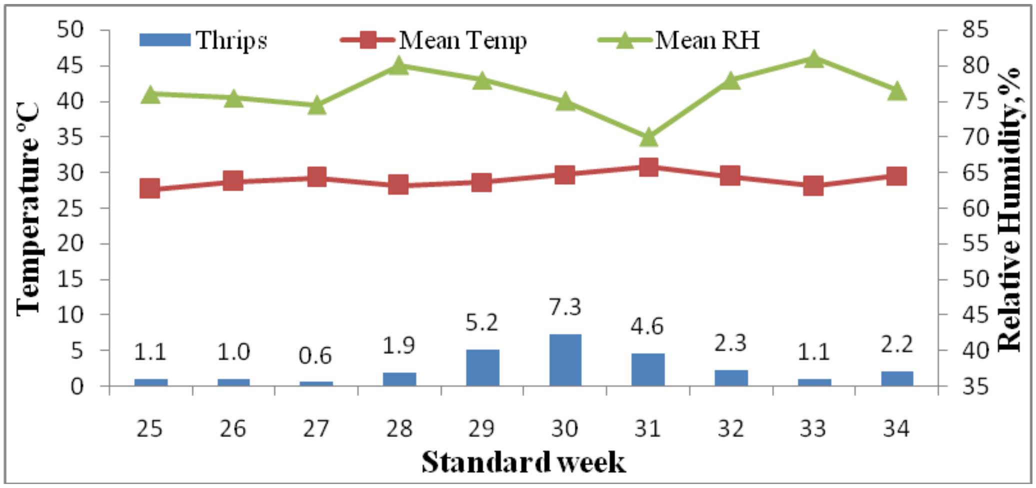

Fig.1 Influence of weather parameters on thrips population during *kharif* in sesame

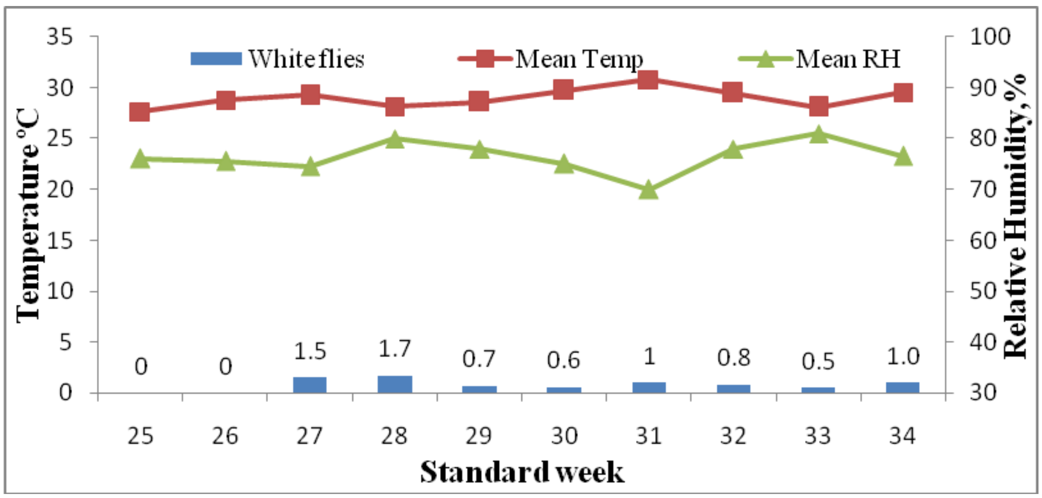

Fig.2 Influence of weather parameters on whitefly population during *kharif* in sesame

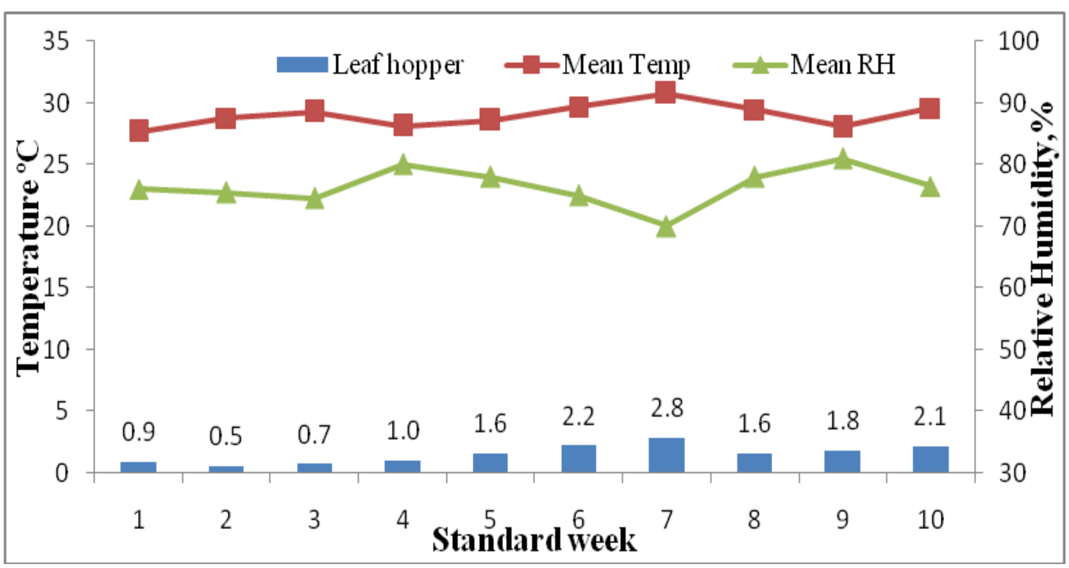

Fig.3 Influence of weather parameters on leaf hoppers population during *kharif* in sesame

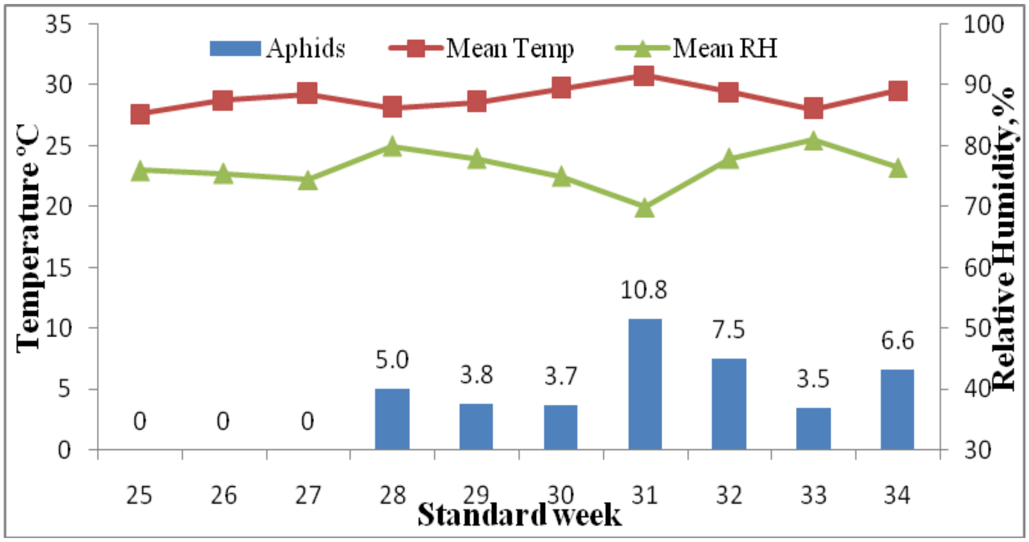

Fig.4 Influence of weather parameters on aphids population during *kharif* in sesame

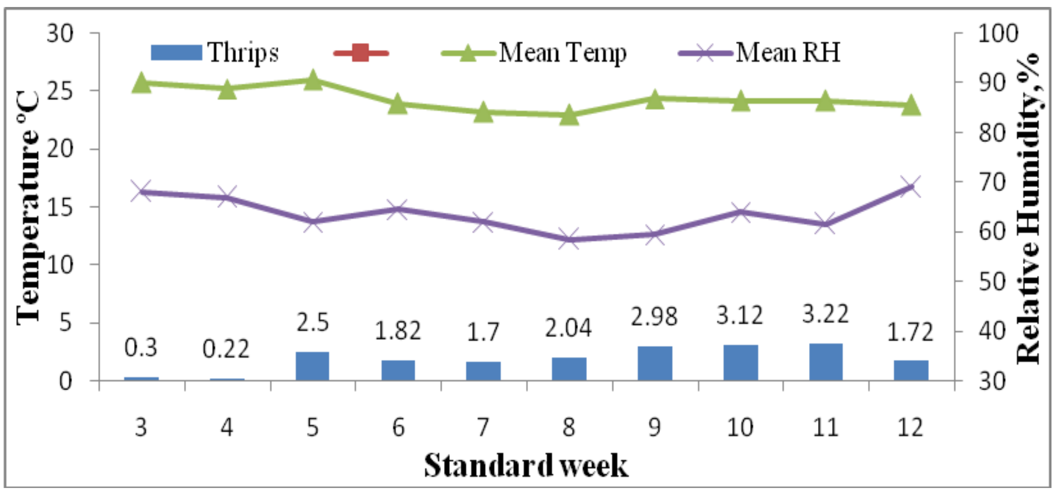

Fig.5 Influence of weather parameters on thrips population during *rabi-summer* in sesame

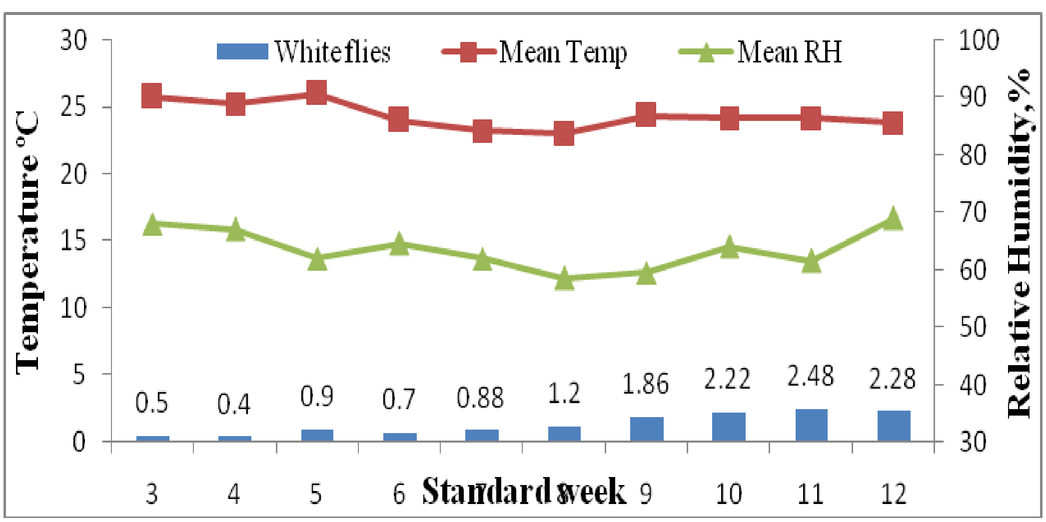

Fig.6 Influence of weather parameters on whitefly population during *rabi-summer* in sesame

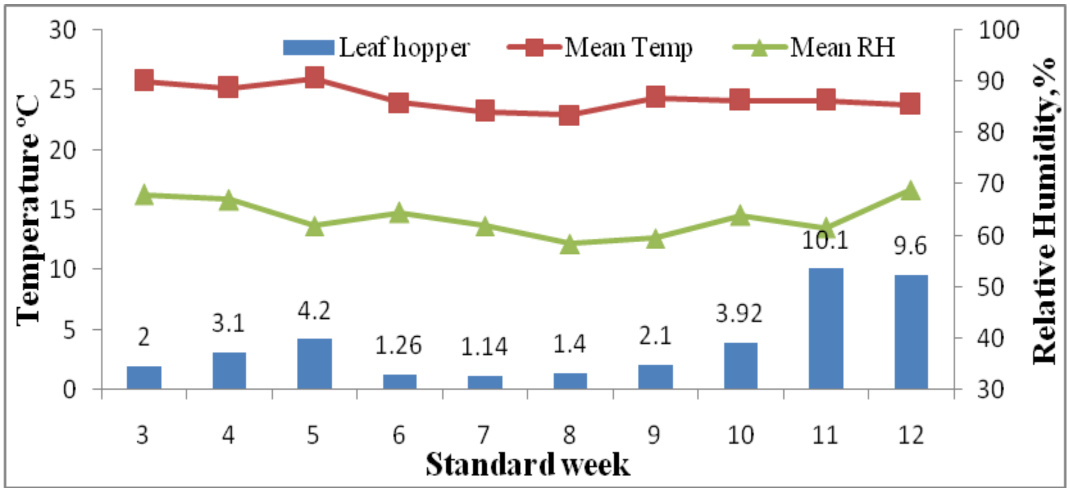

Fig.7 Influence of weather parameters on leaf hopper population during *rabi-summer* in sesame

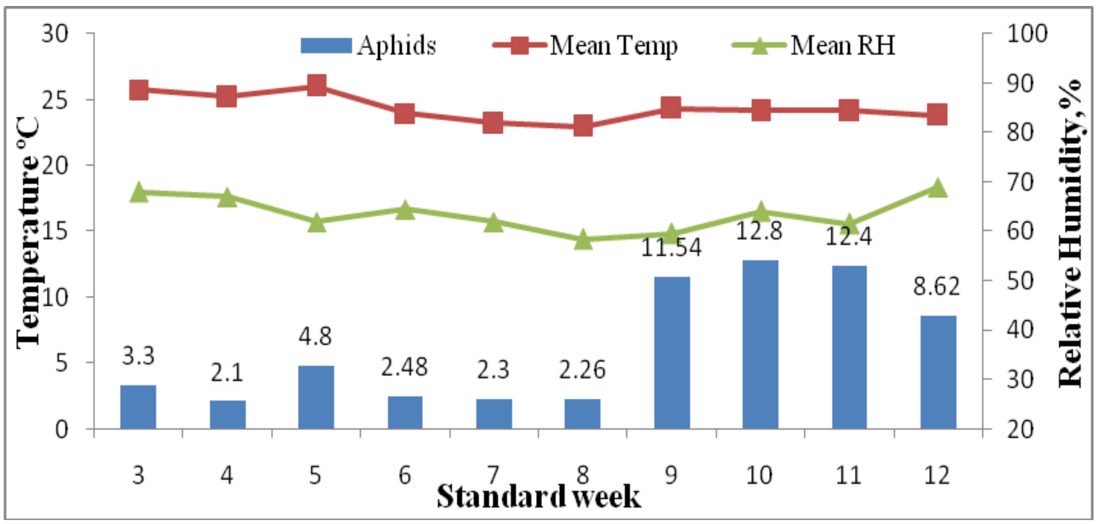

Fig.8 Influence of weather parameters on aphids population during *rabi-summer* in sesame

The mean temperature varied between 27.7-30.8 °C, while the maximum temperature varied in the wide range (31.1-33.8 °C) and minimum temperature in the narrow range (24.2 - 26 °C) with positive correlation with aphid population as shown in Table 1&3.

The mean relative humidity ranged between 70-81%, while the minimum relative humidity varied in the wide range (49-75%) and maximum relative humidity in the narrow range (85-91%) with negative correlation with aphid population as shown in the Table 1&3. Aphid population showed significant positive correlation with mean atmosphere temperature(r = 0.667) and Non significant negative correlative with mean relative humidity(r = -0.236) and rainfall(r = -0.444).

During *rabi-summer* season the aphid population initially observed on 3rd SMW, thereafter the population spiked with 12.8 aphids/plant on 10th SMW (Fig.4). The mean temperature varied between 23-26 °C, while the maximum temperature varied in the range of 31-33.7 °C and minimum temperature in the narrow range (14.3-17.8 °C). Aphid population shown positive correlation with mean atmosphere temperature(r=0.451) and Non-significant negative correlative with mean relative humidity(r= -0.14). It has been confirmed that the temperature favored to building up the pest population and relative humidity and rainfall constrained the aphid population as depicted in Table 2. The findings are in consensus with Kumar *et al.*, 2010.

Regression analysis

The multiple nonlinear regression equation fitted with weather factors during for prediction of aphids, leaf hopper and thrips population and presented in the Table 4. The regression equation for estimation of thrips population during *kharif* season is (T_k) =-103.7-0.98(T_{max}) +2.13(T_{min}) +1.0(RH_{max})-0.004(RH_{min})+ 0.007(Rain) (R^2=0.79), for white fly W_k=-17.16+0.06(T_{max})+1.12(T_{min})-0.2(RH_{max})+0.005(RH_{min})-0.009(Rain)(R^2=0.81), for leaf hoppers L_k=-35.7+0.19(T_{max})-0.11(T_{min})+0.36(RH_{max})-0.03(RH_{min}) - 0.001(Rain) (R^2=0.79) and for aphids (A_k=-173.2+1.94(T_{max}) -0.79(T_{min}) +1.28(RH_{max})+0.34(RH_{min})+0.06(Rain) with R^2 of 0.78.

Similarly the nonlinear regression equation for estimation of pest population for *rabi-summer* season has been developed. The equation for prediction of thrips population is given as (Tr=12.4.+0.59(T_{max})-0.38(T_{min}) -0.22(RH_{max})-0.09(RH_{min}.) (R^2=0.77), for white fly Tr=12.4.+0.59(T_{max})-0.38 (T_{min}) -0.22(RH_{max})-0.09(RH_{min}.)(R^2=0.9) for leaf hoppers Lr = 45.5 + 2.91(T_{max}) -0.74(T_{min})-1.41 (RH_{max}) + 0.07(RH_{min}) (R^2=0.82) and for aphids Ar=-86.9+1.38(T_{max})-3.58 (T_{min})+1.18 (RH_{max})-0.017(RH_{min}) with R^2 of 0.86.

These findings regarding relation of weather parameters to incidence of sap feeders were in conformity with the reports of Harish *et al.*, 2015 and Radhika, 2013 for groundnut, Pramod, 2007 for sunflower and Wagh, 2014 in cotton.

The population dynamics of sucking pests on sesame (aphids, whiteflies, leaf hoppers and thrips) were studied and weather parameters were correlated. The study concluded that, the maximum, minimum temperatures and maximum relative humidity have positive correlation with aphids, leafhopper and thrips population and negative correlation with minimum relative humidity and rainfall. The information about the succession and population dynamics of sap feeders in relation to seasonal incidence may be utilized for devising effective management tactics for these pests and achieving higher yields in sesame.

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