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Influence of Meteorological Factors on Population Build-Up of Aphids and Natural Enemies on Summer Okra

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A B S T R A C T

The study on seasonal incidence of summer okra as influenced by weather parameters on aphid, lady bird beetle and syrphid fly showed its peak presence during 16th MW and maximum population of chyrsopa during 17th MW, predatory spider during 20th MW. The correlation studies indicated that aphid showed positively significant correlation with bright sunshine and negatively significant correlation with rainy days. While lady bird beetle, chrysopa and predatory spider showed positively significant correlation with maximum temperature, minimum temperature, evaporation and negatively significant correlation with morning RH and evening RH. Whereas syrphid fly revealed non-significant correlation. The equations of linear regression was set of aphid, lady bird beetle, chrysopa and predatory spider population by working out regression coefficient (b) and constant (a) but was not possible in syrphid fly population as the impact of all weather parameters were found non-significant. The multiple regression equation fitted were worked out and the coefficient of determination (R^2) mostly showed higher indication, hence the predictions and forewarning of the aphid and natural enemies population by using weather parameters were reliable.

Introduction

Okra in sanskrit is designated as 'Tindisha' and 'Gandhmula', originated from Africa and commonly known as "Lady's finger" or "Bhendi" which is a flowering plant under Malvaceae family producing high valued edible green pods showing good nutritional and multipurpose crop value. India ranks first in okra cultivation and production with an area of 532.64 thousand hectares and production of 6346.40 thousand tones along with productivity of 13.14 mt/ha (Anonymous, 2013). As high as 72 species of insects have been recorded on okra, hence known as the house of pests due to its two distinct i.e., vegetative and fruiting growing stages. Okra crop and its pest complex forms "okra ecosystem" which also includes natural enemies like predatory insects such as lady bird beetle and green lacewing feeding on aphid and soft bodied insects (Sekhon and Verma, 1983).

Due to the above facts, the present investigation were undertaken with an objective to know seasonal incidence, correlation and regression among weather parameters against aphid and natural enemies population on *summer* okra.

Materials and Methods

A field study was conducted to know the summer season incidence, correlation and regression among weather parameters against okra aphid and natural enemies population at Department of Agricultural Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *summer* 2013 and 2014. Population count of aphid and natural enemies were taken from appearance of incidence upto the final harvest of crop on weekly basis without employing any plant protection measures on weekly basis by dividing experimental plot (10m x 10m) into four equal quadra from which 5 plants from each were randomly selected of each plant top, middle and bottom leaves were considered. While in case of natural enemies whole plant was considered for recording their number. The different weather parameters recorded were collected from the meteorological unit and populations of *Aphis gossypii* and natural enemies were correlated with the meterological factors. The data obtained were averaged and subjected to simple correlation, linear and multiple regression analysis as per Panse and Sukhatme (1967).

Results and Discussion

The data regarding aphid and natural enemies infestation versus weather parameters during *summer* 2013 and 2014 (Pooled) study period were recorded with an objective to determine the trend in fluctuations of aphid and natural enemies population with respect to the weather conditions.

Seasonal incidence of aphid (*Aphis gossypii*)

The pooled incidence of aphids was observed throughout the crop season exhibiting a population range from 0.25 to 16.50 aphids /3 leaves (Table 1). The infestation observed was less during earlier stages of crop growth and went on increasing gradually achieving its highest peak of 16.15 aphids/3 leaves on 16^{th} standard week of April when the prevailing rainfall, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, evaporation, bright sunshine hours and wind velocity were 1.85 mm, 38.89^0C, 22.04^0C, 58.79 per cent, 19.79 per cent, 10.10 hrs, 9.87 hrs, and 4.43kmph, respectively. Later on the aphid population started declining reaching 1.83 aphids/3 leaves till 21^{st} standard week of May with an average mean incidence of 6.57 aphids/3 leaves. The present findings are in close aggreement with the results of Anitha and Nandihalli (2008) who studied the seasonal incidence of aphids and revealed that the activity of aphids was noticed throughout the cropping period during summer reached its peaks in the month of April. Shivanna *et al.* (2011) revealed that the population of aphid 45.07% per three leaves during May second forthnight and minimum temperature showed negative effect on aphid population.

Overall seasonal incidence of natural enemies

Pooled data regarding lady bird beetle population on summer okra crop reached its peak on 16^{th} standard week of April with 2.38 beetles per plant due to prevailing rainfall, maximum- minimum temperature, morning-evening relative humidity, evaporation, bright sunshine hours and wind velocity of 1.85 mm, 38.89^0 C, 22.04 ^{0}C, 58.79 per cent, 19.79 per cent, 10.10 hrs, 9.87 hrs, and 4.43 kmph, respectively.

The c*hrysoperla* incidence started more or less appearing from 12^{th} standard week of March, but was seen on regular basis from 14^{th} standard week of April with 0.25 grub/plant reaching highest population of 0.43 grubs/plant on 17^{th} standard week of April.

Syrphid fly population exhibited an high incidence of 4.0 syrphid fly/ plant during 16^{th} standard week of April when the corresponding rainfall, maximum- minimum temperature, morning-evening relative humidity, evaporation, bright sunshine hours and wind velocity were 1.85 mm, 38.89^{0} C, 22.04^{0} C, 58.79 per cent, 19.79 per cent, 10.10 hrs, 9.87 hrs, and 4.43 kmph.

The population of predatory spider was negligible and seen on regular basis from 16^{th} standard week of April (0.20 spider/ plant) which went on increasing and reached its peak incidence of 0.90 spider/ plant during 20^{th} standard week of May (Table 1).

The present results are in conformity with the findings of Hegde *et al.* (2004) who showed that natural enemies such as coccinellids, spiders and *Chrysoperla carnea* (Stephens) were found throughout the year. However, their population was very low. Anitha (2007) also noticed coccinellid population on summer crop during second week of April 2006 while *chrysoperla* population appeared during third week of April 06 and the peak incidence was noticed during fifth week of April 06 (0.56 grub/plant).

Correlation and regression among weather parameters against aphid (*Aphis gossypii*)

Simple correlation studies

The pooled data regarding correlation and regression coefficient between weather parameters and aphid population presented in Table 2 revealed that the non significant and negative correlation was observed between aphid population and rainfall, morning RH, evening RH, wind velocity and evaporation. Positively non-significant correlation was observed between maximum temperature and minimum temperature and aphid population on okra. The data correlated between aphid population on okra and bright sunshine hour (r= 0.538*) was found positively significant, whereas with rainy days (r= -0.555*) was negatively significant.

Linear regression studies

The pooled regression coefficient (b) and constant (a) were worked out to set regression equations (Table 2) revealed that correlation between aphid population and rainfall, minimum temperature, morning RH, evening RH and bright sunshine on aphid on okra was not significant.

Only the rainy days and bright sunshine showed significant positive and negative impact. The regression equation worked out for rainy days (x) and aphid population (y) was Y = 8.529 – 5.232x which indicated that the aphid population decreased by 0.555 for every unit increase in rainy days whereas the regression equation for bright sunshine was Y = - 33.32 + 4.345x which revealed that for every unit increase in bright sunshine the aphid population increased by 0.538.

Multiple correlation studies

The pooled multiple regression coefficient for different weather parameters were worked and the multiple regression equation fitted with weather parameters in order to predict aphid population on okra was as,

$$Y = -77.874 + 1.220 X_1 – 18.878 X_2 + 2.319 X_3 – 0.142 X_4 - 1.161 X_5 + 1.483 X_6 – 3.248 X_7 + 7.815 X_8 - 0.347 X_9.$$

The coefficient of determination (R^2) was 89 per cent (Table 3).

The correlation studies revealed that the present findings are in conformity with those of Sattar *et al.* (2009) studied on population dynamics of *A.gossypii* in relation with abiotic and biotic factors studied on okra, revealed that correlation of bright sunshine was significantly positive and partly agree with those of Singh *et al.* (2013) revealed that aphid population showed negative correlation with rainfall and maximum and minimum relative humidity.

Correlation and regression among weather parameters against natural enemies

Lady bird beetle

Simple correlation studies

The pooled data pertaining to simple correlation and regression coefficients between weather parameters and lady bird beetle population are presented in Table 2 which showed that the correlation between lady bird beetle population on okra and maximum temperature (r= 0.568*), minimum temperature (r= 0.547*) and bright sunshine (r=0.629*) were found positively significant, whereas with morning relative humidity (r= -0.617*) and evening relative humidity (r= -0.594*) were negatively significant.

The non significant and negative correlation was observed between lady bird beetle population and rainfall and rainy days. The results brought out positive and non significant correlation between evaporation, wind velocity and lady bird beetle population on okra.

Linear regression studies

Linear regression was worked out between the weather parameters and incidence of lady bird beetle on okra. The pooled regression coefficient (b) and constant (a) were worked out and linear regression equations were set up. The impact of rainfall, rainy days, evaporation and wind velocity was non significant.

The correlation between maximum temperature, minimum temperature, bright sunshine and lady bird beetle population were positively significant. The regression equation worked out were Y = -3.875 + 0.125x, Y = 4.779 + 0.114x and Y = -4.106 + 0.556x which indicated that for every unit increase in maximum temperature, the lady bird beetle population on okra increased by 0.568, 0.547 and 0.629.

While the regression equation worked out were Y = 4.170 - 0.053x and Y = 2.438 - 0.067x which showed that for every unit increase in morning RH and evening RH the lady bird beetle population on okra decreased by 0.617and 0.594.

Multiple regression studies

The multiple regression equation fitted with weather parameters in order to predict lady bird beetle population on okra was as below.

$$Y = 11.503 + 0.048 X_1 - 0.719 X_2 - 0.475 X_3 + 0.398 X_4 - 0.066 X_5 - 0.074 X_6$$

$$-0.335 X_7 + 0.830 X_8 + 0.188 X_9.$$

The coefficient of determination (R^2) represents the proportion of common variation in the two variables.

The present investigations revealed that the weather parameters contributed 93.3 per cent of total variation in the population of lady bird beetle (Table 3) on okra which was very high indicating that the predictions were reliable.

Chrysopa

Simple correlation studies

The data indicated that the correlation between maximum temperature (r = 0.674**), minimum temperature (r = 0.666**), evaporation (r = 0.621*), bright sunshine (r = 0.611*) and chrysopa population was positive and significant whereas, negatively significant correlation was observed between chrysopa population on okra and morning RH (r = -0.649*), evening relative humidity (r = -0.570*). The correlations of rainfall and rainy days with chrysopa population were found negatively non- significant while wind velocity was positive and non-significant.

Linear regression studies

The pooled regression equations were set by working out regression coefficient (b) and constant (a) (Table 2) showing that the impact of rainfall, rainy days and wind velocity was non-significant.

The chrysopa population on okra were positive and significantly correlated with maximum temperature, minimum temperature, evaporation and bright sunshine. The regression equations worked out were Y = - 1.230 + 0.036x, Y = -0.560 + 0.034x, Y = -0.276 + 0.044x and Y = - 1.030 + 0.132x which indicated that for every unit increase in maximum temperature, minimum temperature, evaporation and bright sunshine the chrysopa population on okra increased by 0.674, 0.666, 0.621 and 0.611.

The regression equations worked out were Y = 1.003 – 0.014x and Y = 0.525 – 0.016x showed that for every unit increase in morning RH and evening RH the chrysopa population on okra decreased by 0.649 and 0.570.

Multiple regression studies

Multiple regression coefficients for different weather parameters were worked out (Table 3). The pooled multiple regression equation with weather parameters in order to predict chrysopa population was as below,

$$Y = 1.487 + 0.029 X_1 - 0.137 X_2 - 0.270 X_3 + 0.225 X_4 + 0.001 X_5 - 0.017 X_6 + 0.198X_7 + 0.348 X_8 - 0.184 X_9.$$

The coefficient of determination (R^2) was 82.4 per cent. This indicated that the total variation in the population of chrysopa on okra was 82.4 per cent due to different weather parameters.

Syrphid fly

Simple correlation studies

The pooled data on simple correlation and regression coefficients between syrphid fly population and weather parameters are presented in Table 2 which showed no positive and negative significant correlation between syrphid fly population on okra and different weather parameters.

The correlation of rainfall, rainy days, morning RH and evening relative humidity with syrphid fly population were negatively non- significant. The syrphid fly population correlated positively non- significant relationship with maximum temperature, minimum temperature, evaporation, bright sunshine and wind velocity.

Linear regression studies

The regression equations could not be set by working out regression coefficient (b) and constant (a) (Table 21) as the impact of rainfall, rainy days, maximum temperature, minimum temperature, morning RH, evening

RH, evaporation, bright sunshine and wind velocity were non-significant.

Multiple regression studies

Multiple regression coefficients for different weather parameters were worked out (Table 4). The pooled multiple regression equation with weather parameters in order to predict syrphid fly population was worked out as below.

$$Y = 22.714 + 0.035\ X_1 - 1.266\ X_2 - 0.733\ X_3 + 0.419\ X_4 - 0.170\ X_5 - 0.040\ X_6 - 0.953 X_7 + 1.767\ X_8 + 0.669\ X_9.$$

The coefficient of determination (R^2) between weather parameters and syrphid fly population on okra was significant with 90.9 per cent showing the importance of these parameters influencing the abundance of syrphid fly on okra.

Table.1 Seasonal incidence of aphid and their natural enemies on okra (pooled of summer 2013 and 2014)

(N=24)

Months	M.W.	Rain-fall (mm)	Rainy days	Temp. (^{0}C)		Humidity (%)		EVP (mm)	B.S.S. (Hrs.)	W.V (kmph)	Aphid	LBB	Chry.	Syrphid fly	Pre. Spider
				Max	Min.	Max	Min.				No. / 3 leaves	No. of natural enemies/plant			
March	10	35.35	2.00	32.14	15.54	76.43	34.50	6.89	7.95	3.88	0.25	0.10	0.00	0.05	0.00
	11	4.30	0.50	35.56	18.95	69.93	28.71	7.73	8.62	1.92	1.73	0.25	0.00	0.28	0.00
	12	0.00	0.00	37.34	19.37	63.79	21.43	8.93	8.96	1.62	3.15	0.40	0.05	0.18	0.05
	13	0.00	0.00	38.86	20.65	61.57	19.64	9.02	9.19	1.60	8.25	0.70	0.00	0.58	0.10
April	14	0.00	0.00	39.34	19.84	56.86	16.43	10.04	9.88	1.75	13.73	0.95	0.25	0.95	0.00
	15	0.25	0.00	39.47	22.01	53.79	18.57	10.15	9.13	3.38	14.75	1.50	0.13	1.93	0.00
	16	1.85	0.00	38.89	22.04	58.79	19.79	10.10	9.87	4.43	16.50	2.38	0.25	4.00	0.20
	17	0.00	0.00	39.96	23.64	59.79	19.86	10.69	9.41	4.34	9.00	1.50	0.43	1.48	0.23
	18	4.30	1.00	41.87	24.09	52.21	17.07	11.91	10.20	4.87	4.90	1.28	0.40	1.23	0.60
May	19	0.50	0.00	40.79	23.84	56.07	18.64	12.40	9.36	6.01	2.48	0.90	0.33	0.53	0.40
	20	2.10	0.50	39.79	25.71	52.50	26.07	12.31	7.99	6.10	2.23	0.90	0.20	0.45	0.90
	21	5.00	0.50	42.80	25.38	55.71	16.57	14.54	9.58	8.01	1.83	1.08	0.18	0.30	0.65
Mean											**6.57**	**1.00**	**0.19**	**1.00**	**0.26**

Table.2 Correlation and linear regression coefficients between aphid and their natural enemies on okra (pooled of summer 2013 and 2014)

(N=24)

Weather Parameters	Aphid Population			LBB Population			Chrysopa Population			Syrphid fly Population			Predatory Spider Population		
	r	**b**	**a**	**r**	**r**	**r**	**r**	**b**	**a**	**r**	**b**	**a**	**r**	**b**	**a**
Rainfall (mm)	-0.425	-0.246	7.667	-0.449	-0.028	1.122	-0.372	-0.006	0.211	-0.287	-0.032	1.140	-0.170	-0.005	0.284
Rainy days	-0.555*	-5.232	8.529	-0.449	-0.463	1.169	-0.236	-0.060	0.207	-0.357	-0.650	1.240	0.098	0.050	0.242
Temp. ^{0}C Max.	0.219	0.441	-10.60	0.568*	0.125	-3.875	0.674**	0.036	-1.230	0.222	0.086	-2.350	0.625*	0.067	-2.366
Temp. ^{0C} Min.	0.043	0.082	4.779	0.547*	0.114	4.779	0.666**	0.034	-0.560	0.199	0.073	-0.598	0.827**	0.085	-1.581
R.H (%) AM	-0.361	-0.284	23.52	-0.617*	-0.053	4.170	-0.649*	-0.014	1.003	-0.324	-0.049	3.927	-0.610*	-0.026	1.799
R.H (%) PM	-0.511	-0.529	17.92	-0.594*	-0.067	2.438	-0.570*	-0.016	0.525	-0.354	-0.071	2.511	-0.193	-0.011	0.491
EVP	-0.057	-0.151	8.137	0.434	0.127	-0.320	0.621*	0.044	-0.276	0.058	0.030	0.686	0.815**	0.117	-0.950
BSS (hr./day)	0.538*	4.345	-33.32	0.629*	0.556	-4.106	0.611*	0.132	-1.030	0.506	0.788	-6.238	0.025	0.011	0.163
W.V (kmph)	-0.299	0.302	9.889	0.318	0.097	0.608	0.476	0.036	0.043	0.034	0.018	0.924	0.809**	0.121	-0.221
Number of observations	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24

Table.3 Multiple regression coefficients between weather parameters and aphid, lady bird beetle, chrysopa population on okra (pooled of summer 2013 and 2014)

(N=24)

Sucking pests	**Pooled correlation coefficient values (r)**								
	Rainfall (mm) (X_1)	**Rainy days (X_2)**	**Temperature (C^0)**		**Relative humidity (%)**		**Evapor -ation (X_7)**	**BSS (Hrs.) (X_8)**	**Wind velocity (X_9)**
			Max. (X_3)	**Min. (X_4)**	**Morning (X_5)**	**Evening (X_6)**			
Aphid Bi	1.220	-18.878	2.319	-0.142	-1.161	1.483	-3.248	7.815	-0.347
S.E.	1.255	16.900	11.043	5.9657	0.738	3.743	6.676	7.936	5.714
't' values	0.972	-1.117	0.210	-0.024	1.574	0.396	-0.487	0.985	-0.061
Path coefficient	2.109	-2.002	1.153	-0.075	-1.478	1.433	-1.220	0.968	-0.125
	B_o = - 77.874		**F-val** = 1.827		**R^2** = 0.890			**SEY** = 4.427	
LBB Bi	0.048	-0.719	-0.475	0.398	-0.066	-0.074	-0.335	0.830	0.188
S.E.	0.108	1.451	0.948	0.512	0.063	0.321	0.573	0.682	0.491
't' values	0.449	-0.496	-0.501	0.778	-1.034	-0.231	-0.585	1.217	0.383
Path coefficient	0.764	-0.696	-2.157	1.906	-0.761	-0.655	-1.150	0.938	0.618
	B_o = 11.503		**F-val** = 3.110		**R^2** = 0.933			**SEY** = 0.380	
Chrysopa Bi	0.029	-0.137	-0.270	0.225	0.001	-0.017	0.198	0.348	-0.184
S.E.	0.043	0.578	0.377	0.204	0.025	0.128	0.228	0.271	0.195
't' values	0.682	-0.237	-0.715	1.103	0.052	-0.135	0.870	1.284	-0.942
Path coefficient	1.887	-0.540	-5.005	4.393	0.062	-0.621	2.779	1.609	-2.470
	B_o = 1.487		**F-val** = 1.039		**R^2** = 0.824			**SEY** = 0.151	

Table.4 Multiple regression coefficients between weather parameters and syrphid fly, predatory spider population on okra (pooled of summer 2013 and 2014)

(N=24)

Sucking pests	Pooled correlation coefficient values (r)								
	Rainfall (mm) (X_1)	Rainy days (X_2)	Temperature (C^0)		Relative humidity (%)		Evapor -ation (X_7)	BSS (Hrs.) (X_8)	Wind velocity (X_9)
			Max. (X_3)	Min. (X_4)	Morning (X_5)	Evening (X_6)			
Syrphid fly Bi	0.035	-1.266	-0.733	0.419	-0.170	-0.040	-0.953	1.767	0.669
S.E.	0.222	2.984	1.950	1.052	0.130	0.661	1.17	1.401	1.009
't' values	0.158	-0.424	-0.376	0.399	-1.302	-0.060	-0.809	1.261	0.664
Path coefficient	0.313	-0.696	-1.890	1.141	-1.120	-0.199	-1.8546	1.135	1.250
	B_o = 22.714		**F-val** = 2.221		**R^2** = 0.909			**SEY** = 0.782	
Pre. Spider Bi	0.010	0.156	-0.157	0.171	0.002	0.021	0.279	0.132	-0.182
S.E.	0.042	0.571	0.373	0.201	0.025	0.126	0.226	0.268	0.193
't' values	0.227	0.274	-0.422	0.849	0.080	0.165	1.239	0.492	-0.943
Path coefficient	0.310	0.309	-1.457	1.669	0.048	0.375	1.954	0.305	-1.220
	B_o = -1.394		**F-val** = 4.949		**R^2** = 0.957			**SEY** = 0.150	

Predatory spider

Simple correlation studies

The pooled data presented in Table 2 indicated that the correlation between maximum temperature (r = 0.625*), minimum temperature (r = 0.827**), evaporation (r = 0.815**), wind velocity (r = 0.809**) and predatory spider population were positive and significant. Whereas negatively significant correlation was observed between predatory spider population on okra and morning RH (r = -0.610*). The correlations of rainfall and evening RH with predatory spider population were found negatively non- significant while rainy days, bright sunshine was positive and non-significant.

Linear regression studies

The pooled regression equations were set by working out regression coefficient (b) and constant (a) showing that the impact of rainfall, rainy days, evening RH and wind velocity was found non-significant.

The predatory spider population on okra were positive and significantly correlated with maximum temperature, minimum temperature, evaporation and wind velocity. The regression equation worked out were Y = - 2.366 + 0.067x, Y = -1.581 + 0.085x, Y = - 0.950 + 0.117x and Y = - 0.221 + 0.121x which indicated that for every unit increase in maximum temperature, minimum temperature, evaporation and wind velocity the predatory spider population on okra increased by 0.625, 0.827, 0.815 and 0.809.

While the regression equation worked out was Y = 1.799 – 0.026x which showed that for every unit increase in morning RH the predatory spider population on okra decreased by 0.610.

Multiple regression studies

Multiple regression coefficients for different weather parameters were worked out (Table 4). The pooled multiple regression equation with weather parameters in order to predict predatory spider population was as below,

$Y = -1.394 + 0.010 X_1 + 0.156 X_2 - 0.157 X_3 + 0.171 X_4 + 0.002 X_5 + 0.021 X_6 + 0.279 X_7 + 0.132 X_8 - 0.182 X_9$.

The coefficient of determination (R^2) revealed that the weather parameters contributed about 95.7 per cent of total variation in the population of predatory spider on okra which was very high indicating that the predictions made were reliable.

The present findings are in agreement with those of Rao *et al.* (1989) who showed that both pest (*B.tabaci*) and natural enemy populations were decreased by rainfall and significant correlation of temperature with the population of predators. Purohit *et al.* (2006) showed that coccienllid population with abiotic factors such as rainfall, rainy days, evaporation and wind velocity had a non-significant correlation while *Chrysoperla* population had a significant negative correlation with morning and afternoon relative humidity. Anitha (2007) in her correlation studies revealed that parameters such as total rainfall had non significant relationship with coccinellid population. Correlation studies between various weather parameters and *Chrysoperla* population showed a significant negative correlation with morning and afternoon relative humidity.

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