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Population dynamics of aphid, *Aphis craccivora* Koch on cowpea ecosystem in middle Gujarat

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Abstract
Aphid population appeared during first week of March in summer, 2017 when crop at vegetative growth stage. Initially, its population was low, gradually increased in its numbers and attained peak level (27.14/3 cm twig) at flowering to pod developing stage during first week of April. Then after, aphid population decreased and disappeared with the maturity of crop from first week of May. Aphid incidence was found higher during 1st to 4th week of April. In *kharif*, 2017 population of aphid first appeared during 4th week of August and gradually increased up to the 3rd week of October and then after disappeared from 1st week of November. Its peak level (30.10/3 cm twig) was found in 1st week of October, coincide with the flowering to pod developing stage of the crop. No significant impact of studied abiotic factors was observed on aphid population. The presence of natural enemies *viz.*, coccinellids and syrphid fly also observed in cowpea. Coccinellid was found more active than syrphid fly during both the seasons. Looking to the association among aphid and natural enemies, aphid population was found significantly correlated with the population of natural enemies *i.e.*, coccinellids and syrphid fly, the population of aphid increased, the activity of natural enemies also increased. The population of natural enemies found highest during the peak period of aphid population in the 1st week of April and 1st week of October during summer and *kharif*, 2017, respectively.

Keywords: Population dynamics, cowpea, coccinellids, Syrphid fly

Introduction
Pulses have been ordinary as major sources of protein in human being as well as restorer of soil fertility by fixing the atmospheric nitrogen in soil. Among the different pulse crops, cowpea is grown all over the India for its long green pods, seed and foliage as feed (Michael *et al.*, 2007) [8]. It constitutes the cheapest source of dietetic protein and energy for poor people so it is known as "vegetable meat" and "poor man's meat" (Davis *et al.*, 1991) [4]. In India, total area under pulses is 25.26 million hectares with the total production of 16.47 million tonnes and productivity of 652 kg per hectare. Whereas in Gujarat, total area under pulses is 0.60 million hectare having total production of 0.53 million tonne with the productivity of 890 kg per hectare. In Gujarat, area under cowpea is 0.52 million hectares and the production 0.35 million tonne with the productivity of 665 kg per hectare (Anon., 2015) [1]. In India, cowpea is mainly grown in the states of Karnataka, Kerala, Maharashtra, and Tamil Nadu for seed, green pods, animal fodder and organic green manure use. The crop is ravaged by many insect pests at different stages of cowpea. As many as 21 insect pests of different groups have been observed damaging the crop right from germination to maturity (Prajapathi *et al.*, 2009) [13]. Among them, aphid is the major pest of cowpea causing economic losses directly by sucking the cell sap from leaves, twigs, pods and produce black sooty mould. Whereas, ultimately through transmission of viral diseases. *Aphis craccivora* causes significant yield loss of about 20-40 per cent in Asia (Ghareeb *et al.*, 2002) [6]. Obopile (2006) [9] reported that allowing aphids to feed on cowpea plants beyond three weeks resulted in more than 50 per cent yield losses. The purpose of study was which stage of crop is highly susceptible to aphid with relation to environmental factor and also study of predatory fauna population with relation to aphid population.

Materials and Methods
The cowpea plot (15.30x 10.80m) was divided into six equal quadrates to record the incidence of aphid population. From each quadrate, five plants were randomly selected and tagged for recording the observations. The observations were recorded at weekly interval

starting from one week after germination till the crop maturity. Aphid population was recorded by counting the number of aphid from 3 twigs of 3 cm per plant. The predators *viz*., adults and grubs of coccinellid, syrphid fly maggots, chrysoperla adults and spiders etc. were also recorded from five randomly selected plants in each quadrate. Observations were recorded during early morning at weekly interval. In order to determine the seasonal incidence of aphid the periodic mean incidence of the population was worked out as per standard week. The population data of *A. craccivora* were correlated with minimum and maximum temperature, relative humidity, morning and evening vapour pressure, sunshine hours, wind velocity as suggested by Steel and Torrie (1980) [17].

Results and Discussion

Summer, 2017

Aphid, *A. craccivora*

The data on population of aphid, *A. craccivora* recorded on cowpea crop are presented in Table 1 and depicted in Fig. 1. Aphid first appeared during first week of March (10th SMW) during summer, 2017 when crop was at vegetative growth stage. Incidence of the pest on cowpea crop was observed from March to April. Initially, its population was low (0.61/twig), which was gradually increased in its numbers and attained peak level (27.14/twig) at flowering and pod developing stage during first week of April (14th SMW). Then after, population showed decreasing trend and disappeared with maturity of crop from last week of April (18th SMW). The higher incidence of this pest was observed during 1st to 4th week of April (14th to 17th SMW).

Coccinellid grubs

The activity of predator *i.e*. coccinellid grubs recorded during the summer season of the year 2017 are presented in Table 1 and depicted in Fig. 1. The activity of coccinellid grub commenced from 1st week of March (10th SMW) with the population of 0.23 grub/ plant. The population of coccinellid grub increased up to 1.67 grubs/ plant in 1st week of April (14th SMW). Population of coccinellid grub declined in trend from 2nd to 5th week of April (15th to 18th SMW). During these periods, the aphid population remained in decreasing trend. The enemies disappeared from 1st week of May (19th SMW), where it was in coincidence with population of aphid.

Table 1: Population fluctuation of *A. craccivora* and its predatory fauna on cowpea during summer, 2017

Month		SMW	Week after sowing	No. of aphid/ twig	Predators/ plant		
					Coccinellids		Syrphid fly maggot
					Grubs	Adult	
February	4	9	3	0.00	0.00	0.00	0.00
March	1	10	4	0.61	0.23	0.00	0.00
	2	11	5	1.90	0.47	0.23	0.20
	3	12	6	2.91	0.93	0.43	0.33
	4	13	7	6.10	0.97	0.50	0.47
April	1	14	8	27.14	1.67	0.87	0.93
	2	15	9	22.16	1.60	0.67	0.70
	3	16	10	20.29	1.17	0.53	0.47
	4	17	11	18.22	0.83	0.50	0.33
	5	18	12	3.02	0.33	0.23	0.00
May	1	19	13	0.00	0.00	0.00	0.00

SMW: Standard Meteorological Week

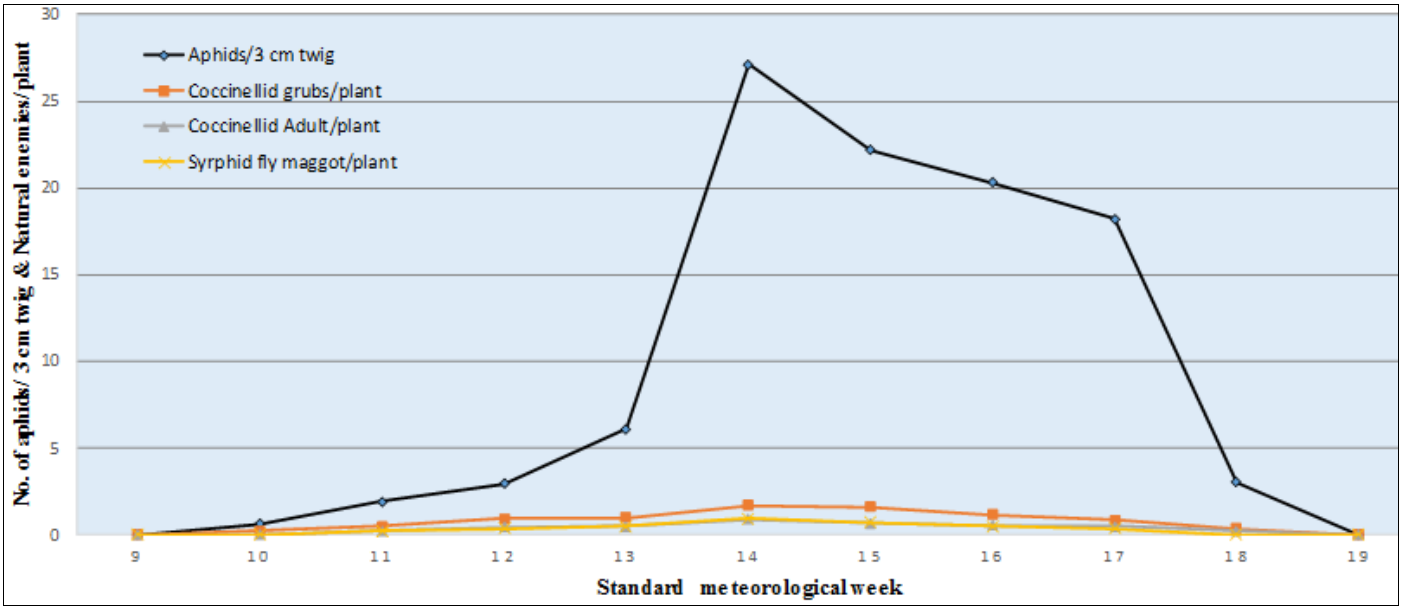

Fig 1: Population fluctuation of *A. craccivora* on cowpea during summer, 2017

Coccinellid adult

The activity of predator *i.e*. coccinellid adult recorded during the summer season of the year 2017 are presented in Table 1 and depicted in Fig. 1 The activity of coccinellid adult commenced from 2nd week of March (11th SMW) with the population of 0.23 adult/ plant. The population of coccinellid

adult increased up to 0.87 adult/ plant in 1st week of April (14th SMW). Population of coccinellid adult declined quickly up to 0.50 adult/ plant in 4th week of April (17th SMW) with the decrease of aphid population. It decreased up to 0.23 adult/ plant in 5th week of April (18th SMW). The activity of adult disappeared on cowpea from 1st week of May (19th SMW).

Syrphid fly maggot

The activity of predator *i.e*. syrphid fly maggot recorded during the summer season of the year 2017 are presented in Table 1 and depicted in Fig. 1. The activity of syrphid fly maggot commenced from 2nd week of March (11th SMW) with the population of 0.20 maggot/ plant. The population of syrphid fly maggot increased up to 0.93 maggot/ plant in 1st week of April (14th SMW). Syrphid fly maggot population declined quickly up to 0.33 maggot/ plant in 4th week of April (17th SMW) and activity of syrphid fly maggot disappeared on cowpea crop from 5th week of April and 1st week of May (18th and 19th SMW).

***Kharif*, 2017**

Aphid, *A. craccivora*

The data on number of aphids/ twig are presented in Table 2 and depicted in Fig. 2. It can be seen from the data that population of *A. craccivora* was 0.29/ twig on 4th week of August (35th SMW) and increased to 3.40/ twig during next week. It decreased drastically (1.01/twig) on 2nd week of September (37th SMW). Again the incidence of aphid jumped and was found 6.10/ twig on 3rd week of September (38th SMW). Its activity continuously increased and reached to peak level (30.10/twig at flowering and pod developing stage) during 1st week of October (40th SMW). After attaining peak level, the pest started declining from 2nd to 4th week of October (41th to 43th SMW). The pest disappeared with maturity of crop from 1st week of November (44th SMW).

Patel *et al*. (2007) [11] reported that the population of aphid first appeared during third week of February, slowly increasing in the subsequent weeks and reached to its maximum (10.22/10 cm twig) level during third week of March. Patel (2006) [10] revealed that the aphid population in cowpea started from the first week after sowing (4th week of February). Further, the population of aphid increased and reached to peak level coinciding with the second week of March, then after the aphid population was observed all over the crop period. Aphid population was maximum at 60 days after sowing and then after declined towards the crop maturation. Thus, the above reports are more or less in corroboration with the present reports.

Table 2: Population fluctuation of *A. craccivora* and it's predatory fauna on cowpea during *kharif*, 2017

Month & week		SMW	Week after sowing	No. of aphids/ twig	Predators/ plant		
					Coccinellids		Syrphid fly maggot
					Grubs	Adults	
August	3	34	3	0.00	0.00	0.00	0.00
	4	35	4	0.29	0.17	0.10	0.07
September	1	36	5	3.40	0.57	0.13	0.17
	2	37	6	1.01	0.33	0.17	0.13
	3	38	7	6.10	0.47	0.23	0.27
	4	39	8	23.66	0.97	0.47	0.53
October	1	40	9	30.10	1.80	1.07	0.97
	2	41	10	26.07	1.67	1.03	0.80
	3	42	11	25.00	1.07	0.73	0.67
	4	43	12	5.07	0.73	0.33	0.23
November	1	44	13	0.00	0.00	0.00	0.00

SMW: Standard Meteorological Week

Coccinellid grubs

The data on population of predator *i.e*. coccinellid grubs recorded during the *kharif* season of the year 2017 are presented in Table 2 and depicted in Fig. 2. The activity of coccinellid grubs commenced from 4th week of August (35th SMW) with the population of 0.17 coccinellid grub/ plant. The population of coccinellid grub increased up to 1.80 grubs/ plant in 1st week of October (40th SMW). Population of coccinellid grubs declined in trend from 2nd to 4th week of October (41th to 43th SMW). During these periods the aphid population was also in decreasing trend. Coccinellid grubs disappeared from 1st week of November (44th SMW) which was in coincidence with population of aphid.

Coccinellid adults

The data on population of predator *i.e*. coccinellid adults recorded during the *kharif* season of the year 2017 are presented in Table 2 and depicted in Fig. 2. The activity of coccinellid adult commenced from 4th week of August (35th SMW) with the population of 0.10 coccinellid adult/ plant. The population of coccinellid adult increased up to 1.07 adults/ plant in 1st week of October (40th SMW). Population of coccinellid adult declined quickly up to 0.73 adult/ plant in 3rd week of October (42th SMW) with the decrease of pest population. It decreased up to 0.33 adult/ plant in 4th week of October (43th SMW). The activity of adults disappeared on cowpea from 1st week of November (44th SMW).

According to Chaoudhary *et al*. (2017) [3], the population of the predators (*Coccinella septempunctata* and *Menochilus sexmataculatus*) increased with the increased aphid population in cowpea. Gauns *et al.* (2014) [5] also reported population of coccinellid beetle from August to October in cowpea at Rahuri with peak population during 42 SMW. In present investigation, the peak population of coccinellid adults was also found during October. Hence, these reports also support the results of present findings.

Syrphid fly maggot

The activity of predator *i.e.* syrphid fly maggots recorded during the *kharif* season of the year 2017 are presented in Table 2 and depicted in Fig. 2. The activity of syrphid fly maggot commenced from 4th week of August (35th MSW) with the population of 0.07 maggot/ plant. The population of syrphid fly maggot increased up to 0.97 maggot/ plant in 1st

week of October (40th SMW). Syrphid fly maggot population declined quickly up to 0.23 maggot/ plant in 4th week of October (43th SMW) and activity of maggot disappeared on cowpea crop from 1st week of November (44th SMW).
Patel (2015) [12] recorded the population of syrphid fly maggot on cauliflower during 3rd SMW (3rd week of January) with 0.16 maggot/ plant. The population of syrphid fly maggot increased up to 1.50 maggots/ plant during 9th SMW (1st week of March). The present findings could not match with these reports.

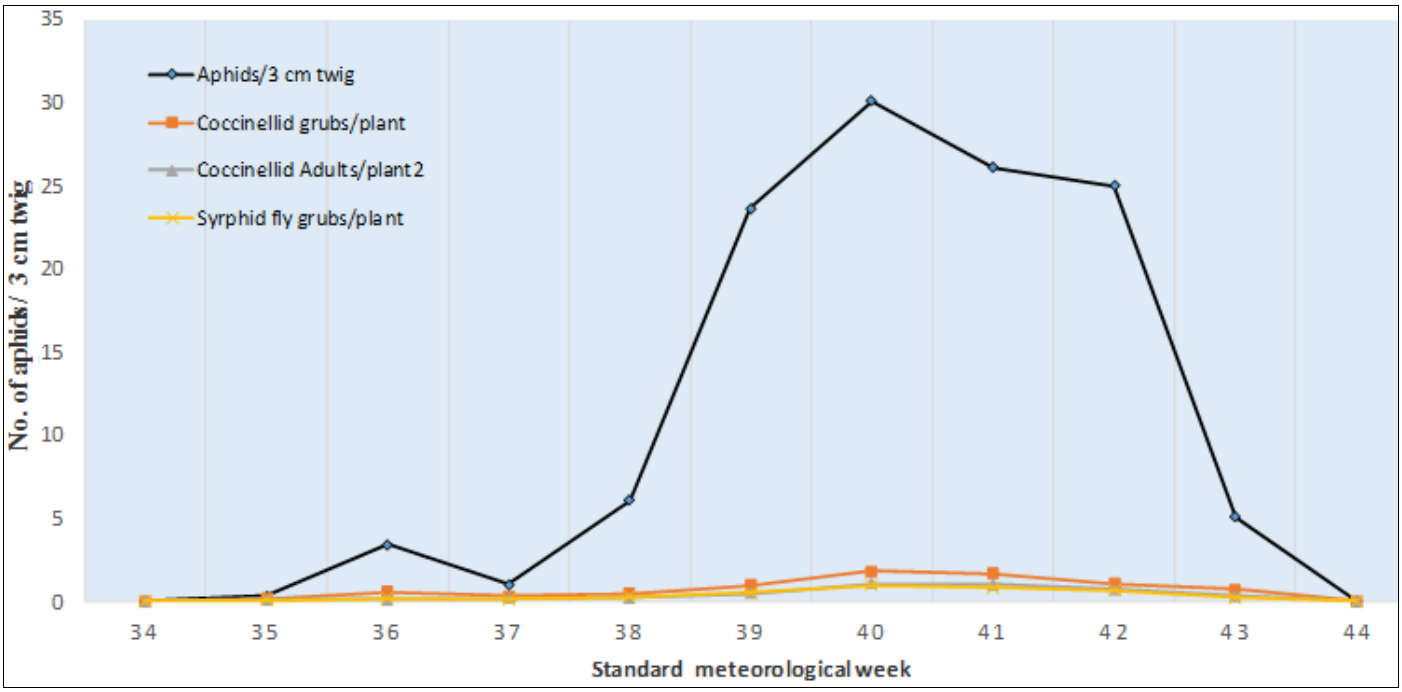

Fig 2: Population fluctuation of *A. craccivora* on cowpea during *kharif*, 2017

Effect of weather parameters on population of aphid and its predators

Summer, 2017

Aphid, *A. craccivora*

The data of aphid population did not exhibit significant correlation with any of the abiotic factors (Table 3). However, maximum temperature (r= 0.278), minimum temperature (0.323), morning vapour pressure (0.233), bright sunshine hours (0.129) and wind velocity (0.497) exhibited positive but non-significant correlation. However, morning relative humidity ((r = -0.017), evening relative humidity (r = -0.077) and evening vapour pressure (r = -0.023) were found to negatively correlated with aphid population but were non-significant. It indicated that there was no established relationship between abiotic factors and aphid activity on cowpea.

Coccinellid grubs

The data of coccinellid grubs did not exhibit any significant correlation with any of the weather factors under study (Table 3). Maximum temperature (r = 0.273), minimum temperature (r = 0.204), morning vapour pressure (r = 0.014) and wind velocity (r = 0.202) exhibited positive but non-significant correlation. Whereas, morning relative humidity (r = -0.257), evening relative humidity (r = -0.269), evening vapour pressure (r = -0.207) and bright sunshine hours (r = -0.146) were found to exhibit negative correlation but were non-significant.

Coccinellid adults

Maximum temperature (r = 0.295), minimum temperature (r = 0.280), morning vapour pressure (r = 0.143) and wind velocity (r = 0.268) exhibited positive but non-significant correlation. However, morning relative humidity (r = -0.115), evening relative humidity (r = -0.133), evening vapour pressure (r = -0.039) and bright sunshine hours (r = -0.089) were found to exhibit negative but non-significant correlation. However, these abiotic factors were found non-significant with the activity of this predator (Table 3).

Table 3: Correlation between weather parameters and *A. craccivora* as well as its natural enemies in cowpea during summer and *kharif*, 2017

Weather parameter	Aphids	Natural enemies		
		Coccinellids		Syrphid maggot
		Grubs	Adults	
Summer, 2017: Correlation coefficient (r)				
Maximum temperature (^{0}C)	0.278	0.273	0.295	0.231
Minimum temperature (^{0}C)	0.323	0.204	0.280	0.168
Morning relative humidity (%)	-0.017	-0.257	-0.115	-0.121
Evening relative humidity (%)	-0.077	-0.269	-0.133	-0.216
Morning vapour pressure (mm)	0.233	0.014	0.143	0.045
Evening vapour pressure (mm)	-0.023	-0.207	-0.039	-0.162
Bright Sunshine (h/day)	0.129	-0.146	-0.089	-0.129
Wind velocity (kphr)	0.497	0.202	0.268	0.233

Kharif, 2017: Correlation coefficient (r)				
Maximum temperature (^{0}C)	0.590	0.587	0.642*	0.614*
Minimum temperature (^{0}C)	0.001	0.018	-0.024	0.024
Morning relative humidity (%)	-0.501	-0.605*	-0.563	-0.581
Evening relative humidity (%)	-0.347	-0.346	-0.364	-0.330
Morning vapour pressure (mm)	-0.090	-0.071	-0.109	-0.070
Evening vapour pressure (mm)	0.157	0.064	0.099	0.140
Rainfall (mm)	-0.483	-0.431	-0.406	-0.442
Bright Sunshine (h/day)	0.541	0.486	0.471	0.491
Wind velocity (kphr)	-0.233	-0.280	-0.295	-0.243

Note: * Significant at 0.05% level of significance (r = 0.602)

Syrphid fly maggot

The data of maggot did not exhibit any significant correlation with any of the weather factors under study (Table 3). Maximum temperature (r = 0.231), minimum temperature (r = 0.168), morning vapour pressure (r = 0.045) and wind velocity (r = 0.233) exhibited positive but non-significant correlation. However, morning relative humidity (r = -0.121), evening relative humidity (r = -0.216), evening vapour pressure (r = -0.162) and bright sunshine hours (r = -0.129) were found negatively correlated but were non-significant.

***Kharif*, 2017**

Aphid, *A. craccivora*

The data of aphid did not exhibit significant correlation with any of the abiotic factors (Table 3). However, maximum temperature (r = 0.590), minimum temperature (r = 0.001), evening vapour pressure (r = 0.157) and bright sunshine hours (r = 0.541) exhibited positive but non-significant correlation. Whereas, morning relative humidity (r = -0.501), evening relative humidity (r = -0.347), morning vapour pressure (r = -0.090), rainfall (r = -0.483) and wind velocity (r = -0.233) were found to exhibit negative correlation but were non-significant with aphid population.

Srikanth and Lakkundi (1990) [15] mentioned that population of aphids increased quickly with crop growth and pod formation stage. The relative humidity showed no significant effect on population fluctuations of aphid by Shalaby *et al.* (2012) [16]. Augustine (2011) [2] noted the peak activity of aphid from 7 to 10 weeks after sowing and remained active all over the crop period. Thus, the present findings are in agreement with the earlier reports.

Coccinellid grubs

Maximum temperature (r = 0.587), minimum temperature (r = 0.018), evening vapour pressure (r = 0.064) and bright sunshine hours (r = 0.486) positively correlated but were non-significant. However, evening relative humidity (r = -0.346), morning vapour pressure (r = -0.071), rainfall (r = -0.431) and wind velocity (r = -0.280) were found to exhibit negative correlation but were non-significant. And morning relative humidity was found to exhibit significant negative correlation between range of 83.71 to 98.00% (r = -0.605*) with the activity of the predator (Table 3).

Coccinellid adults

Maximum temperature exhibited significant positive correlation between temperature range of 31.90 to 37.31 ^{0}C (r = 0.642*) while evening vapour pressure (r = 0.099) and bright sunshine hours (r = 0.471) exhibited positive but non-significant correlation. The abiotic factors *viz.,* minimum temperature (r = -0.024), morning relative humidity (r = -0.563), evening relative humidity (r = -0.364), morning vapour pressure (r = -0.109), rainfall (r = -0.406) and wind velocity (r = -0.295) were found to exhibit negative but non-significant correlation (Table 3). Jadhav *et al.* (2017) [7] showed that the population of lady bird beetle significant correlated with maximum temperature, minimum temperature, evaporation and negatively significant correlated with morning RH and evening RH. Rainfall showed non-significant negative correlation while morning relative humidity showed non-significant positive correlation as reported by Yadav *et al.* (2015) [17]. Thus, present findings are in conformity with the earlier reports.

Syrphid fly maggot

Maximum temperature exhibited significant positive correlation between temperature range of 31.90 to 37.31 ^{0}C (r = 0.614*) while minimum temperature (r = 0.024), evening vapour pressure (r = 0.140) and bright sunshine hours (r = 0.491) exhibited positive but non-significant correlation. However, morning relative humidity (r = -0.581), evening relative humidity (r = -0.330), morning vapour pressure (r = -0.070), rainfall (r = -0.442) and wind velocity (r = -0.243) were found to exhibit negative correlation but were non-significant (Table 3). Jadhav *et al.* (2017) [7] revealed that the population of syrphid fly in okra was non-significant positive correlation with maximum temperature, minimum temperature and bright sunshine hours while morning relative humidity, evening relative humidity and rainfall negative correlation but non-significant. Thus, more or less, present findings are in accordance with the earlier reports but, no information is available on association of abiotic factors with syrphid fly in cowpea.

Association between *A. craccivora* and natural emenies on cowpea

During the study period, the population of aphid, *A. craccivora* and natural enemies *viz.,* coccinellids (grubs and adults) and syrphid fly maggot were recorded on cowpea at various stages of the crop and correlation coefficient was worked out (Table 4) to know the relation in between aphid and predators.

Summer, 2017

The correlation between aphid and predatory population *viz.,* coccinellid grubs (r = 0.881**), coccinellid adult (r = 0.887**) and syrphid fly maggot (r = 0.878**) in summer, 2017 were found in highly significant positive association.

***Kharif*, 2017**

The correlation between aphid and predatory population *viz.,* coccinellid grubs (r = 0.929**), coccinellid adult (r = 0.941**) and syrphid fly maggot (r = 0.976**) in *kharif*, 2017 were found in highly significant positive association. The relationship between pests and predators indicated that with

the increase in population of aphids, the activity of coccinellids and syrphid fly also increased and vice-versa. Sarvaiya (2017) [14] observed that the significant positive correlation between grub of coccinellids and aphid population. Whereas, highly significant positive correlation between syrphid fly population and aphid population was observed. Srikanth and Lakkundi (1990) [15] reported that the activity of predatory coccinellids started from 1 to 3 weeks after the appearance of aphids. The peak predator population was observed when aphid population was very high. Highly significant positive correlation was found between aphid and predator population. These reports are in corroboration with the present findings.

Table 4: Correlation between *A. craccivora* and its natural enemies on cowpea

Natural enemies	Aphids
Summer, 2017: Correlation coefficient (r)	
Coccinellid grubs	0.881**
Coccinellid adults	0.887**
Syrphid fly maggots	0.878**
***Kharif*, 2017: Correlation coefficient (r)**	
Coccinellid grubs	0.929**
Coccinellid adults	0.941**
Syrphid fly maggots	0.976**

Note: ** Significant at 0.01% level of significance (r = 0.735)

In conclusion, aphid incidence on cowpea crop was observed from March to April in summer and from August to October. In *kharif*, 2017, peak level of aphid population was observed when cowpea crop at vegetative to pod formation stage. The incidence of aphid did not exhibit any significant correlation with any of the abiotic factors. The correlation between aphid and predatory population *viz.*, coccinellid grubs, adult and syrphid fly maggot in summer as well as *kharif*, 2017 showed highly significantly association. The relationship between pests and predator indicated that the population of aphid increased, the activity of predators were also increased and vice versa.

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