Journal Home page : www.jeb.co.in ★ E-mail : editor@jeb.co.in

JEB
Journal of Environmental Biology

ISSN: 0254-8704
CODEN: JEBIDP

Seasonal dynamics of wheat aphid complex and predator *Coccinella septempunctata* in relation to abiotic and biotic factors

Rajesh Soni[1], G.S. Deol[1] and Satnam Singh[2]*

[1]*Punjab Agricultural University, Ludhiana-141 004, India*
[2]*Punjab Agricultural University, Regional Station, Faridkot-151 203, India*
**Corresponding Author email : drsatnamsinghs@gmail.com*

Publication Info

Paper received:
07 September 2011

Revised received:
07 June 2012

Re-revised received:
30 June 2012

Accepted:
08 August 2012

Abstract

Seasonal dynamics studies on wheat aphid complex, comprising of four major species and its predator *Coccinella septempunctata* were conducted in context to abiotic and biotic factors. The alate form of aphids appeared on the crop during the I[st] week of December. The colony build up of aphid complex started during the 2[nd] week of January and peak was observed after the I[st] week of March. Wheat aphid complex started declining in the last week of March and disappeared by mid April. The abiotic factors like maximum temperature and evaporation were most important for the build up of aphids. The grubs and adults of *C. septempunctata* appeared on the crop during mid February and their population increased with the increase in aphid population. The grubs and adult population showed a strong positive correlation with aphid complex. The population of predators had significant positive correlation with maximum, minimum, mean temperature, sunshine and vapour pressure. The population of aphids declined after the 2[nd] week of March due to the rise in temperature, crop maturity and this in turn resulted in the lowering of the predator population. The studies evaluate in detail the abiotic and biotic factors regulating the wheat aphid complex and *C. septempunctata* populations under wheat agro-ecosystem.

Key words

Coccinella septempunctata, Wheat aphid, Biotic and abiotic factors

Introduction

In India wheat (*Triticum aestivum*) is a premier winter cereal crop and attacked by more than eleven aphid species, out of them four species namely *Sitobion avenae* (Fabricius), *S. miscanthi* and *Rhopalosiphum padi* and *R. maidis* are reported to be most predominant (Jarosik *et al.,* 2003) and combined population of these four is designated as wheat aphid complex (Aslam *et al*., 2004). The aphid attacks wheat crop from seedling stage onwards, but are not easily detected on the crop owing to their small size and green colour (Aheer *et al.,* 2008). Aphid populations stay on wheat for a short, distinct time period during which they multiply rapidly and cause heavy losses to the crop (Jarosik *et al.*, 2003). Aphids number 5, 15, 30 and 50 per earhead can cause 13.3, 27.8, 38.1 and 47.7 % reduction in grain weight, respectively (Deol *et al*., 1987), however, a single aphid has been reported to cause 2.20 % loss in grain yield (Aheer *et al.*, 2007). The wheat aphid population under the agro ecosystem is regulated by number of biotic and abiotic factors (Asin and Pons, 2001), among biotic, Coccinellids, Syrphids and *Leucopis* spp. are generally known to prey on aphids (Shujing *et. al.* 2004). Seven spotted ladybird beetle, *C. septempunctata* is a potential feeder of wheat aphids and regulates aphid populations significantly in the field (Soni *et al.,* 2007). Thus both abiotic and biotic factors play an important role in the population build up of aphid complex and its predator population in the field (Aheer *et al*., 2007; Ashfaq *et al.*, 2007; Aheer *et al.*, 2008; Wains *et al.*, 2008).

Most of the studies in context to aphid seasonal dynamics i.e. seasonal appearance under natural conditions, have been carried out either with abiotic or biotic factors and only few reports are on the mutual effect of both factors on the

incidence of aphids as well as its predator. Keeping in view the gap, the present studies have been formulated to find out the interaction between prey, predator and environment factors to understand the population dynamics in order to evolve better management practices to reduce the damage caused by aphid complex.

Materials and Methods

The test wheat variety PBW 343 was sown in *Rabi* season in the Experimental Area of Department of Plant Breeding, Genetics and Biotechnology, PAU, Ludhiana. The crop was grown as per recommendation of PAU, Package and Practices for Rabi Crops (Anonymous, 2002). Four, 10 m^2 (5m x 2m) plots were chosen randomly and from each plot 10 plants were selected randomly and tagged. Aphid complex and predator (grubs and adults) populations were counted per shoot per earhead at weekly interval (from 40 shoots per earheads). The date of first appearance of aphid and predator (grub and adult) were recorded. The data on aphid complex and predator population (biotic factor, grubs and adults) were recorded from germination onwards and continued till crop maturity.

The data on weather parameter viz. maximum, minimum, mean temperature, mean relative humidity, rainfall, evaporation, sunshine hours, wind velocity and mean vapour pressure were obtained from the Agrometeorological Observatory PAU, Ludhiana, India. The mean and simple correlation was calculated in order to find possible relationship of wheat aphid complex and *C. septempunctata* population with various meteorological factors (abiotic) and biotic factors (predator for aphid and aphid for predator).

Results and Discussion

Incidence of wheat aphid complex: The data presented in Table 1 reveals that the different environmental parameters are closely associated with the incidence of aphid complex and predator population. The winged (alate) aphids appeared during the 1st week of December, when plants were in the seedling stage and atmospheric temperature, relative humidity, evaporation, sunshine, wind velocity and vapour pressure were 13.1˚C (5.6-20.7 ˚C), 59 %, 2 mm, 10 hrs, 41 km hr^{-1} and 5.9 mm, respectively. The population of alate forms disappeared at the end of December and was not detected up to early January. There was no aphid population from last week of December to 1st week of January probably because of rainfall (3 mm) on 30th December which washed away the aphid population and also resulted in lowering of temperature, sudden increase of humidity from 74 to 95 % and less sunshine hours, all favouring the decline in aphids population. Singh *et al*. (2001) also reported that mild rainfall in early winter season is highly contributing to the decline in the aphid complex population and this may due to the rain water washing away the aphids as well also lowering of temperature. However, Aheer *et al.* (2007) demonstrated that the effect of rainfall was found to be non- significant.

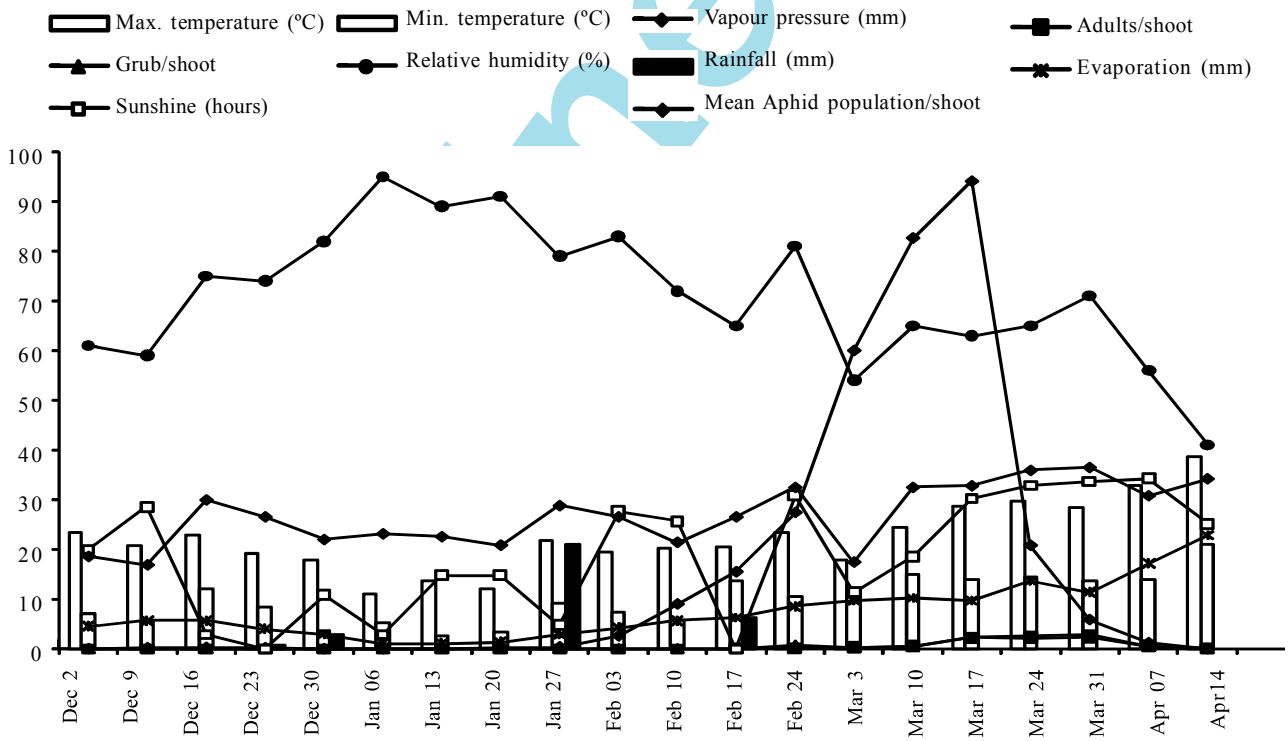

Fig. 1 : Influence of abiotic and biotic factors on aphid complex and *C. septumpunctata* population

Table 1 : Influence of abiotic and biotic factors on aphid complex and predator, *C septempunctata* population

Month	Date	Mean Aphid* /shoot	*C. septempunctata**/shoot			Air temperature (°C)			RH (%)	Rainfall (mm)	Evaporation (mm)	Sunshine (hours)	Wind velocity (km hr^{-1})	Vapour pressure (mm)
			Adult	Grub	Grub + adult	Max.	Min.	Mean						
Dec.	2	0.00	0.00	0.00	0.00	23.5	7.0	15.3	61.0	0.0	1.6	7.0	2.2	6.5
	9	0.05	0.00	0.00	0.00	20.7	5.6	13.1	59.0	0.0	2.0	10.0	4.1	5.9
	16	0.08	0.00	0.00	0.00	23.0	12.0	17.5	75.0	0.0	2.0	1.0	1.2	10.5
	23	0.05	0.00	0.00	0.00	19.2	8.4	13.8	74.0	0.9	1.4	0.0	4.4	9.3
	30	0.00	0.00	0.00	0.00	18.0	3.8	10.9	82.0	3.0	1.0	3.8	2.5	7.7
Jan.	6	0.00	0.00	0.00	0.00	11.0	5.2	8.1	95.0	0.0	0.4	1.0	2.6	8.1
	13	0.03	0.00	0.00	0.00	13.6	2.5	8.1	89.0	0.0	0.4	5.2	5.0	7.9
	20	0.08	0.00	0.00	0.00	12.2	3.4	7.8	91.0	0.0	0.5	5.2	3.7	7.3
	27	0.12	0.00	0.00	0.00	21.8	9.2	15.5	79.0	2.1	1.0	1.7	2.7	10.1
Feb.	3	0.90	0.00	0.00	0.00	19.4	7.4	13.4	83.0	0.0	1.5	9.7	3.4	9.3
	10	3.15	0.00	0.00	0.00	20.2	5.8	13.0	72.0	0.0	2.0	9.0	2.1	7.5
	17	5.42	0.05	0.00	0.05	20.4	13.8	17.1	65.0	6.2	2.2	0.0	17.1	9.3
	24	9.60	0.20	0.75	0.95	23.4	10.5	16.9	81.0	0.0	3.0	10.8	3.9	11.4
Mar.	3	21.02	0.35	0.17	0.52	17.8	10.8	14.3	54.0	0.0	3.4	4.0	3.6	6.1
	10	28.95	0.58	0.42	1.00	24.5	15.0	19.7	65.0	0.0	3.6	6.5	7.1	11.4
	17	32.96	2.30	2.35	4.65	28.8	14.0	21.4	63.0	0.0	3.4	10.6	2.7	11.5
	24	7.28	2.50	2.20	4.70	29.7	14.4	22.1	65.0	0.0	4.8	11.5	4.1	12.6
	31	2.05	2.85	2.25	5.10	28.4	13.8	20.5	71.0	0.0	4.0	11.8	5.0	12.8
April	7	0.43	0.55	0.40	0.95	33.0	13.9	23.5	56.0	0.0	6.0	12.0	4.5	10.8
	14	0.00	0.15	0.02	0.17	38.8	21.0	29.9	41.0	0.0	8.0	8.8	3.9	12.0

*Mean of 40 observations

Table 2 : Correlation coefficient between various abiotic and biotic factors and wheat aphid complex

Factors	Month wise correlation coefficient (r)				
	December	January	February	March	December-April
Abiotic factors					
Maximum temperature	0.207	0.842	0.956	-0.291	0.179
Minimum temperature	0.749	0.659	0.553	0.012	0.385
Mean temperature	0.564	0.806	0.815	-0.175	-0.275
Mean relative humidity	-0.008	-0.872	-0.039	-0.471	-0.293
Rainfall	-0.524	0.827	0.118	0.000	-0.150
Evaporation	0.703	0.903	0.993	-0.738	0.237
Sunshine	-0.336	-0.012	0.001	-0.483	0.186
Wind velocity	0.061	-0.226	0.173	-0.054	0.115
Vapour pressure	0.587	0.637	0.735	-0.329	0.241
Biotic factors					
Adult	0.000	0.000	0.948	-0.550	0.416
Grub	0.000	0.000	0.867	-0.373	0.457
Adult + Grub	0.000	0.000	0.931	-0.468	0.436
r (p=0.05)	0.878	0.950	0.950	0.878	0.444

The aphid colony build up started from 2nd week of January, however the population was very low (0.12 aphid per shoot per earhead) at the end of January when minimum and maximum temperature was 9.2°C and 23.8°C and relative humidity was 79 %. With the slight increase in maximum temperature from February onwards there was steady increase in aphid complex population. The aphid population crossed the economic threshold level from the mid February and was above the economic injury level in the month of March. The maximum aphid complex population (32.96 aphids per shoot per earhead) was recorded in 3rd week of March (Table 1). Consequently this population started declining at the end of March and disappeared completely during 2nd week of April when maximum temperature was 38.8°C and mean relative humidity was 41%, possibly owing to the combined action of weather factors, high density of natural enemies, maturity of crop and migration of alate forms.

Temperature may be considered as a key factor for regulating the aphid complex population in wheat, the temperature range from 20.2 to 28.8°C was most favourable for buildup of aphid colonies in the field. The slight increase in temperature after mid January (6-22°C) contributed to the appearance of the both winged and wingless aphid colonies in leaf whorls on early sown wheat (Singh and Deol, 1994). Hassan *et al.* (2004) also concluded that population of aphids was maximum in the 4th week of February and temperature from mid February to mid March was most favourable for the aphid multiplication. The present findings are also comparable with Nasir and Ahmad (2001) reporting abiotic factors to be very important for population build-up of wheat aphid complex.

Incidence of *C. septempunctata* population: The first appearance of predator *C. septempunctata* adult was recorded (0.05 adult per shoot per earhead) in 3rd week of February (Table 1). The colony of aphids started appearing; when temperature and humidity was 17.1°C (13.8-20.4°C) and 65 %, respectively. The appearance of grub was recorded week after the appearance of adult. The population of adults, grubs and pupae steadily increased due to the availability of plenty food (aphids). The adult population reached peak at the end of March (2.85 adults per shoot per earhead) when temperature and atmospheric humidity was 20.5°C (13.8-28.4°C) and 71 %, respectively. The population of grubs reached peak in 3rd week of March (2.35 grubs per shoot per earhead) when, temperature and atmospheric humidity was 21.4°C (14-28.8°C) and 63 %, respectively. The population of adult *C. septempunctata* declined steadily from the 1st week of April probably due to scarcity of food (aphids) which caused the migration of adults and also decreased the young stages (grubs) of *C. septempunctata.*

The environmental factors like high maximum temperature (33ºC), low humidity (56 %), high evaporation (6 mm), more sunshine (12 hrs), high wind velocity (4.5 km hr^{-1}) and high vapour pressure (10.8 mm) after the 1st week of April, also played a key role in the decline of adult and grub population. Soni *et al.* (2007) reported seven spotted ladybird beetle, *C. septempunctata* as a potential feeder of wheat aphids that played a predominant role in regulating the aphid population. The first appearance of predator (grubs and adults) during February coincided with the appearance of wheat aphids. The population of predator reached peak when the aphid population was maximum. This infers that the abiotic factors regulating the aphid complex population have a similar impact on the predator populations.

Correlation between abiotic and biotic factors and wheat aphid complex : Correlation study revealed that none of the abiotic and biotic factors had significant correlation with

Table 3 : Correlation coefficient between various factors and *C. septempunctata* population

Factors	Month wise correlation coefficient (r)								
	February			March			Overall month +April		
	Adult	Grub	Grub+ adult	Adult	Grub	Grub+ adult	Adult	Grub	Grub + adult
Abiotic factor									
Maximum temperature	0.979	0.969	0.982	0.882	0.899	0.895	0.487	0.464	0.477
Minimum temperature	0.444	0.212	0.381	0.437	0.456	0.449	0.467	0.435	0.453
Mean temperature	0.736	0.545	0.686	0.774	0.804	0.792	0.484	0.458	0.473
Mean relative humidity	0.269	0.460	0.325	0.722	0.652	0.692	-0.227	-0.206	-0.218
Rainfall	-0.088	-0.333	-0.159	0.000	0.000	0.000	-0.173	-0.165	-0.169
Evaporation	0.939	0.882	0.928	0.566	0.462	0.519	-0.432	0.386	0.411
Sunshine	0.224	0.459	0.293	0.979	0.966	0.978	0.548	0.532	0.542
Wind velocity	-0.011	-0.259	-0.082	-0.325	-0.420	-0.372	-0.002	-0.028	-0.014
Vapour pressure	0.886	0.847	0.881	0.769	0.749	0.764	0.632	0.607	0.622
Biotic factor									
Wheat aphid complex (Host)	0.948	0.867	0.931	-0.550	-0.373	-0.468	0.416	0.457	0.436
Grub	0.968			0.979			0.991		
Adult		0.968			0.979			0.991	
r (p=0.05)	0.950	0.900	0.950	0.878	0.878	0.878	0.444	0.444	0.444

population build up of aphids during the month of December, January and March. However, in February, maximum temperature and evaporation had significant positive correlation with aphid population. In overall (December-April), aphid complex population had significant positive correlation with grubs population with 'r' value of 0.457 among biotic factor. Similar to our findings Aheer *et al.* (2007, 2008) reported that minimum and maximum temperatures had a significant and positive role in causing fluctuation in the aphid population, however relative humidity revealed a negative and significant correlation with aphid population (Wains *et al.*, 2008).

Correlation between abiotic and biotic factors with *C. septumpunctata:* In February, the adults had significant positive correlation with maximum temperature and population of grubs (Table 3). Similarly, in March the adult predator population had a significant positive correlation with maximum temperature, sunshine and population of grubs. The population of grubs had significant positive correlation with maximum temperature and adults in February. However, in March besides these two factors sunshine hours also influenced the grub population. Overall the grubs population had significant positive correlation with maximum temperature (r = 0.464), mean temperature (r = 0.458), sunshine hours (r = 0.532) and vapour pressure (r = 0.607) from December-April. Among the biotic factor grubs population had significant positive correlation with aphid and adult predator population with latter having significant positive correlation with grubs population across the wheat season. The combined population of grubs and adults had significant positive correlation with maximum temperature in February and with sunshine and maximum temperature in March.

Khan *et al.* (2011) reported that *C. septempunctata* populations in wheat had a strong positive and significant correlation with the aphid numbers in the field. The high temperature, low humidity, high evaporation rate, long sunshine day, high wind velocity, high vapour pressure, maturity of crops and migration of alate forms probably declines the aphid population in the field after the Ist week of April and ultimately the decline of predator population due to the unavailability of the food (aphids). Present findings reveal that the aphid population declined from the second fortnight of March and completely disappeared in the 2nd week of April due to combined effect of natural enemies, high temperature and maturity of crop and same has been reported by many workers (Singh and Deol, 1994; Wains *et al.,* 2010)

Overall correlation study of wheat aphid complex showed positive correlation with the grubs population of predator, as the grub is potential feeder of aphids than adults (Soni *et al.,* 2008), while the population of predator has significant positive correlation with maximum, minimum, mean temperature, sunshine and vapor pressure. The information generated from the present studies can be used for management of the aphid under field conditions through conservation of the *C. septumpunctata*, appropriate time of insecticide applications and manipulation of sowing time. It is thus evident that among abiotic factors, maximum temperature and evaporation were most important for population build up of aphids. The correlation coefficient

study revealed that grub population showed significant effect on aphid complex population. The population buildup of adults and grubs of *C. septempunctata* were mainly dependent on different abiotic factor like temperature, sunshine, vapour pressure and availability aphid food.

References

Aheer, G.M., A. Ali and M. Munir: Abiotic factors effect on population fluctuation of alate aphids in wheat. *J. Agric. Res*., **46**, 367–371 (2008).

Aheer, G.M., M. Munir and A. Ali: Impact of weather factors on population of wheat aphids at Mandi Baha-ud-Din district. *J. Agric. Res.,* **45**, 61–66 (2007).

Anonymous: Package of Practices for crops of Punjab- Rabi 2002. Punjab Agricultural University, Ludhiana (2002).

Ashfaq, M, J. Iqbal, A. Ali and U. Farooq: Role of abiotic factors in population fluctuation of aphids on wheat. *Pak. Entomol*.**, 29**, 117–122 (2007).

Asin, L. and X. Pons: Effect of high temperature on the growth and reproduction of corn aphids (Homopetra: Aphididae) and implication for their population dynamics on the North Eastern Iberian Peninsula. *Environ. Entomol.*, **30**, 1127-34 (2001).

Aslam, M., M. Razaq, F. Ahmad, M. Faheem and W. Akhter: Population of aphid (*Schizaphis graminum* R.) on different varieties/lines of wheat (*Triticum aestivum* L.). *Intl. J. Agric. Biol.,* **6**, 974-977 (2004)

Deol, G.S., K.S. Gill and J.S. Brar: Aphid out break on wheat and barley in Punjab. *Newsletter Aphid Soc. India* **6**, 7-9 (1987).

Hassan, M.M., G. Nisar, A. Ali and G.M. Aheer: Impact of predators on aphids in normal sown wheat advanced lines/varieties. *J. Nat. Sci*., **2,** 41–49 (2004).

Jarosik, V., A. Honek and A. Tichopad: Comparison of field population growths of three cereal aphid species on winter wheat. *Plant Protect. Sci.,* **39**, 61–64 (2003).

Khan, A.A., A.M. Khan, H.M. Tahir, M. Afzal, A. Khaliq, S.Y. Khan and I. Raza: Effect of wheat cultivars on aphids and their predator populations. *African J. Biotech.,* **10**, 18399-18402 (2011).

Nasir, S. and F. Ahmad: Correlation between wheat aphid population and abiotic factors. *Pak. Entomol.,* **23**, 23–25 (2001).

Shujing, G., P. Baoping, Y. Yang and L. Hui: Seasonal dynamics and structures of insect communities in wheat fields. *Chinese J. Ecol.,* **6**, 47-50 (2004).

Singh, V.S., S.M.V. Sekhar and R.P. Sharma: Root aphid infestation in wheat at Delhi and its control. *Indian J. Enotomol.,* **63**, 197-201 (2001).

Singh, S. and G.S. Deol: Studies on the biology of grain aphid *Sitobion avenae* (Fabricius) on wheat. *J. Res. Punjab. Agric. Univ.,* **31**, 412-20 (1994).

Soni, R., G.S. Deol and K.S. Brar: Feeding potential of *Coccinella septempunctata* Linnaeus on wheat aphid complex response to level/intensity of food. *J. Insect Sci.,* **21**, 90-92 (2008).

Soni, R., G.S. Deol and K.S. Brar: Feeding potential of *Coccinella septempunctata* Linn. (Coleoptera: Coccinellidae) on wheat aphid complex under cage conditions. *J. Insect Sci.,* **20**,118-119 (2007).

Wains, M.S, M.A. Ali, M. Hussain, J. Anwar, M. Zulkiffal and S. Waseem: Aphid dynamics in relation to meteorological factors and various management practices in bread wheat. *J. Plant Protec. Res.,* **50**, 386-392 (2010)

Wains, M.S., Aziz-ur-Rehman, M. Latif and M. Hussain: Aphid dynamics in wheat as affected by weather and crop planting time. *J. Agric. Res*., **46**, 361-366 (2008).