SVU-International Journal of Agricultural Science
Volume 2 Issue (1) pp.: 27-37, 2020
Print ISSN 2636-381X | Online ISSN 2636-3801
Doi: 10.21608/svuijas.2020.22750.1000

RESEARCH ARTICLE

Effect of biotic and abiotic factors on the population dynamics of wheat greenbug, *Schizaphis graminum* (Rondani) (Hemiptera: Aphididae) under Sohag governorate conditions.

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Abstract: The present study was carried out in the Agriculture Experimental of Shandaweel Agriculture Research Station, Sohag Governorate during two successive seasons of 2015/2016 and 2016/2017. Results of both seasons showed the population fluctuation of S. *graminum*. The obtained results revealed that greenbug increased from 0.60, 0.63 nymphs/tiller on 3rd, 4th week of January respectively, to reach a peak of 82.80, 66.40 nymphs/tiller in 2nd,3rd week of March respectively. Aptera of *S. graminum* started to appear in 4th week of January and increased to reach a maximum of 11.00, 4.7 individuals/tiller on both seasons respectively. The peak of alatae reached 3.90, 4.70 individuals/tiller respectively, in the 4th week of March. The population of all morphs started declining in the last week of March from field and disappeared by 1st week of April. The grubs and adults of *Coccinella septempunctata* Linné appeared on the crop during the beginning of February and their population increased with the increase in aphid population. Its abundance was maximum on the 4th week of March with average of 7.80, 9.06 individuals/tiller on both seasons respectively. The population of aphids had significant positive correlation with maximum, minimum, mean temperature were 0.6524, 0.481, 0.542 in first season and 0.5687,0.472, 0.364 in the second season respectively. But it showed negative correlation with humidity in both seasons -0.454, -0.391 respectively. The studies evaluate in detail the abiotic and biotic factors regulating the wheat aphid populations.

Keywords: Wheat aphid, *Schizaphis graminum* (R), biotic and abiotic factors.

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important and the most grown cereal crop. It is the staple food of many countries including Egypt. Its importance is derived from many properties and uses of its kernels, which make it a staple food for more than one-third of world ‘s population. Moreover, its straw is used as animal feed and in manufacturing paper (Milad *et al.*, 2013). Various factors like late sowing, traditional method of seedbed preparation, poor quality seed imbalance use of fertilizer, water shortage and especially poor insect control were responsible for the low production of wheat (El-Gizawy, 2009). However, aphids and thrips were considered two of the important pests attacking wheat plants and causing sever reduction in the yield (Slman, 2002). During the last few years, cereal

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Received: January 20, 2020;
Accepted: February 27, 2020;
Published: March 31, 2020.

aphid became serious insect pests attacking wheat plants in Egypt. Cereal aphids, *Rhopalosiphum padi* (L.), *Schizaphis graminum* (Rondani), *Sitobion avenae* (F). and *Diuraphis noxia* (Mordvilko) are the most destructive aphid species on wheat. They cause serious yield loss by reducing the number of grains and grain weight per spike of wheat, and indirectly by transmitting viruses (Crespo-Herrera *et al*., 2013).

The greenbug, *Schizaphis graminum*, is Palearctic but has been introduced to other parts of the world and is now in North and South America, Europe, Asia, and Africa (Blackman & Eastop, 2007). It was recorded on wheat plants for the first time by (El-Hariry, 1979). Biological control is a major element of integrated pest management plan. Coccinellids are common biological agents for controlling the aphid on cotton and wheat (Khan and Suhail, 2001). The number of lady beetles that develop in a field depends on environmental conditions and the size of the aphid population (Knutson *et al.*, 1997). Thus, both abiotic and biotic factors play an important role in the population buildup of aphid complex and its predator population in the field (Wains *et al.*, 2008). The aim of this study to find out the interaction between predator and environmental factors tounderstand the population dynamics in order to evolve better management practices to reduce the damage caused by aphids.

Materials and Methods

Studies were carried out on wheat, *Triticum aestivum* L. var. Shandaweel 1 that planted during the third week of November in both seasons, at Shandaweel Agric. Research Station, Sohag Governorate, through two successive growing seasons of 2015/2016 and 2016/2017. An experimental plot equivalent to 1/100 feddan (i.e. $42m^2$= 6mx7m), samples were taken periodically at seven days intervals from the 1st January until the harvest. No chemicals were used at the experimental plots. 10 plants were gathered randomly from three plots in order to direct count for aphid, *S. graminum* and *C. septempunctata*. The total number of aphid nymphs, alates and apterous adults of aphids (No. of aphids/tiller) were counted and recorded during the two studied seasons as well as its predator, *C. septempunctata*in situ on each plant. The individuals of aphids were recorded according to El Heneidy and Adly (2014). Data was analyzed by using average mean population of aphid and its bio-control agents in wheat crop based on monthly recording data.

The data on weather parameter viz. maximum, minimum, mean temperature and mean relative humidity (R.H.%) were obtained from ; www.accuweather.com and then recorded to correlate with the mean number of aphids in both studied seasons. The mean and simple correlation was calculated in order to find possible relationship of wheat aphid and *C. septempunctata* population with abiotic factors.

Results and Discussion

The population fluctuation of greenbug, *S. graminum* was studied during two successive seasons of 2015/2016 and 2016/2017. Data in Table (1) indicated the population densities of aphids in wheat plants during 2015/2016-2016/2017 seasons. The nymphs and apterae was first observed in the 4th week of January on 27 January with an average of 8.30, 0.70 and 6.33, 0.33

aphids/duplicate respectively in both seasons. Its alatae started to appear in 2nd week of February on 10 February (three weeks later) with an average of 0.50 aphids/duplicate in 2015/2016 while in 2016/2017 started to appear in 3rd week of February on 17 February with an average of 0.60 aphids/duplicate.

Thereafter the population fluctuated to reach a maximum of 82.80, 11.00 and 3.90 individuals for nymphs, aptera and alate on 9, 9 and 23 March respectively in season 2015/2016 and in the next season 2016/2017 the population reached the maximum number of aphids 66.40, 5.10, 4.70 individuals for nymphs, aptera and alate respectively on 16 March . A decline in the aphid population was recorded on 30 March. It is clear that population of alatae in both seasons nearly disappeared from wheat fields a week earlier than other forms. The decline of aphid at the end of month March is of course attributed to the senescence of the.crop.

Table 1. Population density of greenbug (*S. graminum*) in wheat fields at Shandaweel, Sohag, 2015/2016 and 2016/2017 seasons.

Sampling date		2015/2016				2016/2017			
		Nymph	Aptera	Alate	Total	Nymph	Aptera	Alate	Total
Jan.	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	27	8.30	0.70	0.00	9.00	0.63	0.33	0.00	0.96
Feb.	3	11.60	1.80	0.00	13.40	4.10	1.10	0.00	5.20
	10	16.70	2.40	0.00	19.10	11.20	1.90	0.50	13.60
	17	28.90	3.20	0.60	32.70	19.40	2.60	2.70	24.70
	24	47.30	7.60	1.30	56.20	32.00	3.40	3.10	38.50
Mar.	2	69.40	10.20	2.40	82.00	48.70	4.20	3.90	56.80
	9	82.80	11.00	3.20	97.00	59.90	4.80	4.20	68.90
	16	76.00	4.30	3.70	84.00	66.40	5.10	4.70	76.20
	23	33.40	1.20	3.90	38.50	21.30	3.30	2.30	26.90
	30	1.20	0.60	0.00	1.80	1.40	0.00	0.00	1.40
	Total	375.60	43.00	15.10	433.70	265.03	26.73	21.40	313.16
	Mean	28.892	3.31	1.16	33.362	20.387	2.06	1.65	24.089

Figure 1, show nymphs were common as compared with other forms in all aphid species. It consisted generally 86.62% as compared to 9.90% and 3.48% of grand total for apterous and alate forms, respectively in season 2015/2016 and in season 2016/2017 almost the same proportions nymphs 84.64%, 8.53%,6.83% for apterous and alate forms, respectively.

The obtained data of both seasons in Table (1 and 2) explaining the population growth of aphids that are similar with El-Heneidy and Abdel-Samad (2001) who said that *S. graminum* starts its occurrence with low population by early January Then, the population declined and approximately vanished from wheat fields during the last week of March .(Aslam *et al.*, 2004; Zeb *et al.*, 2011; Khan *et al.*, 2012) and Abd El-Awal (2005) reported that the first appearance of cereal aphids (regardless of species) occurred during the last week of January, The maximum number (248.60 individuals / tiller) occurred on 4th March, the population of cereal aphids declined quickly thereafter and approximately vanished from wheat fields during the last week of March. El-khayat, *et al.*, (2016) found that On wheat, *R. padi* (L.) and *R. maidis* (Fitch) were represented by one peak at the last week of February in 2012/2013 and 2013/2014 seasons (320 & 285 and 450 & 266 individuals/sample, respectively), while *S. graminum* (Rond.) recorded one peak on the first week of March in 2012/2013 and 2013/2014 seasons (87 and 79 individuals/sample, respectively). Asid *et al.*, (2015) reported that the aphids population increased from mid of February till the end of March and decreased after that at all locations and also inconsistant with Muhammad *etal.*,(2013) and Abbas *et al.*, (2014). Results were full agreement with Ajmal *et al.*, (2018) who said that aphid population on wheat crop was on track from 1st week of February to 3rd week of April. The most critical period when the aphid population was observed above the economic threshold level was started from 3rd week of February to 4th week of March which ultimately tend to decrease towards the maturity of crop as temperature started to rise. While results differ from John *et al.*, (2017) who concluded that the maximum aphid infestation was recorded in crops in the 3rd week of February and decline of aphid population was observed in mid-March, the highest aphid population was recorded in mid-Dec sown crop followed by end-Nov and mid-Nov sown crops.

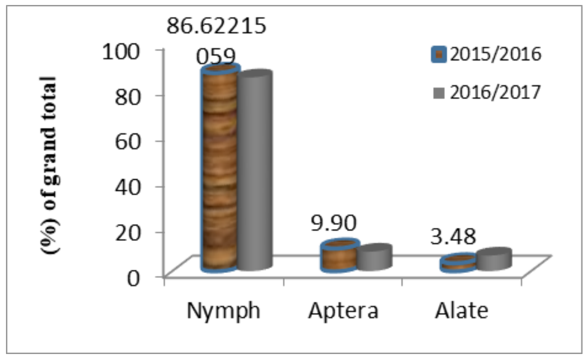

Figure 1. Percentages of grand total of greenbug (*S. graminum*) in wheat fields at Shandaweel, Sohag, 2015/2016 and 2016/2017 seasons

The Figure 2, showed the winged aphids trapped with sticky trap and explained that there are significant differences between the mean numbers of aphids to different directions. The highest mean number of aphids caught on wheat field was recorded in the eastern direction followed by northern, southern and western sides of the field, respectively. It seems that the eastern direction of the field was sunny and warm so, it is appropriate for receiving the winged aphids and reproduction.

These results were partially consistent with El-Wakeil (2013) who said that wheat aphids was found on the northern direction of the field, while Salem (2012), was in a full agreement with my results when he said that the highest number of cereal aphids was in the eastern side of wheat fields.

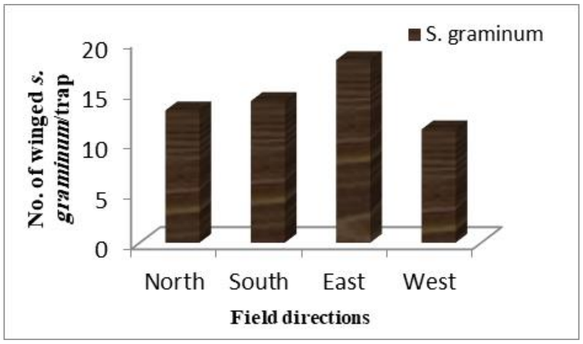

Figure 2. Number of winged *S. graminum* collected from wheat fields in relation to field direction at Shandaweel, Sohag, 2016/2017

Data in Table (2) and Fig. (3) 2015/2016 season showed the first appearance of predator *C. septempunctata* adult was recorded in 4th week of February. The lady bird started appearing; when temperature and mean humidity was 20.29°C and 39.57 % RH, respectively with an average (0.37 individuals/tiller). The appearance of lady bird was recorded five weeks after the appearance of aphids. The population of it reached peak in 4th week of March (7.80 individuals/tiller) when, temperature and mean humidity was 24.71°C and 49.24 % RH, respectively. The aphid started appearing from 4th week of January, however the population was very low (0.60 aphid /tiller) at the end of January when minimum and maximum temperature was 7.57°C and 22.00°C and relative humidity was 48.43 %. With the slight increase in maximum temperature from February onwards there was steady increase in aphid 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 population (97.00 aphids/tiller) was recorded in 2nd week of March. Consequently this population started declining at the end of March and disappeared completely during 1st week of April when maximum temperature was 33.30°C and mean relative humidity was 49.57% RH, possibly owing to the combined action of weather factors, high density of natural enemies, maturity of crop and migration of alate forms.

Table 2. Population density of *S. graminum* and the predator, *C. septempunctata* in wheat fields at Shandaweel, Sohag, 2015/2016 season.

. Sampling date		Total no. of aphids/ tiller	No. of predator/ tiller	Meteorological data			R.H (%)
				Temperature (C)			
				Max.	Min.	Mean	
Jan.	6	0.00	0.00	21.00	5.83	13.67	45.00
	13	0.00	0.00	24.14	8.86	16.71	44.14
	20	0.60	0.00	22.00	7.57	14.86	48.43
	27	9.60	0.00	18.43	6.86	13.00	49.00
Feb.	3	13.40	0.00	24.42	5.14	13.71	44.71
	10	19.10	0.00	23.00	9.00	16.14	39.43
	17	32.70	0.00	29.00	9.86	19.71	42.00
	24	56.20	0.37	27.00	13.14	20.29	39.57
Mar.	2	82.00	1.17	31.86	13.43	22.71	41.11
	9	97.00	1.70	29.57	12.43	21.29	43.00
	16	84.00	3.90	30.14	18.29	24.29	42.27
	23	38.50	5.57	29.43	13.29	21.57	50.69
	30	1.80	7.80	31.56	17.43	24.71	49.24

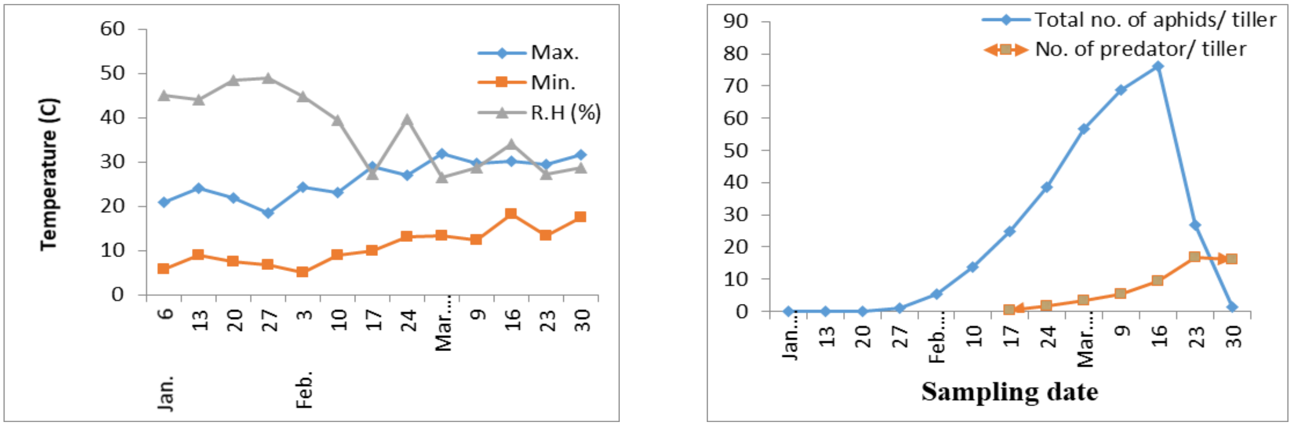

Figure 3. Population density of *S. graminum* and the predator, *C. septempunctata* in wheat fields at Shandaweel, Sohag, 2015/2016 season.

In second season, 2017 Table (3) the predator *C. septempunctata* adult was recorded for the first time in 3rd week of February when temperature and mean humidity was 22.43° and 51 %, respectively with an average (0.40 individuals/tiller). The population of it reached peak in 4th week of March (9.06 individuals/tiller) when, temperature and mean humidity was 28°C and 45.29 %, respectively. The aphid started appearing from 4th week of January, however the population was very low (0.96 aphid /tiller) at the end of January when minimum and maximum temperature was 9.57°C and 25.86°C and relative humidity was 54 %. The maximum aphid population (76.20 aphids/tiller) was recorded in 3rd week of March. Consequently, this population started declining at the end of March and disappeared completely during 1st week of April when maximum temperature was 30.30°C and mean relative humidity was 47.86%. Soni *et al.*, (2007) reported ladybird beetle, *C. septempunctata* as a potential feeder of wheat aphids that played a predominant role in regulating the aphid population. 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 decreased the young stages (grubs) of *C. septempunctata*. Obtained results are in accordance with the findings of El-Heneidy *et al.*, (2004) who stated that the population density of the predators depended on the densities of aphids and reached its maximum value during February and March, then decreased at the end of the season. Abd EL-Megid *et al.,* (2007) reported that the highest count of the predators was detected during the third and fourth week of March with maximum value of 10 and 13 predators, synchronized with 69 and 37 aphids respectively. The environmental factors like high maximum temperature (34ºC), low humidity (56 %), more sunshine after the 1st week of April, also played a key role in the decline of adult and grub population. This infers that the abiotic factors regulating the aphid complex population have a similar impact on the predator populations.

Data in Table (4) explained that during the first season, data indicated that a positive correlation was detected between the population density of aphids and (maximum temperature, minimum temperature, the average daily temperature and the predator number) as the calculated (r) values were (+0.624, +0.481, +0.524, +0.402) respectively. Regarding the effect of relative humidity, the population density of aphids affected insignificantly negative as r value was -0.454. However, the coefficient of determination (R^2) was 72.74 indication that the five mentioned variables were together responsible for 72.74% of changes in aphid populations in 2016 season. The studied variable can be arranged in a descending order as follows: Average daily temperature, maximum temperature, average relative humidity, minimum temperature and the predator numbers, where their efficiency were 23.70, 20.37, 1.90, 1.79, 1.32 respectively.

Table 3. Population density of *S. graminum* and the predator, *C. septempunctat*in wheat fields at Shandaweel, Sohag,2016/2017 season.

Sampling date		Total no. of aphids/ tiller	No. of predator/ tiller	Meteorological data			R.H (%)
				Temperature (C̊)			
				Max.	Min.	Mean	
Jan.	4	0.00	0.00	20.57	6.00	14.00	53.43
	11	0.00	0.00	24.14	4.57	12.57	51.29
	18	0.00	0.00	24.29	6.86	15.71	49.00
	25	0.96	0.00	25.86	9.57	17.86	54.00
Feb.	1	5.20	0.00	22.57	7.29	15.14	42.14
	8	13.60	0.00	23.86	8.00	16.29	45.14
	15	24.70	0.40	22.43	8.29	15.71	51.00
	22	38.50	1.52	21.29	6.43	14.14	48.86
Mar.	1	56.80	2.84	27.57	10.29	19.14	50.29
	8	68.90	4.37	28.29	10.57	19.71	52.86
	15	76.20	6.01	28.00	11.57	20.00	49.14
	22	26.90	7.80	26.86	12.43	20.00	47.43
	29	1.40	9.06	29.29	13.86	21.71	45.29

Table 4. Multiple-regression analysis between the total number of S. *graminum*, predator and abiotic factors during 2015/2016season.

Variable removed	R	R	R^2*100	Decrease in R^2*100	Efficiency
Non	-	0.831	72.74	-	-
Max. temp.	0.6524*	0.747	51.80	20.94	20.371
Mini. Temp.	0.4810	0.862	70.90	1.84	1.7916
Avg. daily temp.	0.5420	0.640	48.37	24.37	23.703
Avg. R.H. (%)	-0.4540	0.814	74.70	1.96	1.9004
Predator no.	0.4012	0.844	71.38	1.36	1.3202

r = Simple correlation coefficient. R^2 = Coefficient of determination

R = Multiregression coefficient. *=significant at 0.05 level of probability.

In the second season, data in Table 5, the results took the same trend as in the first season, the population density of aphids correlated insignificantly positive with maximum, minimum temperature, the average daily temperature and the predator number, and insignificantly negative with relative humidity, where the values were (+0.6587, +0.4720, +0.3640, +0.4580, -0.3910) respectively. And the coefficient of determination (R^2) was 50.27 that is mean the five mentioned variables were together responsible for 50.27% of the changes in aphid populations during 2017 season. Most of the changes in aphids' populations however were due to the predator numbers (39.05) and maximum temperature (33.36).

Overall correlation study of wheat aphid populations showed good positive correlation with the maximum temperature, the average daily temperature, minimum temperature and the predator number, while the aphid populations showed negative correlation with relative humidity in both seasons. Temperature in 2015/2016 season and predator number in 2016/2017 season played an important role in regulating aphids' populations.

From the previous results of the effect of climatic factors on the population density of aphid are partially agree with that obtained by several authors on different crops. Similar to our findings Abd El-Awal, (2005) 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). Saleem *et al.*, (2009) mentioned that major activities of aphid species were correlated with the rising temperature in the month of February, but as the crop mature, fewer aphids were found in wheat plants. Wains *et al.*, (2010) reported that aphids' density was positively associated with maximum and minimum temperature, while it showed negative correlation with relative humidity. Hussein *et al.*, (2015) reported that during the first season, data indicated that a positive correlation was detected between the population density of aphids and both of maximum and minimum temperature and the effect of relative humidity, it is clear that the population density of aphids affected insignificantly negative.

Table 5. Multiple-regression analysis between the total number of S. graminum, predator and abiotic factors during 2016/2017season.

Variable removed	R	R	R^2*100	Decrease in R^2*100	Efficiency
Non	_	0.696	50.27	_	_
Max. temp.	0.5687	0.7654	58.48	8.21	33.362
Mini. Temp.	0.4720	0.6115	50.64	0.37	1.9487
Avg. daily temp.	0.3640	0.6891	48.07	2.20	11.510
Avg. R.H. (%)	-0.3910	0.7078	52.34	2.07	10.740
Predator no.	0.4580	0.7642	57.67	7.40	39.048

r = Simple correlation coefficient. R = Multiregression coefficient. R^2 = Coefficient of determination

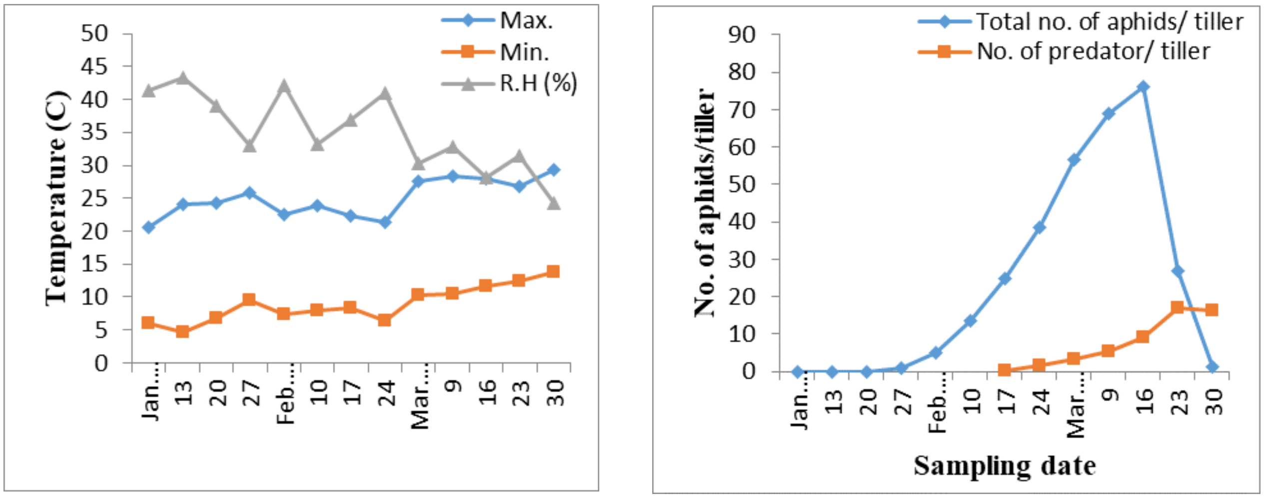

Figure 4. Population density of *S. graminum* and the predator, *C. septempunctata in* wheat fields at Shandaweel, Sohag, 2016/2017 season.

In the second season, the results took the same trend as in the first season, the population density of aphids correlated insignificantly positive with maximum & minimum temperature and insignificantly negative with maximum and minimum relative humidity. These obtained results completely different with Aml *et al*., (2019) who found that the correlation coefficient between *S. graminum* infesting barely plants and maximum temperature was negative and insignificant (r1 = - 0.324 and - 0.422) in the two seasons, respectively. The correlation coefficient between *S. graminum* and minimum temperature was negative and insignificant (r2 = - 0.135 and - 0.365) in the two seasons, respectively. While, relative humidity was negatively insignificant and positively insignificant (r3 = - 0.013 and 0.003) in the two seasons, respectively).

Conclusion

Generally, it could be concluded *C. septempunctata* should be considered a promising candidate for utilization in biological control of *S. graminum* and the abiotic factors were the most important for management this pest under field conditions.

Conflict of interest

The authors hereby declare that no competing and conflict of interests exist.

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