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Research Article

Population dynamics of wheat aphids *Rhopalosiphum padi* (Linnaeus) and *Sitobion avenae* (Fabricius) at District Mardan, Khyber Pakhtunkhwa Pakistan

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Abstract

Wheat (*Triticum aestivum* L.) is one of the major source of food worldwide. However, it suffers from numerous constraints. The aphids, particularly *Rhopalosiphum padi* (Linnaeus) and *Sitobion avenae* (Fabricius) species are among the major causes that severly affect wheat production acrossthe globe. To determine the population dynamics of aphids associated with wheat crop in Khyber Pakhtunkhwa, we examined the mean population of both species in the selected areas (Maho Dheri, Sarband, Kandare, Rag Narai and Khazana Dheri) of district Mardan in 2015. The mean population of *R. padi* and *S. avenae* per plant were recorded every week by counting the number of aphids on 5 plants picked up randomly from each selected wheat field using the diagonal methods. The results on current study showed that the infestation of both aphid species was started in the 1st week of February (05 standard weeks). The densities of aphids per plant increased as the vegetative growth proceeded and was highest till the mid of March (10th and 11th standard week). The declined in aphid populations for both species were started after mid of March and ended in April. The mean population of both aphid species was found low in the 1st week of February (05th standard week) that is probably due to the low temperature. The population density of aphids reached to the its peak in the second week of March due to suitable temperature for aphid infestation.

Keywords: District Mardan; Population dynamics; *Rhopalosiphum padi*; *Sitobion avenae* and Wheat

Introduction

Wheat (*Triticum aestivum* L.) is the primary food source, and use as a staple food contains 13% protein providing 20% world food calories. Wheat is used as a food for nearly 40% of the world's population [1]. The wheat crop is grown on 23% global cultivated land having utmost importance in international trade for worldwide market [2]. During 2017-18 the total yield of wheat grown in Pakistan was 26.7 million metric tons, and their consumption was 25.3 million tons [3], while

755 million metric tons of wheat was produced during 2015-16 worldwide. In Pakistan, Wheat is a major crop and use as a staple food [4]. . The straw and bran are used to feed livestock and also in industries to make several products. Owing to the immense cosumptions, wheat crop is considered to be the 2nd largest crop having 12.5% contribution in agriculture and 2.6% to the GDP (Government of Pakistan. 2012). However, various factors affect the quality and quantity of wheat production in Pakistan [5]. Wheat production has been severly affected by so many factors such as immproper seedbeds, low aquality seeds and fertilizers, water shortage and most importantly lack of IPM techniques to mnage insect pests. [6, 7]. Aphids attack is one of the most crucial factors for wheat disease and low yield. Aphid is an economically significant insect pest damaging a broad variety of crops, fruits, and vegetable plants [8].

The bird cherry-oat aphid, *Rhopalosiphum padi* (Linnaeus) and grain aphid, *Sitobion avenae* (Fabricius) are deleterious insect pests of wheat crops in Pakistan [9, 10] and worldwide [11-13]. *R. padi* and *S. avenae* are polyphagous sucking insects having worldwide distribution [14] and cause 15% reduction in the yield of the wheat crop at flowering stage only [15]. These two wheat aphids usually coexist in the wheat crops and cause damage through direct feeding on the sap from shoots and leave, causing distortion, curling, and chlorosis of leaves growth [16, 17]. Besides, these aphid species also act as a vector to transmit numerous fungal and viral diseases that ultimately reducing the yield up to 80% [18, 19]. Furthermore, they also act as a vector to transmit barley yellow dwarf virus (BYDV), which cause the indirect destruction of wheat crops [20]. The plants are also damaged indirectly by the excess production of honeydew [21]. The outbreaks of *R. padi* and *S. avenae* lead to severe yield losses in wheat crops [22]. Wheat crops sown in the late season may have high chances of aphids outbreak if the weather remains cool till the end of March [23].

Aphid epidemic could be controlled by sowing cereal crops earlier in the season [24], because low aphid infestation has been documented on early sown wheat crops. Early maturing varieties of wheat can avoid aphids outbreak [25] while infestation increases on late sowing, ultimately cause yield reduction [26]. The seasonal fluctuation in their dynamics are determined through the population growth rate and duration at which the population can grow. Aphids growth rate mainly disturbed by the host plant quality, predators, parasitoids and environmental factors [27]. Diverse factors were encouraged in search for determining the cyclic dynamic of aphids including long-term trends in agriculture practices [21], weather alterations [28], natural enemy profusion, and intra-specific competition [29].

We hypothesized that the annual deviation of aphid populations are driven by the temperature fluctuations. Their profusion is predominantly determined by the duration of aphid population growth. Winter and early spring temperatures thus define stages when aphids attack on cereal crops and the duration available to them prior the onset of plant senescence. In this study, we determine the field population trend of *R. padi* and *S. avenae* in wheat crops at different locations of District Mardan. This constitutes a step towards exploring the diversity of wheat aphid throughout the wheat growing season to elaborate an appropriate control plan against these pests and thus contributing to increase in the production of cereal crops.

Materials and methods

Field site

The current experiment was carried out at randomly selected five different locations of District Mardan in Khyber Pakhtunkhwa

during the wheat grwing growing season i.e. February 2015 - April 2015.

Study design

Population dynamics of two aphid species *R. padi* and *S. avenae* were estimated following previously described method [30]. Data were recorded at each site by counting aphid population per tiller. At each location, five spots were randomly spaced along a diagonal across the field. The selected spots for samples collecction were not closer than 10 feet from the field edge [30]. The tillers were randomly chosen at each spot and was checked for the *R. padi* and *S. avenae* infestation. Considering the population build-up, which was started in February, therefore data collection was started in the first week (05 standard weeks) of February 2015. Data on mean mean population density of aphid species was recoreded at each location till the crop maturity.

Data analysis

To assess the mean (±SE) number of *R. padi* and *S. avenae* per plant, raw data were subjected to the SPSS 22.0 **(**IBM Statistics). The statistical differences among data related to the population dynamics of *R. padi* and *S. avenae* were examined using one-way ANOVA followed by Tukey post hoc test ($P < 0.05$) (IBM, SPSS Statistics). Sigma Plot 12.0 (Systat Software Inc., San Jose, CA) was applied to generate line graphs with error bars.

Results

Population dynamic of *R. padi* in wheat fields

The mean population density of *R. padi* is reported in (Table 1). The estimated mean values shows the increasing trend of aphids population from February till April, as the plant growth proceeded. The highest population growth of 46.67 ± 0.384, 44.17 ± 0.366, 52.50 ± 0.311 and 33.66 ± 0.304 was recorded for *R. padi* in Maho Dheri, Sarband, Rag Narai and Khazana Dheri at the 6th week (SW 10), respectively whereas a mean population of 31.50 ± 0.311 of aphids were recorded as highest for Kandare in the 7th week (SW 11) (Table 1).

Population dynamic of *S. avenae* in Wheat fields

The estimated highest population of *S. avenae* per plant was recorded in the 6th week (SW 10) in Maho Dheri, Rag Narai, Sarband and Khazana Dheri, having 54.83 ± 0.280, 48.16 ± 0.435, 43.33 ± 0.192 and 42.50 ± 0.311. The highest population of *S. avenae* in wheat crops at Kandare area was recorded as 36.00 ± 0.942 in the 5th week (SW 09). The overall mean population of *S. avenae* in all the selected sites of District Mardan was found high as compared to *R. padi* (Table 2).

Table 1. Population dynamic (Mean±SE) of *Rhopalosiphum padi* (Linnaeus) in wheat crops from Feb to April 2015 at various locations in District Mardan

Survey timing (SW 05-14)	Maho Dheri*	Sarband*	Kandare*	Rag Narai*	Khazana Dheri*
Week 01	11.00 ± 0.577f	7.00 ± 0.333f	10.50 ± 0.772g	16.16 ± 0.280f	11.00 ± 0.235f
Week 02	20.66 ± 0.304e	18.67 ± 1.097de	14.83 ± 0.366f	21.00 ± 0.235d	14.33 ± 0.561e
Week 03	27.50 ± 0.390d	31.67 ± 0.192b	24.33 ± 0.384	21.00 ± 0.235d	17.16 ± 0.683f
Week 04	34.00 ± 0.471c	17.16 ± 0.280e	17.33 ± 0.304e	35.83 ± 0.548c	21.66 ± 0.192c
Week 05	43.00 ± 0.527b	26.00 ± 0.942c	26.50 ± 0.905bc	45.33 ± 0.384b	26.50 ± 0.204b
Week 06	46.67 ± 0.384a	44.17 ± 0.366a	26.83 ± 0.280b	52.50 ± 0.311a	33.66 ± 0.304a
Week 07	43.67 ± 0.304b	31.83 ± 0.152b	31.50 ± 0.311a	44.00 ± 0.333b	17.66 ± 0.384d
Week 08	21.66 ± 0.304e	21.33 ± 0.384d	21.33 ± 0.192d	23.00 ± 0.577d	7.00 ± 0.333g
Week 09	11.00 ± 0.577f	12.50 ± 0.204f	5.00 ± 0.471h	18.66 ± 0.509e	3.33 ± 0.384h
Week 10	3.00 ± 0.333g	2.16 ± 0.597g	1.16 ± 0.152i	12.33 ± 0.384g	0.00 ± 0.00

* Within the same column, different letters indicate significant differences at $P < 0.05$ level (one-way ANOVA followed by Tukey HSD tests).

Table 2. Population dynamic (Mean±SE) of *Sitobion avenae* (Fabricius) in wheat crops from Feb to April 2015 at various locations in District Mardan

Survey timing (SW 05-14)	Maho Dheri*	Sarband*	Kandare*	Rag Narai*	Khazana Dheri*
Week 01	21.66 ± 0.192f	21.83 ± 0.152d	19.16 ± 0.548e	21.66 ± 0.192e	22.50 ± 0.311e
Week 02	26.16 ± 0.548e	34.66 ± 0.509b	23.83 ± 0.366cd	26.33 ± 0.838d	26.50 ± 0.807d
Week 03	37.00 ± 0.623c	27.66 ± 0.384c	25.66 ± 1.097bc	36.83 ± 0.641bc	26.16 ± 0.796d
Week 04	46.16 ± 0.597b	35.00 ± 0.235b	35.33 ± 0.509a	28.00 ± 0.333d	28.00 ± 0.333cd
Week 05	54.50 ± 0.204a	46.33 ± 0.384a	36.00 ± 0.942a	39.50 ± 0.456b	36.16 ± 1.065b
Week 06	54.83 ± 0.280a	48.16 ± 0.435a	27.83 ± 0.435b	43.33 ± 0.192a	42.50 ± 0.311a
Week 07	34.33 ± 0.451d	24.00 ± 0.235d	22.16 ± 0.435de	34.33 ± 0.451c	31.33 ± 0.693c
Week 08	25.50 ± 0.311e	15.50 ± 0.772e	12.00 ± 0.408f	23.16 ± 0.435e	16.16 ± 0.723f
Week 09	17.66 ± 0.192g	11.33 ± 0.192f	10.33 ± 0.192f	15.50 ± 1.099f	11.83 ± 0.641g
Week 10	11.33 ± 0.192h	4.16 ± 0.548g	1.50 ± 0.390g	3.33 ± 0.384g	2.66 ± 0.384h

* Within the same column, different letters indicate significant differences at $P < 0.05$ level (one-way ANOVA followed by Tukey HSD tests)

Population dynamics of *R. padi* and *S. avenae* in Maho Dheri

The highest mean population of *R. padi* were recorded 46.67 ± 0.384. In case of *S. avenae*, it was recorded as 54.83 ± 0.280 during 6th week (SW 10). The population growth of *S. avenae* declined after week 6 (SW 10), whereas the population of *R. padi* remain high that was later on declined after 7th week (SW 11) (Fig. 1).

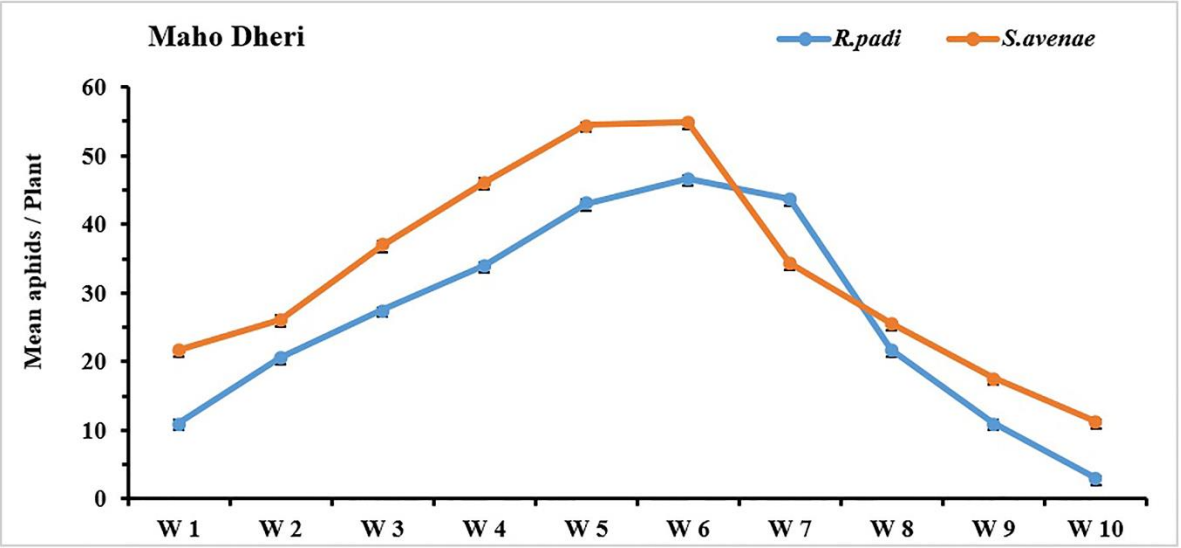

Figure 1. Mean (± SE) population of *Rhopalosiphum padi* (Linneas) and *Sitobion avenae* (Fabricius) per plant in wheat crops froms Februray 2015 to April 2015 at Maho Dheri

Population dynamics of *R. padi* and *S. avenae* in Sarband

In Sarband, the highest mean value for *R. padi* and *S. avenae* were recorded at week 6 (SW 10) having 44.17 ± 0.366 and 48.16 ± 0.435 aphids per plant (Fig. 2). The population of *R. padi* was decreased at week 4 (SW 08) up to 17.16 ± 0.280, while *S. avenae* remain high. Population growth of both species was declined after week 6 (SW 10) (Fig. 2).

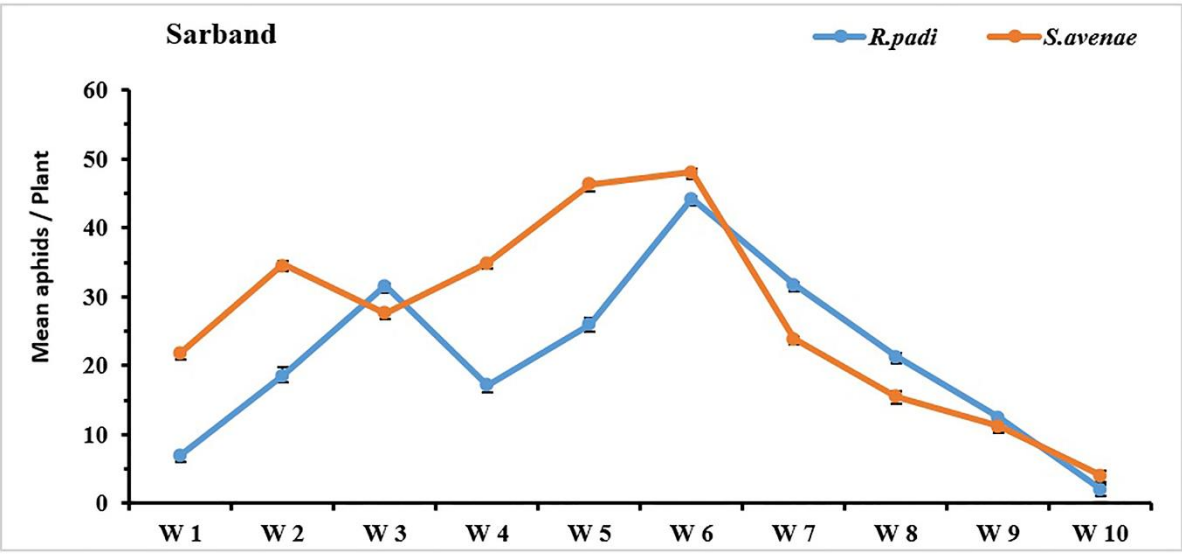

Figure 2. Mean (± SE) population of *Rhopalosiphum padi* (Linneas) and *Sitobion avenae* (Fabricius) per plant in wheat crops froms Februray 2015 to April 2015 at Sarband

Population dynamic of *R. padi* and *S. avenae* in Kandare

The mean population of both species (*R. padi* and *S. avenae*) per plant was observed low as compared to other locations of District Mardan. The highest mean value were 31.50 ± 0.311 and 36.00 ± 0.942 at week 7 (SW 11) and 5 (SW 09) respectively for both species (Fig. 3). The population of *S. avenae* started to decline after week 5 (SW 09), while population of *R. padi* went down after week 07 (SW 11).

Population dynamic of *R. padi* and *S. avenae* in Rag Narai

The mean highest population of *R. padi* was observed in Rag Narai (52.50 ± 0.311) as compared to all locations of District Mardan (Table 1, Fig. 4) while mean highest value (43.33 ± 0.192) for *S. avenae* was also recorded at week 6 (SW 10). Both species populations were declined after week 6 (SW 10) (Fig. 4).

Population dynamic of *R. padi* and *S. avenae* in Khazana Dheri

The highest population growth for *S. avenae* and *R. padi* was 33.66 ± 0.304, and 42.50 ± 0.311 observed at week 6 (SW 10) respectively, after which population of aphids was rapidly decreased and ended at week 10 (SW 14) (Fig. 5).

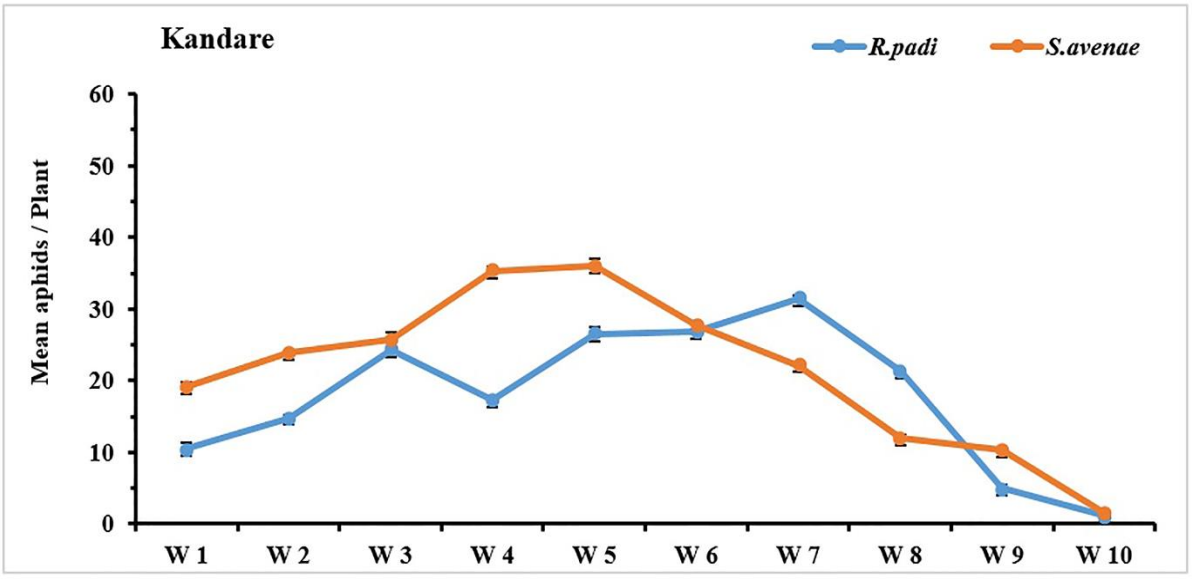

Figure 3. Mean (± SE) population of *Rhopalosiphum padi* (Linneas) and *Sitobion avenae* (Fabricius) per plant in wheat crops froms Februray 2015 to April 2015 at Kandare

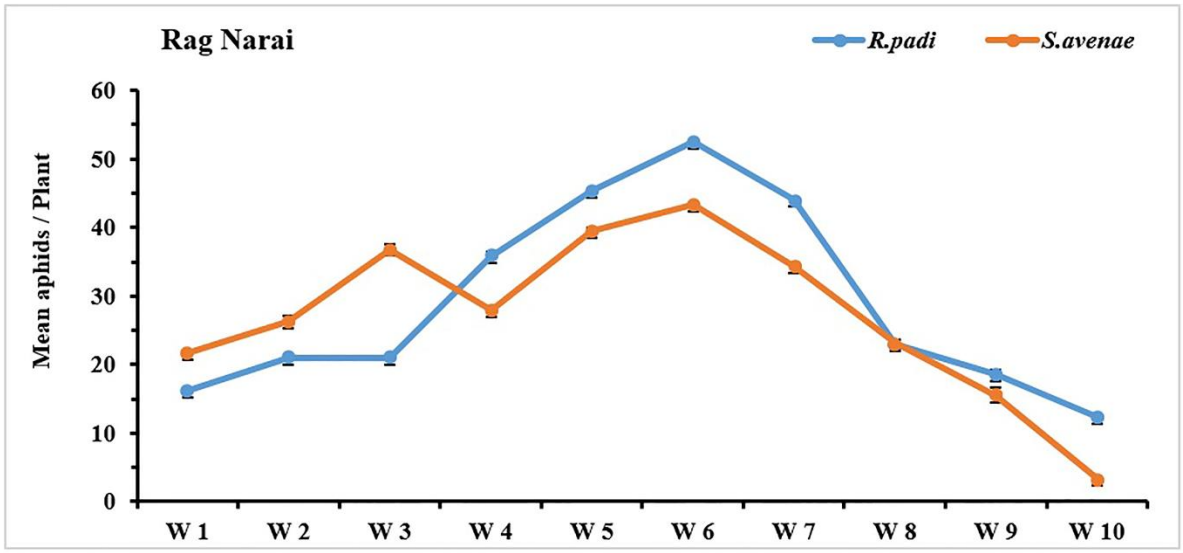

Figure 4. Mean (± SE) population of *Rhopalosiphum padi* (Linneas) and *Sitobion avenae* (Fabricius) per plant in wheat crops froms Februray 2015 to April 2015 at Rag Narai

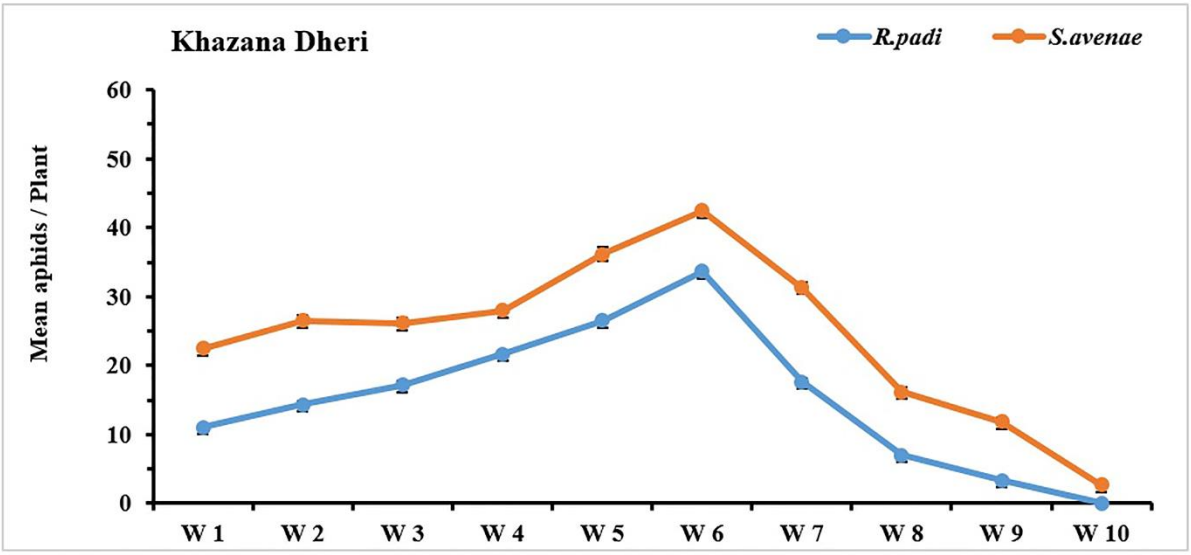

Figure 5. Mean (± SE) population of *Rhopalosiphum padi* (Linneas) and *Sitobion avenae* (Fabricius) per plant in wheat crops froms Februray 2015 to April 2015 at Khazana Dheri

Discussion

The mean population growth of two cereal aphids associated with wheat fields were investigated from February 2015 to April 2015. Our findings are consistent with the previouse study reported that aphid infestation were increased in February and increase with vegetative growth of wheat plant and started decline at the end of March [30].

The mean population of both species of aphid *R. padi* and *S. avenae* was found low in first three weeks (February) at all locations in wheat fields of district Mardan. These results concur with the previous findings showing that aphids population were lower during the end of January or start of February in wheat crops [30]. The highest mean population growth of both aphid species in all the selected sites was found in the end of March. Similar results were documented by [30, 31] that the aphid infestation occurred during the 3rd week of March on all wheat varieties.

A gradual increasing trend in population desnity of both species was noticed at vegetative growth stage of wheat crops in all areas. However, some variations occurred in aphid density tiller^{-1}, which might be due to the resistance response of wheat varieties against aphids. [8] reported that the aphid population decreased when the temperature reached to the maximum and minimum limit (24°C and 9°C). We found similar results, in which the population growth of both species was lower at the start of February and end of April because in February temperature is less than 10ºC, while in April it is above 24ºC. The population growth of *R. padi* and *S. avenae* was estimated maximum in March when the temperature was in a favorable range of aphid. We also found fluctuation in the mean population for both aphids at different locations, which may be due to various abiotic factors such as temperature, humidity, and rainfall. The rapid increase and decrease in the aphid population were affected by numerous factors [8]. Moreover, it has also been found that alterations in the densities of the aphid population were due to the various physical and biological factors [32]. According to [8, 33] temperature have a crucial role in the fluctuation of the aphid population. Similarly, the abundance of aphid

population was also affected owing to the heavy rainfall [34].

Conclusion

Based on current study, it is concluded that the population density *R. padi* and *S. avenae* could be controlled by early sowing of wheat crops. Additionally, the indiscriminate use of insecticide influence the population growth of natural enemies, and due to the decrease population of natural enemies in wheat crops, aphids' outbreak occurs and cause severe destruction to the wheat crops.

Authors' contributions

Conceived and designed the experiments: F Ullah, Performed the experiments: F Ullah, Hina & A Ali, Analyzed the data: F Said, K Tariq, M Zaman & D Song, Contributed materials/ analysis/ tools: F Ullah & D Song, Wrote the paper: F, Ullah & F Said.

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