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Negative effects of the infestation by *Schizaphis graminum* on the vegetative growth measurements, yield and its components of bread wheat cultivar (Giza 171) in Luxor governorate, Egypt

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Abstract
Field experiments were conducted at El-Mataana Agricultural Research Station, Agricultural Research Center, Luxor Governorate, Upper Egypt, during 2017/2018 and 2018/2019 wheat growing seasons to study the impact of the infestation by *Schizaphis graminum* (Rondani) (Hemiptera: Aphididae) on yield and its components on bread wheat cultivar Giza 171. Results indicated that *S. graminum* infested wheat plants from December, 17th 2017 to April, 8th 2018 during the first growing season and from January, 27th 2019 to April, 13th 2019 in the second growing season. The total population density of *S. graminum* during the first growing season (2017/2018) was higher than second growing season (2018/2019). As well, the cumulative counts of *S. graminum* were 597.00 and 310.33 individuals per season for the two growing seasons, respectively. The means of *S. graminum* total counts throughout the whole period of two seasons were 35.12 ± 3.31 and 25.86 ± 1.96 individuals per 10 tillers, respectively.
Data obtained during both (2017/2018 and 2018/2019) growing seasons revealed that vegetative growth measurements (leaf area, number of spikes/m^2 and plant height) of the infested wheat plants by *S. graminum* exhibited smaller rates. Furthermore, three yield parameters i.e., grain, straw and yield (ton/fed) increased obviously of the uninfested plants (control) as compared to those of the infested plants by *S. graminum*. As for the negative effects on yield components, the infested wheat plants by *S. graminum* exhibited an obvious decrease in (average number of grains/spike, spike height (cm) and average weight of 1000-grains (gm). As well as, the infested wheat plants showed, significantly, the highest reduction in all studied growth measurements, yield and its components.

Keywords: Wheat, yield, Aphids, Schizaphis graminum, population density.

Introduction
Wheat (*Triticum aestivum* L) is the most widely grown cereal crop in the world. It considered the first strategic food crop in Egypt as wheat grains are the main source for production of bread necessary for feeding. Wheat is the main winter cereal crop and is widely distributed all over the country. Therefoore, increasing wheat production becomes an important national goal to reduce the gap between wheat production and consumption, to reduce wheat importation and to save foreign currency. It was anticipated that high and stable wheat yield could be achieved by applying the most favorable cultural practices and using high yielding cultivars.
Heat stress is a common abiotic factor that results in stunted plants, reduced tillering, and accelerated development leading to small spikes, shriveled grains and finally reduced yields. In Upper Egypt, terminal heat stress during inflorescence development and grain filling is a recurrent phenomenon that hinders wheat production. Moreover, the exposure to hot wind, even for a short time, could drastically reduce spike fertility and grain filling (Fischer & Maurer 1976) [17]. Temperatures accelerate organ development in few days without any increase in net photosynthesis and assimilate resulting in smaller biomass (Fischer 1985; Shpiler & Blum 1986) [16, 26]. Yield in stressed environments depends upon susceptibility or tolerance level of grown plants. Therefore, the productive genotypes under stress conditions are the highest tolerant genotypes for these conditions.
The green cereal aphid, *Schizaphis graminum* (Rondani) (Hemiptera: Aphididae) is one of the 14 aphid species that considered as a worldwide key pest (Blackman & Eastop 2007) [9]. Severe damage was happend by sucking the plant sap followed by deformation and excreting large amount of honeydew that encourages the growth of sooty mould. Then photosynthesis and vegetative growth of the infested plants decreased. Furthermore, it is so important because of transmission of viral diseases ability (El-Fatih 2000 & 2006) [11, 12]. In recent years, *S graminum* has become the most frequent species on wheat crop, and is abundant throughout all developmental stages of wheat plants (Youssef 2006; Parizoto *et al.* 2013; Ahmad *et al.* 2016; Awadalla *et al.* 2018) [30, 24, 6, 7]. During different growth stages, wheat plants are attacked by many insect pest species which aphids are the most destructive the crop loss assessment was 7.5-18.7% (Tantawi 1985) [27].
The present investigation was carried out to estimate the negative impacts of the infestation by *S graminum* on yield and its components on bread wheat cultivar Giza 171 under Luxor Governorate, Upper Egypt conditions.

Materials and Methods

The present study was carried out at El-Mataana Agricultural Research Station, Agricultural Research Center, Upper Egypt, during 2017/2018 and 2018/2019 wheat growing seasons. Treatment and replicates were arranged in randomized complete blocks (RCBD), with eight plots (3m x 7m each). Sowing of wheat cultivar (Giza 171) took place at the optimum sowing date (November, 25th every season). All the normal agricultural practices of sowing, irrigation and fertilization were regularly done in due time and those were the same in all plots. The first four plots were kept without application any chemical control measures before and during the period of study to allow for natural aphid infestation (data of the population density of the above-mentioned pest was considered a main indicator for the presence of *S. graminum*).

The other four plots were treated with Sumithion pesticide 50% EC at the rate (2.5 ml/ liter water) when the population density of *S. graminum* appeared on wheat plants in December, 17th 2017 and January, 27th 2019 in few numbers during the two successive seasons, respectively and considered as uninfested plots.

Seasonal abundance of *S. graminum* infesting wheat plants

For estimating the population density of *S. graminum*, 10 tillers were, weekly, sampled randomly in the morning using 10x lense in the field. Sampling was started when the seedlings grew above ground and continued until crop harvesting. Direct count of aphids per sample was conducted on the same day as described by Dewar *et al*. (1982) [10]**.** Numbers of alive insects (nymphs and apterous adults) on tillers were counted and recorded to represent every inspection date.

Aphid-days and the cumulative aphid-days

Aphid-days are cumulative number was used as a term to express the total impact of an ever-changing population over time. Aphid-days, also, allow better comparisons between treatments, locations and other variations observed during the experiment. The obtained data of aphid population at the two successive growing seasons were used here to calculate the Aphid-days cumulative values according to Ruppel's formula (1983) [25] the follows

1. Aphid-days = 3 x $[(a_1+a_2) / 2]$ where

a_1= Mean of aphids count per 10 tillers before the present inspection date.

a_2= Mean of aphids count per 10 tillers at the present inspection date.

Cumulative aphid-days = Aphid-days from last inspection + Aphid-days from present inspection, for each sampling date to obtain a running, cumulative total.

- Plant phenological characters *i.e*. plant age (in days) and growth stage (as decimal code)

Growth stage (ZGS**)**

Growth stage refers to a decimal code for the cereal growth stage according to Zadoks *et al*. (1974) [32]. The decimal growth stage can help in understanding crop adaptation and development (Barber *et al*. 2015) [8]**.**

Data were recorded for agronomic characters as following

1. **Plant height (cm):** measured from the soil surface to the top of the spike of ten main stems chosen at random from each experimental plot.
2. **Spike length (cm):** expressed as the length from the spike base to the tip of the main spike excluding awns.
3. **Leaf area (cm^2) per plant:** was measured at 90 days from planting using the following equation as reported by Montgomery (1911) [22]**,** where leaf area = 0.75 × (leaf length ×leaf width at the broadest place).
4. **Number of spikes/m^2:** as an average number of spikes/m^2 of three collected samples from each experimental plot.
5. **Biological yield (ton/fed):** the total biomass produced by the plant during the season (excluding the roots).
6. **Grain yield (ton/fed):** was computed from the weight of grains from the (plot area 9 m^2).
7. **Straw yield (ton/fed):** obtained by weighing all the harvested plants in ton (biological yield) subtracted from the grain yield of harvested area, for each plot.
8. **Number of grains /spike:** estimated as an average from ten spikes.
9. **1000-kernel weight (g):** was determined as a weight of 1000 grains from the bulk of the plot

   The amount of damage and losses due to *S. graminum* infestation were calculated according to the following equation**:**

Loss % = (A-B) / A *100

Where: A= mean of a given measurement of the uninfested plants, while B= mean of the same parameter of the infested plants.

Statistical analysis

For any tested parameter, means for infested and uninfected replicates were compared using paired T-test at $P \leq 0.05$, carried out by Computer using (MSTATC Program software 1980) [23].

Results and discussion

The weekly counts of *S. graminum* that infested wheat plants at El-Mataana Agricultural Research Station in Luxor Governorate were recorded through the two successive growing seasons (2017/18 and 2018/19) and tabulated in Table (1) and Fig. (1). The seasonal abundance of *S. graminum* was estimated on the basis of average number of alive insects' (Nymphs and apterae individuals) counts per ten tillers in the successive sampling dates.

Population studies

Seasonal abundance of *S. graminum* population on wheat plants

The first growing season (2017/2018)

The population density of *S. graminum* appeared in few numbers on wheat plants on December 17th and then it highly increased continuously to reach the first peak of abundance on January 7th during the tillering stage, with mean counts of 24.33 ± 0.88 individuals per 10 tillers (Table, 1 and Fig. 1 A). Furthermore, the phenological characters of wheat plant viz. (plant age, 42 days and the decimal code for the growth stages, 27). The population decreased on January 14th and then increased gradually to reach the second peak on January 21st (59.00 ± 4.51 individuals per 10 tillers) and the phenological characters (plant age, 56 days and the decimal code, 31), as suitable with growth up to the first node of stem becomes visible. Then, the population decreased on January 28th and then increased gradually to reach the third peak on February 4th

(69.00 ± 3.79 individuals per 10 tillers) when the phenological characters were (plant age, 70 days and the decimal code, 35), as compatible with the stem extension period. Afterward, the population decreased successively until it reached to February 18th. Another increase in population took place on February 25th indicating the fourth peak (66.33 ± 3.28 individuals per 10 tillers) at plant age, 91 days and the decimal code, 50 as coincided with the date of first heading. After that, the population of aphids decreased gradually until April 8th till the disappearance of any aphid infestation during the period between the end of heading and maturation (Table, 1 and Fig., 1 A).

The second growing season (2018/2019)

The results presented in (Table, 1) and illustrated in Fig. (1 B), indicated that *S. graminum* appeared in few numbers on wheat plants on January 27th (6.00 ± 0.58 individuals per 10 tillers), then its population increased gradually, until reaching its maximum (30.67 ± 1.20 individuals per 10 tillers) on March, 2nd when the phenological characters of wheat plants were (plant age, 91 days and the decimal code for the growth stages, 45), being coincided with the period after emergence of the flag leaf sheath. Then, aphids' population decreased on March, 16th and it reincreased gradually to reach the highest peak of abundance on March, 30th (44.67 ± 1.45 individuals per 10 tillers) and the phenological characters (plant age, 119 days and the decimal code, 65), is compatible with the anthesis period. After that, the population decreased continuously until April, 13th and this aphid species disappeared during the maturation period.

The present results agree with those of Abou-El-hagag & Abdel-Hafez (1999); Abdel-Aziz *et al.* (2002); El-Rawy (2013); Youssif *et al.* (2017) [4, 3, 15, 31] who recorded that the maximum population density of cereal aphids occurred during February and March on wheat plants. El-Heneidy *et al.* (2004) [13] found that the population densities of cereal aphids on wheat plants in Sakha and Sides regions occurred in high numbers during February and March. Abd El-Megid *et al.* (2007) [2] in Egypt, stated that the infestation by aphids on wheat started during the 2nd week of February. The population reached a peak during the 1st week of March and disappeared towards the end of April.

It was obvious that infestation by *S. graminum*, completely, disappeared on wheat plants from December to the 3rd week of January during the second growing season. This may be due to the low temperature during these periods. El-Rawy (2013) [15] recorded that the lowest number of cereal aphid species on wheat plants (61.6 aphids/10 plants) occurred in January.

The obtained results cleared that the total population density of *S. graminum* during the first growing season (2017/18) was higher than the subsequent growing season (2018/19). The mean total *S. graminum* population through the whole season was 35.12 ± 3.31 and 25.86 ± 1.96 individuals per 10 tillers over the first and second growing seasons, respectively. This may be due to the influence of environmental factors in this region and the plant phenology of wheat as recorded in Table (1) and illustrated in Fig. (1 A & B).

It was noticed that *S. graminum* disappeared during the maturation period of wheat plants during the two successive growing seasons. The same findings were noticed by Vidya (1982) [28] who reported that the aphid population started to decline when ear head emergence started.

Cumulative Aphid-Days

Data in Table (1) and illustrated in Fig. (1 A & B), presented the aphid-days and the cumulative aphid-days for *S. graminum* on wheat plants to express the total impact of an ever-changing population over time. These present results indicated that the impact of *S. graminum* population on wheat plants was higher at the first growing season (1782.00 cumulative aphid-days) as compared to the second one (898.00 cumulative aphid-days). Thus resulting in higher impact on plant phenology in the first season than the second one. The cumulative aphid-days method was used to express the total impact of an ever-changing population over time in the field by El-Fatih (2006) [12] that used the same technique for cereal aphids on barely.

Impact of infestation by *S. graminum* population on vegetative growth and wheat yield and its components:

Vegetative growth measurements

Leaf area per plant

Data in Tables (2 and 3) revealed that the uninfested wheat leaves had bigger leaf area than the infested ones. Generally and regardless the effect of infestation by *S. graminum* on the leaf areas among infested and uninfested plants, the infested leaves had, significantly, smaller leaves (1111.42 ± 22.73 and 833.99 ± 9.03 cm^2) than the uninfested ones (1205.35 ± 2.71 and 911.14 ± 5.89 cm^2) during the two successive growing seasons, respectively. Also, the leaf areas of the infested wheat plants were reduced by 7.79 and 8.47 % compared to the uninfested ones during the two growing seasons, respectively. Also, statistical analysis of data showed significant differences in the leaf area per plant among the uninfested and infested wheat plants (paried T-test values were 4.46 and 5.27) during the two successive seasons, respectively. Kindler *et al.* (1995) [20] observed chlorosis and curling of leaves caused by feeding aphids.

Number of spikes/m^2

Results revealed that the infested wheat plants produced less tillers as an average was (533.00 ± 2.89 and 438.00 ± 1.15 tillers/m^2) than the uninfested ones (558.00 ± 1.53 and 454.00 ± 3.46 tillers/m^2). Also, number of tillers $m^{-2}$was reduced by 4.48 and 3.52% as compared with those for the uninfested ones (Tables, 2 and 3). Also, the differences in number of tillers/m^2 among infested and uninfested wheat plants was highly significant (paried T-test values; 8.33 and 6.93) during the two seasons, respectively.

Plant height (cm)

Height of plant in the infested wheat plants measured 115.47 ± 0.41 and 116.00 ± 1.15 cm as compared to 117.19 ± 0.80 and 120.67 ± 0.67 cm for the uninfested ones during the two growing seasons, respectively (Tables, 2 and 3). So, it was reduced by 1.46 and 3.87 % as compared with the uninfested wheat plants during the two seasons, respectively. The difference in height of plant among infested and uninfested wheat plants was significant during the two successive seasons, respectively.

Grain Yield (ton/fed)

Data obtained in Tables (2 and 3) proved that the uninfested wheat plants had more grain yield (average weight was 2.58 ± 0.01 and 2.27 ± 0.01 ton/fed) than the infested ones (2.36

± 0.02 and 2.13 ± 0.01 ton/fed) during the two successive seasons, respectively. Analysis of data showed significant differences in the weight of grain yield per feddan among the uninfested and infested ones (paried T-test). Also, the grain yield from the infested plants lost about 8.53 and 6.18% from their weight as compared with the uninfested ones during the two growing seasons, respectively.

Straw yield (ton/fed)

Data in Tables (2 and 3) showed that the infested wheat plants had smaller straw yield (average weight was 7.34 ± 0.08 and 6.35 ± 0.03 ton/fed) than the uninfested ones (8.08 ± 0.08 and 7.15 ± 0.20 ton/fed). The difference in straw yield among infested and uninfested wheat plants was highly significant and significant (T values were 8.20 and 4.62) during the two successive seasons, respectively. Also, the straw yield from the infested plants lost about 9.12 and 11.19% from their weight as compared with the uninfested ones during the two growing seasons, respectively.

Biological yield (ton/fed)

Data depicted in Tables (2 and 3) revealed that the uninfested wheat plants were higher with mean weight of biological yield was an average (10.41 ± 0.03 and 9.10 ± 0.12 ton/fed) as compared to (9.65 ± 0.11 and 8.38 ± 0.04 ton/fed) for the infested ones during the two growing seasons, respectively. The differences among uninfested and infested wheat plants were highly significant and significant (paired T-test were 9.07 and 9.28) during the two seasons, respectively. Also, average weight of biological yield for infested wheat plants was reduced by 7.35 and 7.87% compared with the uninfested ones during the two growing seasons, respectively.

Number of* Grains*/Spike

Data obtained in Tables (2 and 3) revealed that the uninfested wheat plants produced more number of grains per spike with the averages (60.30 ± 1.10 and 56.33 ± 0.33 grains per spike) than the infested ones (56.60 ± 0.12 and 53.00 ± 0.58 grains/spike), during the two growing seasons, respectively. Also, number of grains/spike was reduced by 6.14 and 5.92% as compared with those for the uninfested ones during the two successive seasons, respectively. Also, the differences in number of grains per spike among infested and uninfested wheat plants were significant and highly significant during the two seasons, respectively.

Spike's height (cm)

Data in Tables (2 and 3) revealed that the infested wheat plants were smaller with mean spike heights; (8.73 ± 0.01 and 9.88 ± 0.02 cm) as compared to (9.15 ± 0.03 and 10.30 ± 0.06 cm) for the uninfested ones, during the two growing seasons, respectively. Also, height of spike of the infested wheat plants was reduced by 4.64 and 4.05% as compared with those on the uninfested ones during the two successive seasons, respectively. Data analysis showed highly significant spike's height differences among uninfested and infested wheat plants (paired T-test values were 9.81 and 9.45) during the two seasons, respectively.

1000-kernel weight (g)

Data presented in Tables (2 and 3) showed that the average weights of 1000-grains in the infested wheat plants was smaller (average weight were 43.16 ± 0.32 and 44.03 ± 0.27 g) as compared to 47.45 ± 0.14 and 48.72 ± 0.42 g for the uninfested ones during the two growing seasons, respectively. Analysis of data showed highly significant differences among kernel's weight from uninfested and infested wheat plants (paired T-test values were 9.24 and 6.81). Also, average weight of 1000- grains from infested wheat plants was reduced by 9.05 and 9.64% compared with those from the uninfested ones during the two successive seasons, respectively.

Based on the data summarized in Tables (2–3), it could be concluded that the vegetative growth measurements of the uninfested wheat plants exhibited a considerable increase in (leaf area, number of tillers/m^2 and plant height) during both (2017/2018 and 2018/2019) growing seasons. Moreover, three yield parameters i.e., grain yield y, straw yield y and biological yield were obviously decreased by *S. graminum* infestation as compared to those of the uninfested plants (control). As for the impact on both yield components, the infested wheat plants by *S. graminum* exhibited an obvious decrease in (average number of grains/spike, spike's height and average weight of 1000- grains. On the other side, the infested wheat plants showed, significantly, the highest reductions in all studied growth parameters, yield and its components.

The present data regarding the respond of the investigated vegetative growth measurements, yield and its components of wheat plants are in general agreement with the findings of Ghanim & El-Adl (1983) [18] in Egypt, they determined the wheat yield loss caused by the English Grain Aphid, *Sitobion avenae* (Hemiptera- Aphididae) was 40%. Kurppa (1989) [21] in Finland, determined the yield loss caused by outbreak of aphid specie *Rhopalosiphum padi* (20- 60 individuals per tiller), synchronized with seedling emergence, being 153 kg/ha. Infestation caused decreased yield by a mean of 30 kg/ha per day, and decreased to 41 kg/ha per day when delayed. Aheer *et al*. (1994) [5] found that a single aphid individual caused 2.20 percent loss in grain yield. Losses ranged from 30 to 40% at 15 aphids individuals/plant has also been reported by Keickhefer & Kantack (1980) [19].

El-Heneidy *et al*. (2003) [14] reported that, the stress of a massed cereal aphids *R. padi* and *S. graminum* caused yield reduction by every species and the two species together (21.2- 75%, 21.3-80.8% and 22.2-84.2%, respectively). Wains *et al*. (2010) [29] in Pakistan, stated that the number of aphids/tiller was positively correlated with loss in grain yield. Abbas & Niaz (2019) [1] in Pakistan, mentioned that the mean spike length, number of grains per spike, 100 grains weight and yield kg/ha was significantly affected by the population density of an aphid species.

Table 1: Weekly mean numbers, aphid days and cumulative aphid-days of *S. graminum* on wheat plants (Giza 171 cultivar), during two growing season (2017-2019).

Sampling date		First growing season (2017/2018) Plant age (days)	Growth stage (ZGS)*	Aphids count per 10 tillers ± S.E.	Aphid -Days	Cumulative aphid-days	Sampling date		Second growing season (2018/2019) Plant age (days)	Growth stage (ZGS)*	Aphids count per 10 tillers ± S.E.	Aphid -Days	Cumulative aphid-days
Dec., 2017	17	21	23	1.33 ± 0.33	2.00	2.00	Jan., 2019	27	56	29	6.00 ± 0.58	9.00	9.00
	24	28	24	3.67 ± 0.67	7.50	9.50	Feb.	2	63	31	10.33 ± 0.88	24.50	33.50
	31	35	25	12.00 ± 1.15	23.50	33.00		9	70	34	17.33 ± 1.20	41.50	75.00
Jan., 2018	7	42	27	24.33 ± 0.88	54.50	87.50		16	77	39	21.33 ± 1.20	58.00	133.00
	14	49	29	18.67 ± 0.33	64.50	152.00		23	84	41	27.00 ± 1.53	72.50	205.50
	21	56	31	59.00 ± 4.51	116.50	268.50	Mar.	2	91	45	30.67 ± 1.20	86.50	292.00
	28	63	32	41.00 ± 2.08	150.00	418.50		9	98	47	22.33 ± 1.45	79.50	371.50
Feb.	4	70	35	69.00 ± 3.79	165.00	583.50		16	105	55	28.00 ±1.15	75.50	447.00
	11	77	39	62.33 ± 1.20	197.00	780.50		23	112	60	42.00 ± 2.31	105.00	552.00
	18	84	41	52.67 ± 2.40	172.50	953.00		30	119	65	44.67 ± 1.45	130.00	682.00
	25	91	50	66.33 ± 3.28	178.50	1131.50	April	6	126	71	38.67 ± 2.40	125.00	807.00
Mar.	4	98	55	58.67 ± 1.86	187.50	1319.00		13	133	75	22.00 ± 1.15	91.00	898.00
	11	105	60	50.67 ± 1.76	164.00	1483.00	Total				310.33	898.00	
	18	112	65	36.67 ± 1.86	131.00	1614.00	General average				25.86 ± 1.96		
	25	119	69	24.00 ± 1.15	91.00	1705.00							
April	1	126	71	10.67 ± 0.67	52.00	1757.00							
	8	133	73	6.00 ± 0.58	25.00	1782.00							
Total				597.00	1782.00								
General average				35.12 ± 3.31									

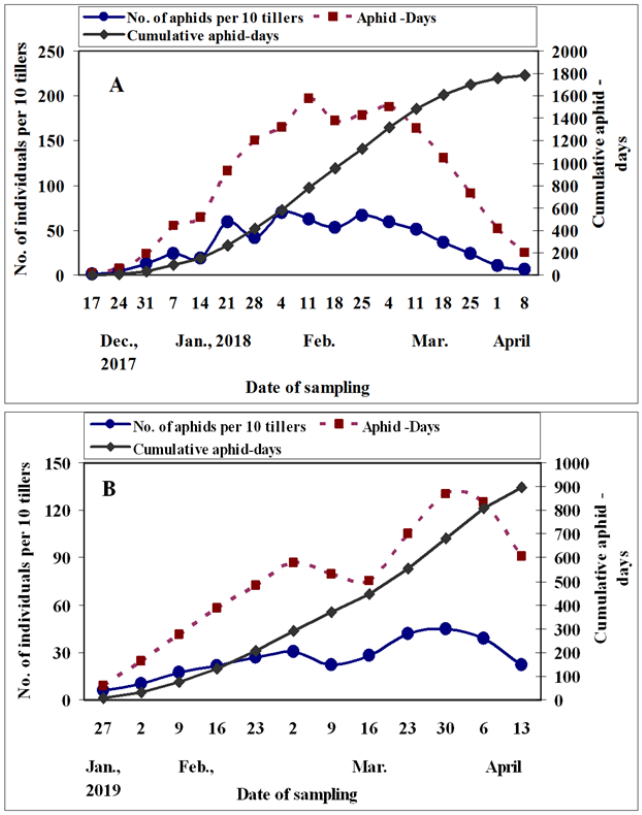

Fig 1: Weekly mean counts of aphid-days, cumulative aphid-days of *S. graminum* on wheat plants, during the two successive seasons [(2017/2018 (A) and 2018/2019 (B)]

Table 2: Effects of infestation by *S. graminum* on yield and its components of infested and uninfested bread wheat plants during the first growing season (2017/2018). (Values are the means of four different replicates ± S.E.):

Parameters	Uninfested plants (Treated)	Infested plants (Untreated)	Average	Reduction	Paired T -test
Leaf area	1205.35 ± 2.71	1111.42 ± 22.73	1158.39 ± 22.43	7.79	4.46 *
NO. of tillers m^{-2}	558.00 ± 1.53	533.00 ± 2.89	545.50 ± 5.78	4.48	8.33 **
Plant height	117.19 ± 0.80	115.47 ± 0.41	116.33 ± 0.55	1.46	4.46 *
Grain Yield (ton/fed)	2.58 ± 0.01	2.36 ± 0.02	2.47 ± 0.05	8.53	11.00 **
Straw yield (ton/fed) and	8.08 ± 0.08	7.34 ± 0.08	7.71 ± 0.17	9.12	8.20 **
Biological yield (ton/fed)	10.41 ± 0.03	9.65 ± 0.11	10.03 ± 0.18	7.35	9.07 **
NO. grains/spike	60.30 ± 1.10	56.60 ± 0.12	58.45 ± 0.96	6.14	3.05 *
Spike height	9.15 ± 0.03	8.73 ± 0.01	8.94 ± 0.10	4.64	9.81 **
1000-kernel weight (gm)	47.45 ± 0.14	43.16 ± 0.32	45.30 ± 0.97	9.05	9.24 **

Table 3: Effects of infestation by *S. graminum* on yield and its components of infested and uninfested bread wheat plants during the second growing season (2018/2019). (Values are the means of four different replicates ± S.E.):

Parameters	Uninfested plants (Treated)	Infested plants (Untreated)	Average	Reduction	Paired T -test
Leaf area	911.14 ± 5.89	833.99 ± 9.03	872.56 ± 17.91	8.47	5.27 *
NO. of tillers m^{-2}	454.00 ± 3.46	438.00 ± 1.15	446.00 ± 3.93	3.52	6.93 **
Plant height	120.67 ± 0.67	116.00 ± 1.15	118.33 ± 1.20	3.87	3.50 *
Grain Yield (ton/fed)	2.27 ± 0.01	2.13 ± 0.01	2.20 ± 0.03	6.18	6.06 *
Straw yield (ton/fed) and	7.15 ± 0.20	6.35 ± 0.03	6.75 ± 0.20	11.19	4.62 *
Biological yield (ton/fed)	9.10 ± 0.12	8.38 ± 0.04	8.74 ± 0.17	7.87	9.28 **
NO. grains/spike	56.33 ± 0.33	53.00 ± 0.58	54.67 ± 0.80	5.92	10.00 **
Spike height	10.30 ± 0.06	9.88 ± 0.02	10.09 ± 0.10	4.05	9.45 **
1000-kernel weight (gm)	48.72 ± 0.42	44.03 ± 0.27	46.37 ± 1.07	9.64	6.81 **

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