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Vegetative Growth Measurements, Yield and Its Components of Bread Wheat *Cultivar Misr* 2 as Influenced by *Rhopalosiphum p*adi L. Infestation under Upper Egypt Conditions

Moustafa M.S. Bakry [1*], M.M. Mohiy [2] and Islam R.M. El-Zoghby [3]
[1] Plant Protection Research Institute, A.R.C, Dokki, Giza, Egypt.
[2] Wheat Research Department, Field Crop Research Institute, A.R.C, Giza, Egypt.
[3] Plant Prot. Dept., Fac. of Agric. and Natural Resources, Aswan Univ., Aswan, Egypt.
*Corresponding author email id: md.md_sabry@yahoo.com

***Abstract* – The presented investigation was conducted at El-Mataana Agricultural Research Station, Agricultural Research Center, Upper Egypt, during 2017/2018 and 2018/2019 wheat growing seasons to study the effect of the infestation by *Rhopalosiphum padi* L. (Hemiptera: Aphididae) on yield and its components on bread wheat cultivar Misr 2. Results indicated that *R. padi* 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 *R. padi* during the first growing season (2017/2018) was higher than second growing season (2018/2019). As well, the cumulative counts of *R. padi* were 568.33 and 222.67 individuals per season for the two growing seasons, respectively. The means of *R. padi* total counts throughout the whole period of two seasons were 33.43 ± 3.05 and 18.56 ± 1.27 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 uninfested wheat plants exhibited higher rates. Moreover, three yield parameters i.e., grain, straw and yield (ton/fed) decreased obviously by *R. padi* infestation as compared to those of the uninfested plants (control). As for the impact on yield components, the infested wheat plants by *R. padi* exhibited an obvious decrease in (average number of grains/spike, spike height (cm) and average weight of 1000- grains (gm). On the other hand, the infested wheat plants showed, significantly, the highest reduction in all studied growth measurements, yield and its components.**

***Keywords* – *Rhopalosiphum padi*, Wheat, Yield, Aphids, Population Abundance.**

I. 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. Therefore, 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 and Maurer, 1976).** Temperatures accelerate organ development in few days without any increase in net photosynthesis and assimilate resulting in smaller biomass **(Fischer, 1985)** and **(Shpiler and Blum, 1986).** 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 conditi-

-ons.

Many pests attack wheat plants from sowing to harvesting. Aphids comprise one of the most destructive pests attacking wheat plants in Egypt, as mentioned by **Tantawi (1985)**, who recorded losses in crop yield reached 7.5 – 18.7% of the total grain production. The bird cherry-oat aphid, *Rhopalosiphum padi* (Linnaeus) is one of the 14 aphid species considered of most agricultural pest species worldwide **(Blackman and Eastop, 2007).** This pest causes severe damage to infested plants by sucking the plant sap with their mouth parts, causing thereafter deformations, by the action of the toxic saliva and excreting large amounts of honeydew that encourages the growth of sooty mould which inhibits photosynthesis and decreases vegetative growth of the infested plants and, in addition, aphids transmit of viral diseases to plants **(El- Fatih, 2000 and 2006).** Aphids cause substantial yield losses by the direct effect of feeding **(Keickhefer and Kantack, 1980)**. *R. padi* was found as the most abundant aphid species in Egyptian wheat fields **(El-Heneidy, 1994).** In recent years, *R. padi* has become the most frequent species on wheat crop, and is abundant throughout all developmental stages of wheat plants **(Parizoto *et al*., 2013 and Ahmad *et al*., 2016).** Therefore, the present study was undertaken to determine the effects of *R. padi* infestations on yield and its components of bread wheat plants under Upper Egypt conditions.

II. 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 (Misr 2) 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 *R. padi*).

The other four plots were treated with Sumithion pesticide 50% EC at the rate (2.5 ml/ liter water) when the population density of *R. padi* 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.

1. *Seasonal Abundance of R. padi Infesting Wheat Plants:*

For estimating the population density of *R. padi*, 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).** 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)** the

follows:

$$\text{Aphid-days} = 3X[\frac{a_1 + a_2}{2}]$$

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)**. The decimal growth stage can help in understanding crop adaptation and development **(Barber *et al.*, 2015).**

Data were recorded for agronomic characters as following:

1. Plant height in cm (PlH): 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), 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 kernels/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 *R. padi* infestation were calculated according to the following equation:

$$\text{Loss \%} = \frac{A - B}{A} X100$$

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

≤ 0.05, carried out by Computer using (**MSTATC Program software, 1980**). The averages of total alive insect population and the measurements of both vegetative growth and yield and its components of bread wheat cultivar Misr 2 were subjected to calculations and were depicted graphically by Microsoft Excel 2010.

III. RESULT AND DISCUSSION

The weekly counts of *R. padi* 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 *R. padi* was estimated on the basis of average number of alive insects' (Nymphs and apterae individuals) counts per ten tillers in the successive sampling dates.

1. *Population Studies:*

1.1. *Seasonal Activity of R. padi Population on Wheat Plants:*

A. *The First Growing Season (2017/2018):*

Data presented in Table (1) and illustrated in Fig. (1 A), showed that the population density of *R. padi* appeared in few number (2.00 ± 0.58 individuals per 10 tillers) on wheat plants in December, 17th and then it highly increased continuously to reach the first peak of abundance in February, 4th (68.33 ± 2.73 individuals per 10 tillers) and the phenological characters were (plant age, 70 days and the decimal code, 35). Thereafter, the population decreased on February, 11th (61.00 ± 2.08 individuals per 10 tillers) and then reincreased gradually to reach second peak in February, 25th (64.00 ± 2.31 individuals per 10 tillers) when the phenological characters were (plant age, 91 days and the decimal code, 50). After that, the population of aphids decreased gradually until April, 8th (Table, 1 and Fig., 1).

B. *The Second Growing Season (2018/2019):*

Results presented in (Table, 1) and illustrated in Fig. (1 B), indicated that *R. padi* appeared in few numbers on wheat plants on January, 27th (2.67 ± 0.33 individuals per 10 tillers), then its population increased gradually until reached a pack of abundance (26.00 ± 1.15 individuals per 10 tillers) on March, 2nd. As well, the phenological characteristics 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 flag leaf sheath. Aphids' population decreased on March, 16th and it reincreased gradually until reached the second peak of abundance on March, 30th (26.67 ± 0.67 individuals per 10 tillers) and the phenological characters were (plant age, 119 days and the decimal code, 65), being coincided with the anthesis period. After that, aphids' population decreased continuously until April, 13th and this aphid species disappeared during the maturation period.

It was obvious that infestation by *R. padi*, completely, disappeared on wheat plants during December up to the 3rd week of January on wheat plants during the second growing season. This may be due to the low temperature during this period. **El-Rawy (2013)** recorded that the lowest number of cereal aphid species on wheat plants (61.6 aphids/10 plants) occurred in January. It was noticed that *R. padi* appeared in April month during the two successive growing seasons. The same findings were noticed by **Vidya (1982)** who reported that the aphid population started to decline when ear head emergence started.

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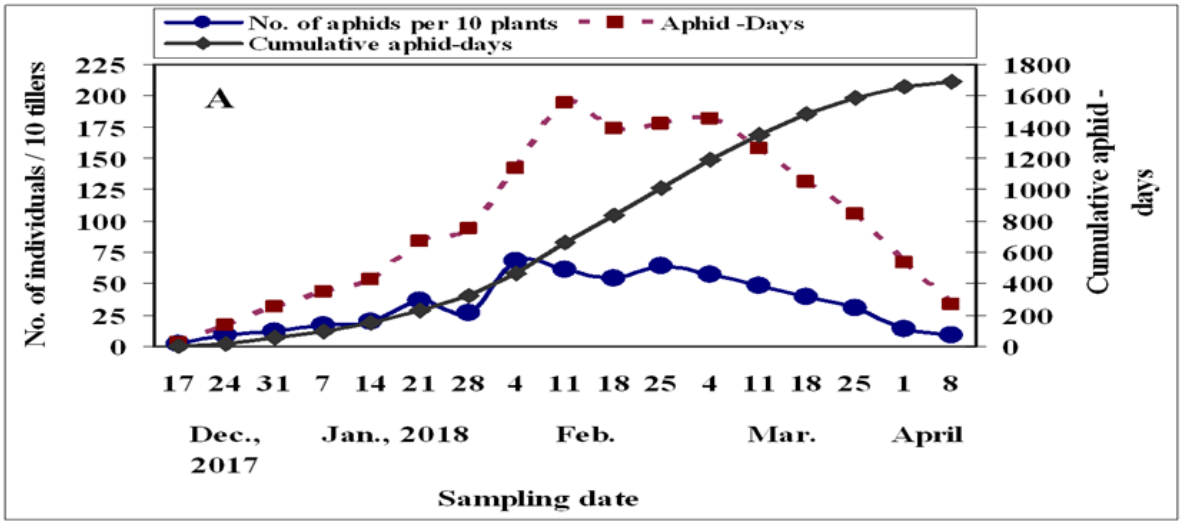
Table 1. Weekly mean numbers, aphid days and cumulative aphid-days of *R. padi* on wheat plants (Misr 2 cultivar), during two growing season (2017-2019).

Sampling Date		First Growing Season (2017/2018)					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			Plant Age (Days)	Growth Stage (ZGS)*	Aphids count per 10 tillers ± S.E.	Aphid-Days	Cumulative Aphid-Days
Dec., 2017	17	21	23	2.00 ± 0.58	3.00	3.00	Jan., 2019	27	56	29	2.67 ± 0.33	4.00	4.00
	24	28	24	9.00 ± 0.58	16.50	19.50	Feb.,	2	63	31	14.00 ± 1.00	25.00	29.00
	31	35	25	12.33 ± 0.88	32.00	51.50		9	70	34	17.33 ± 0.67	47.00	76.00
Jan., 2018	7	42	27	16.33 ± 0.88	43.00	94.50		16	77	39	22.00 ± 1.15	59.00	135.00
	14	49	29	19.33 ± 0.88	53.50	148.00		23	84	41	25.00 ± 0.58	70.50	205.50
	21	56	31	36.33 ± 2.33	83.50	231.50	Mar.	2	91	45	26.00 ± 1.15	76.50	282.00
	28	63	32	26.33 ± 1.86	94.00	325.50		9	98	47	22.00 ± 1.15	72.00	354.00
Feb.,	4	70	35	68.33 ± 2.73	142.00	467.50		16	105	55	21.00 ± 2.08	64.50	418.50
	11	77	39	61.00 ± 2.08	194.00	661.50		23	112	60	24.00 ± 1.15	67.50	486.00
	18	84	41	54.67 ± 5.36	173.50	835.00		30	119	65	26.67 ± 0.67	76.00	562.00
	25	91	50	64.00 ± 2.31	178.00	1013.00	April	6	126	71	15.33 ± 0.88	63.00	625.00
Mar.	4	98	55	57.33 ± 2.91	182.00	1195.00		13	133	75	6.67 ± 0.88	33.00	658.00
	11	105	60	48.00 ± 3.06	158.00	1353.00	Total				222.67	658.00	
	18	112	65	39.67 ± 2.03	131.50	1484.50	General Average				18.56 ± 1.27		
	25	119	69	31.00 ± 1.53	106.00	1590.50							
April	1	126	71	13.67 ± 0.88	67.00	1657.50							
	8	133	73	9.00 ± 0.58	34.00	1691.50							
Total				568.33	1691.50								
				33.43 ± 3.05									



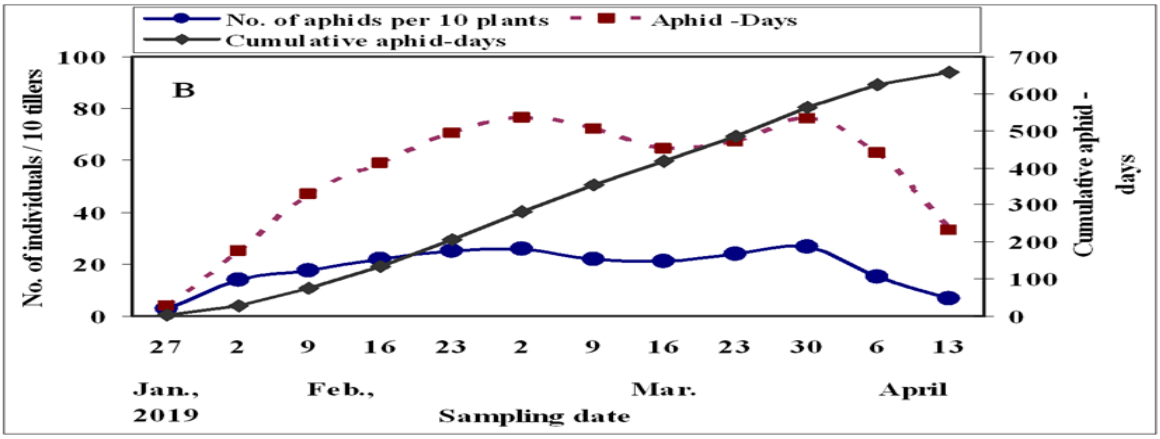


Fig. 1. Weekly mean counts of aphid-days, cumulative aphid-days of *R. padi* on wheat plants, during the two successive seasons [(2017/2018 (A) and 2018/2019 (B)].

The present results agree with those of **Abdel-Aziz *et al*. (2002), El- Rawy (2013), El-Mitwally *et al*. (2013)** and **Youssif *et al*. (2017)** who recorded that the maximum population density of cereal aphids occurred during February and March on wheat plants. **El-Heneidy *et al*. (2004)** 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),** 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. **Aheer *et al*. (1994)** recorded that Aphid population on wheat is high during Feb-March due to the favourable host available in the wheat field. **El-Maraghy *et al*. (2015)** reported that the aphid, *R. padi* began to infest wheat plants early during the middle of January when wheat plants were in the stem-elongation stage. Thereafter, numbers of aphids increased gradually to reach a peak, when the plants were at the flowering stage during the third week of February; during the next three weeks the number of the oat aphid declined sharply.

The obtained results cleared that the total population density of *R. padi* during the first growing season (2017/18) was higher than the second growing season (2018/19). The mean total *R. padi* population through the whole season was 33.43 ± 3.05 and 18.56 ± 1.27 individuals per 10 tillers over first and second growing seasons, respectively. The increase reached approximately 1.80 times as recorded in Table (1) and illustrated in Fig. (1 A&B). Also, the cumulative numbers of *R. padi* were 568.33 and 222.67 individuals per season for the two growing seasons, respectively.

1.2. *Cumulative Aphid-Days:*

Data in Table (1) and illustrated in Fig. (1 A & B), presented the aphid-days and the cumulative aphid-days for *R. padi* on wheat plants in order to express the total impact of an ever-changing population over time. The presented results indicated that the impact of *R. padi* population on wheat plants was higher at the first growing season (1691.50 cumulative aphid-days) as compared to the second one (658.00 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)** that used the same technique for cereal aphids on barely.

2. *Effect of Infestation by R. padi 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 infested wheat leaves had smaller leaf area than the uninfested ones. Generally and regardless the effect of infestation by *R. padi* on the leaf areas among infested and uninfested plants, the uninfested leaves had, significantly, bigger leaves (1205.35 ± 15.25 and 908.43 ± 10.64 cm^2) than the infested ones (1070.23 ± 48.46 and 818.96 ± 5.74 cm^2) during the two successive growing seasons, respectively. Also, the leaf areas of the infested wheat plants were reduced by 11.21 and 9.85 % compared to the uninfested ones during the two growing seasons, respectively. Also, statistical analysis of data showed significant and highly significant differences in the leaf area per plant among the uninfested and infested wheat plants (paried T-test values were 3.24 and 18.26) during the two successive seasons, respectively. **Kindler *et al.* (1995)** observed chlorosis and curling of leaves caused by feeding aphids.

Number of Spikes/m^2:

Results revealed that the uninfested wheat plants produced more tillers as an average was (548.00 ± 7.00 and 446.67 ± 6.67 tillers/m^2) than the infested ones (523.33 ± 6.77 and 420.00 ± 11.55 tillers/m^2). Also, number of tillers m^{-2} was reduced by 4.50 and 5.97% 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 and significant (paried T-test values; 16.98 and 4.00) during the two seasons, respectively.

Plant Height (cm):

Height of plant in the uninfested wheat plants measured 118.99 ± 0.94 and 119.00 ± 0.58 cm as compared to 112.56 ± 1.28 and 112.67 ± 1.76 cm for the infested ones during the two growing seasons, respectively (Tables, 2 and 3). So, it was reduced by 5.40 and 5.32% 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 infested wheat plants had less grain yield (average weight was 2.31 ± 0.05 and 2.11 ± 0.02 ton/fed) than the uninfested ones (2.56 ± 0.02 and 2.29 ± 0.03 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 9.78 and 7.86% 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 uninfested wheat plants had higher straw yield (average weight was 8.01±0.14 and 6.69 ± 0.16 ton/fed) than the infested ones (7.23 ± 0.13 and 6.13 ± 0.22 ton/fed).The difference in straw yield among infested and uninfested wheat plants was highly significant (T values were 10.41 and 9.33) during the two successive seasons, respectively. Also, the straw yield from the infested plants lost about 9.73 and 8.73 % from their weight as compared with the uninfested ones during the two growing seasons, respective-

-ly.

Biological Yield (ton/fed):

Data depicted in Tables (2 and 3) revealed that the infested wheat plants were smaller with mean weight of biological yield was an average (9.54 ± 0.15 and 8.05 ± 0.33 ton/fed) as compared to (11.27 ± 0.14 and 9.01 ± 0.14 ton/fed) for the uninfested ones during the two growing seasons, respectively. The differences among uninfested and infested wheat plants were highly significant and significant (paired T-test were 15.59 and 3.76) during the two seasons, respectively. Also, average weight of biological yield for infested wheat plants was reduced by 15.36 and 10.65% compared with the uninfested ones during the two growing seasons, respectively.

Number of Kernels/Spike:

Data obtained in Tables (2 and 3) revealed that the infested wheat plants produced less number of grains per spike with the averages (56.20 ± 1.47 and 50.00 ± .15 grains per spike) than the uninfested ones (59.11 ± 1.66 and 52.13 ± 2.13 grains/spike), during the two growing seasons, respectively. Also, number of grains/spike was reduced by 4.93 and 4.09% 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 insignificant during the two seasons, respectively.

Spike's Height (cm)

Data in Tables (2 and 3) revealed that the uninfested wheat plants were higher with mean spike heights; (9.03 ± 0.03 and 10.20 ± 0.06 cm) as compared to (8.73 ± 0.09 and 9.93 ± 0.09 cm) for the uninfested ones, during the two growing seasons, respectively. Also, height of spike of the infested wheat plants was reduced by 3.32 and 2.61% as compared with those on the uninfested ones during the two successive seasons, respectively. Data analysis showed significant spike's height differences among uninfested and infested wheat plants (paired T-test values were 3.00 and 4.00) 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 uninfested wheat plants was higher (average weight were 47.35 ± 0.20 and 48.89 ± 0.45 g) as compared to 43.54 ± 0.44 and 44.75 ± 0.77 g for the infested ones during the two growing seasons, respectively. Analysis of data showed significant differences among kernel's weight from uninfested and infested wheat plants (paired T-test values were 9.05 and 4.67). Also, average weight of 1000- grains from infested wheat plants was reduced by 8.04 and 8.46% 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 *R. padi* infestation as compared to those of the uninfested plants (control). As for the impact on both yield components, the infested wheat plants by *R. padi* 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 and El-Adl (1983)** in Egypt, they determined the wheat yield loss caused by the English Grain Aphid, *Sitobion avenae* (Hemiptera- Aphididae) was 40%. **Kurppa (1989),** in Finland, determined the yield loss caused by outbreak of aphid specie *R. 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)** 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 and Kantack (1980). El-Heneidy *et al.* (2003)** reported that, the stress of a massed cereal aphids *R. padi* and *Schizaphis 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)** in Pakistan, stated that the number of aphids/tiller was positively correlated with loss in grain yield. **Abbas and Niaz (2019)** 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 2. Effects of infestation by *R. padi* on yield and its components of *R. padi* infested and uninfested bread wheat plants during the first growing season (2017/2018). (Values are the means of four different replicates ± S.E.):

Parameters	Untreated Plants (Infested)	Treated Plants (Uninfested)	Average	Reduction	Paired T-test
Leaf Area	1070.23 ± 48.46	1205.35 ± 15.25	1137.79 ± 37.52	11.21	3.24 *
No. of Tillers m^{-2}	523.33 ± 6.77	548.00 ± 7.00	535.67 ± 7.03	4.50	16.98 **
Plant Height	112.56 ±1.28	118.99 ± 0.94	115.78 ± 1.60	5.40	2.93 *
Grain Yield (ton/fed)	2.31 ± 0.05	2.56 ± 0.02	2.43 ± 0.06	9.78	4.18 *
Straw Yield (ton/fed) and	7.23 ± 0.13	8.01 ± 0.14	7.62 ± 0.19	9.73	10.41 **
Biological Yield (ton/fed)	9.54 ± 0.15	11.27 ± 0.14	10.41 ± 0.40	15.36	15.59 **
NO. Grains/Spike	56.20 ± 1.47	59.11 ± 1.66	57.66 ± 1.19	4.93	1.76
Spike Height	8.73 ± 0.09	9.03 ± 0.03	8.88 ± 0.08	3.32	3.00 *
1000-Kernel Weight (gm)	43.54 ± 0.44	47.35 ± 0.20	45.45 ± 0.88	8.04	9.05 **

Table 2. Effects of infestation by *R. padi* on yield and its components of *R. padi* infested and uninfested bread wheat plants during the second growing season (2018/2019). (Values are the means of four different replicates ± S.E.):

Parameters	Untreated Plants (Infested)	Treated Plants (Uninfested)	Average	Reduction	Paired T-test
Leaf Area	818.96 ± 5.74	908.43 ± 10.64	863.69 ± 20.72	9.85	18.26 *
No. of Tillers m^{-2}	420.00 ± 11.55	446.67 ± 6.67	433.33 ± 8.43	5.97	4.00 **
Plant Height	112.67 ± 1.76	119.00 ± 0.58	115.83 ± 1.64	5.32	5.27 *
Grain Yield (ton/fed)	2.11 ± 0.02	2.29 ± 0.03	2.20 ± 0.04	7.86	3.90 *
Straw Yield (ton/fed) and	6.13 ± 0.22	6.69 ± 0.16	6.41 ± 0.17	8.37	9.33 **
Biological Yield (ton/fed)	8.05 ± 0.33	9.01 ± 0.14	8.53 ± 0.27	10.65	3.76 *

Parameters	Untreated Plants (Infested)	Treated Plants (Uninfested)	Average	Reduction	Paired T-test
NO. Grains/Spike	50.00 ± 1.15	52.13 ± 2.13	51.07 ± 1.19	4.09	1.68
Spike Height	9.93 ± 0.09	10.20 ± 0.06	10.07 ± 0.08	2.61	4.00 *
1000-Kernel Weight (gm)	44.75 ± 0.77	48.89 ± 0.45	46.82 ± 1.01	8.46	4.67 *

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AUTHOR'S PROFILE

First Author
Moustafa M.S. Bakry, Plant Protection Research Institute, A.R.C, Dokki, Giza, Egypt.

Second Author
Mohamed M. Mohiy, Wheat Research Department, Field Crop Research Institute, A.R.C, Giza, Egypt.

Third Author
Islam R.M. El-Zoghby, Plant Prot. Dept., Fac. of Agric. and Natural Resources, Aswan Univ., Aswan, Egypt.