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ENTOMOLOGY

POTENTIAL IMPACT OF NITROGEN ON POPULATION FLUCTUTATION OF APHID AND YIELD PARAMENTERS IN BARLEY

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ABSTRACT

Balanced nitrogenous fertilizer is of utmost importance for managing aphids population and achieving sustainable barley production. The present study was carried out on the Farm area of farmer field under the supervision of the Department of Plant Protection and quality control of pesticides during 2020 and 2021.Barley cultivar 'Haider-93' was sown in a randomized complete block design (RCBD) with three replications to examine the effect of two levels ofnitrogen fertilizer, 50 and 100 kg/ha along with control (no fertilizer), on population fluctuation of aphid and on barley yield components like grain protein (%), 1000-grain weight and the grainyield of barley. Aphid incidence was recorded throughout the cropping season. The results revealed thatpeak infestation of aphids per tiller were recorded in the 3rd week of February in successive year. The study indicated asignificant relationship between nitrogen fertilizer and aphid population density per tiller. The mean aphid population per tiller was recorded asignificantly higher (34.12 ± 0.81 and 28.65 ± 0.17 for the years 2020 and 2021, respectively) at 100 kg/ha of nitrogen level while lowest infestation (14.51 ± 0.20 and 12.30 ± 0.10 aphids per tiller for the year 2020 and 2021, respectively) was recordedat 0 kg/ha of nitrogen fertilizer. Nitrogen fertilizer level at 100 kg/ha gave significantly higher grain protein (12.80 ± 0.17 and 13.70 ± 0.26 % for the years 2020 and 2021, respectively) and grain yield (2758.75 ± 60.82 and 2673.79 ± 61.88 kg/ha produce for the year 2020 and 2021, respectively) of the barley crop. However, treatment differences for 1000-grain weight (g) were recorded as non-significant. These findings suggest that the nitrogen fertilizer at 100 kg/ha level produced significantly higher grain protein (%) and grain yield at the same time, also supported the higher infestation of aphids per tiller. Still, this aphid density did not affect the accumulation of grain protein (%) and grainyield of the barleycrop. The results of thisstudy may be used for the decision-making process for applying nitrogen fertilizer to get better grain yield of barley cropbut at the same time considering the colonizing aphid population.

KEYWORDS: Aphid; nitrogen; grain protein; 1000-grain weight; grainyield; barley crop

INTRODUCTION

Barley (*Hordeumvulgare* L.) is cultivated as a minor crop in Pakistan.Multiple biotic and abiotic factors play a vital role in suppressing the average yield of this crop. (Gul *et al*., 2019). Among the biotic factors, insects are considered as one of the major factor in the declining yield potential of barley. Aphid is the most destructive pest of cerealsthat sucks the cell sap and transmits several plant diseases (Wosula and Clark, 2012). Its unrestrained growth is probably due to adaptation under the given circumstances and alternate host plants (Nigam, 2021). The key speciesof aphidsare *Rhopalosiphum padi* (L.), *Schizaphis graminum* (R.), and *Sitobion avenae* (F.). *Rhopalosiphum padi* is considereda serious threat to crops from juvenile to crop maturity (Yahya *et al*., 2017). Aphids weakens plants by depriving them of the cell sap, causing withering and death (Singh and Garima, 2021). If the populationof aphids is not checked timely, aphid would build their population and provide a growth medium through saliva secretion for sooty molds, ultimately impairing the photosynthesis and promoting the fungal disease attack (Panchal, 2020).

Fertilizers (nitrogen, phosphorus, and potassium) play an important role on the developmental stages and on the nutritional value by altering the metabolites that

ultimately influence the population of aphid (Bado *et al*., 2002). Nitrogen is an important component, pivotal in plant growth and development. Barley requires regular application of nitrogen for optimum growth and grain yield production. The application of Nfertilizers affects the aphid preference for host selection and changes inthe volatile compounds of plants may affect the aphid landing (Powell *et al*., 2006). According to some estimates, plants supplied with N fertilizer accumulate higher free protein and amino acid in their leaves and attract many aphids (SARE, 2012). The increase in the population under higher N rates might be more, as aphid on N-rich plants feeds 2-3 times longer. Using excessive nitrogen fertilizer increases the aphid infestation and found a positive correlation betweenthe incidence of aphid population dynamics and different doses of nitrogen fertilizers on the wheat crop (Tetarwal *et al.*, 2012).

Barley, a nitrogen-sensitive crop, requires limited nutrients, and its area is decreasing continuously in Pakistan (Alley *et al.*, 2009; Naheed *et al.*, 2015). Barley production and grain quality can be increased by improving the nitrogen fertilizer to the crop.Keeping in view the havoc caused by the aphid and the importance of nitrogen fertilizer doses to the barley crop, this study has been carried out to evaluate the effects of different levels of nitrogen fertilizer on aphid populationdynamics and on grain protein (%), 1000-grain weight(g) and the grainyield of the barley crop.

MATERIALS AND METHODS

Research Plan

The barley crop (Haider-93) was sown at the farm area of Farmer (Latitude 31.427761; Longitude 73.075798) under the supervision of pest warning and quality control of pesticides, Faisalabad, Pakistan, for two consecutive seasons, 2020 and 2021, respectively. Seed rate, plant-plant distance and irrigation pattern was adopted as recommended agronomic practices. Three treatments, viz. two levels of nitrogen fertilizer (50 and 100 kg/ha) along with a control plot, were applied. The plot size under each treatment was 2 × 6 m (12 m^2) with triplet replications for the whole experiment.

Data recording

Observation regarding aphid population fluctuation was recorded throughout the cropping season. The couting of aphids was recorded from randomly selected 10 tillers per plot per replication at weekly basisuntil harvest. Average count of aphids per tiller was calculated to estimate theseasonal infestation. At time of maturity, crop was harvested manually and through mini thresher, grains were separated from chaff. The grains were sun-dried, and the weight was taken after this period. Grain yield per replication was recorded and was converted into kilogram per hectare. One thousand seed grainsand weighed in grams (g) was also recoded. Sample grains from each plot were analyzed for percent protein contentusing the method mentioned by Moroi *et al.* (2011) from the laboratory of Wheat Research Institute, Ayub Agriculture Research Institute, Faisalabad.

Statistical analysis

Statistical analysis was performed by Statistix 8.1 software package (Analytical software, Statistix; Tallahassee, Florida, USA, 1985-2005). Data were expressed as mean values ± standard error (S.E). Data were subjected to analysis of variance (ANOVA) for RCBD design (Steel *et al.,* 1997).Means were compared between treatments by using Fischers' LSD test. Difference among treatments wasconsidered significant at a p-value ≤ 0.05.

RESULTS AND DISCUSSION

Aphids invasion to barley cropwas started on 28 January, 2020 **(Table 1)** and 26 January, 2021 **(Table 2)** respectively, at all nitrogen fertilizer levels. The population of aphid gradually increased and peak infestation was recordedon 18 February, 2020 and on 16February, 2021 respectively in all nitrogen fertilizers levels. The aphid population then gradually decreased as crop started to mature and the least population of aphid was recorded on 18 March, 2020 **(Table 1)** and on 22 March, 2021 **(Table 2)** in all nitrogen fertilizers levels.

The present study showedthat there exists a significant difference of aphid infestationsat different nitrogen levels (0, 50 and 100 kg/ha). The nitrogen fertilizer exerted a positive significant effecton aphid infestation. The statisticallysignificant highest aphid population per tiller was observed at 100 kg/ha nitrogen level in both years 2020 and 2021. At 100 kg/ha nitrogen level, insect infestations were highly significant*i.e.* 34.12 ± 0.81 aphids per tiller in 2020 **(Table 1)** and 28.65 ± 0.17 aphids per tiller in 2021 **(Table 2)**, respectively. At 0 kg/ha nitrogen fertilizer level, the lowest insect infestation were observed *i.e.* 14.51 ± 0.20 aphids per tiller in 2020 **(Table 1)** and 12.30 ± 0.10 aphids per tiller in 2021 **(Table 2)** respectively.

Grain protein (%) was significant at all three levels (0, 50 and 100 kg ha^{-1}) of nitrogen fertilizer **(Table 1 and 2)**. The grain protein (%) was found significantly highest (12.80 ± 0.17 in 2020 and 13.70 ± 0.26 in 2021) at 100 kg/ha nitrogen level. The significantly lowest

Table 1. Aphid infestation, grain protein, 1000-grain weight and grain yield of barley crop sown under different levels of nitrogen fertilizer during year 2020.

Aphid infestation on different observation dates in barley crop					
Observation Dates	**0 kg/ha**	**50 kg/ha**	**100 kg/ha**	**P-value**	**LSD test value**
28-Jan	0.73 ± 0.15 c	1.50 ± 0.29 b	2.33 ± 0.44 a	0.01*	0.72
4-Feb	6.47 ± 0.51 c	9.53 ± 0.56 b	13.63 ± 0.76 a	0.00*	2.85
11-Feb	22.70 ± 1.46 c	37.07 ± 0.80 b	55.80 ± 1.29 a	0.00*	6.08
18-Feb	40.23 ± 1.12 c	61.37 ± 1.12 b	98.57 ± 2.61 a	0.00*	7.94
25-Feb	25.67 ± 0.94 c	38.07 ± 0.91 b	59.33 ± 0.45 a	0.00*	2.79
4-Mar	10.80 ± 0.83 c	16.80 ± 1.00 b	24.07 ± 1.01 a	0.00*	5.11
11-Mar	6.57 ± 0.61 c	10.87 ± 0.54 b	15.50 ± 0.57 a	0.00*	3.02
18-Mar	1.10 ± 0.17 c	2.83 ± 0.58 b	3.70 ± 0.64 a	0.06*	0.55
Seasonal mean	14.51 ± 0.20 c	22.25 ± 0.36 b	34.12 ± 0.81 a	0.00*	2.35
Yield and yield components in barley crop					
Yield components	0 kg/ha	50 kg/ha	100 kg/ha	P-value	LSD test value
Grain protein (%)	10.57 ± 0.52 c	11.53 ± 0.75 b	12.80 ± 0.17 a	0.02*	0.90
1000-grain weight (g)	31.97 ± 0.95	34.43 ± 0.43	34.77 ± 1.17	0.06 ns	-
Grain yield (kg ha^{-1})	1819.18 ± 50.04 c	2503.33 ± 80.77 b	2758.75 ± 60.82 a	0.00*	115.33

Aphid infestation = Number of aphids per tiller ± S.E; Grain protein = % content ± S.E; 1000-grain weight = g ± S.E; Grain yield = kg/ha; * = Significant at 0.05 using LSD test; NS = Non-significant at 0.05using LSD test. Statistical lettering is to compare within rows, thus mean values sharing different letters are statistically different.

Table 2. Aphid infestation, grain protein, 1000-grain weight and grain yield of barley crop sown under different levels of nitrogen fertilizer during year 2021.

Aphid infestation on different observation dates in barley crop					
Observation dates	**0 kg/ha**	**50 kg/ha**	**100 kg/ha**	**P-value**	**LSD test value**
26-Jan	0.67 ± 0.12 c	0.80 ± 0.06 b	0.97 ± 0.18 a	0.03*	0.12
2-Feb	3.97 ± 0.46 c	6.30 ± 0.35 b	11.50 ± 0.51a	0.00*	2.29
9-Feb	20.17 ± 1.16 c	33.47 ± 1.16b	50.43 ± 1.10 a	0.00*	5.08
16-Feb	35.37 ± 0.90 c	53.83 ± 0.95 b	82.40 ± 1.27 a	0.00*	4.15
23-Feb	21.43 ± 0.56 c	37.67 ± 1.56 b	46.63 ± 1.21 a	0.00*	4.42
1-Mar	13.93 ± 0.92 c	22.73 ± 0.38 b	30.57 ± 0.52 a	0.00*	3.10
8-Mar	10.90 ± 0.26 c	14.10 ± 0.26 b	19.57 ± 0.64 a	0.00*	1.18
15-Mar	4.00 ± 0.40 c	8.63 ± 0.73 b	14.10 ± 0.68 a	0.00*	2.13
22-Mar	0.27 ± 0.12 c	1.50 ± 0.20 b	1.70 ± 0.32 a	0.00*	0.62
Seasonal mean	12.30 ± 0.10 c	19.89 ± 0.47 b	28.65 ± 0.17 a	0.00*	1.20
Yield and yield components in barley crop					
Yield components	0 kg/ha	50 kg/ha	100 kg/ha	P-value	LSD test value
Grain protein (%)	11.60 ± 0.56 c	12.87 ± 0.67 b	13.70 ± 0.26 a	0.00*	0.72
1000-grain weight (g)	32.97 ± 0.19	34.07 ± 1.35	35.11 ± 1.39	0.31ns	-
Grain yield (kg ha^{-1})	1671.97 ± 74.89 c	2403.62 ± 39.20 b	2673.79 ± 61.88 a	0.00*	243.22

Aphid infestation = number of aphids per tiller ± S.E; grain protein = % content ± S.E; 1000-grain weight = g ± S.E; Grain yield = kg/ha; * α=0.05

grain protein (%) was recordedfrom seed grains of control plot (0 kg/ha nitrogen level)*i.e.*10.57 ± 0.52 in 2020 and 11.60 ± 0.56 in 2021. 1000-grain weight(g) was found statistically non-significant in all nitrogen fertilizer levels.

The results revealed that the apid infestation of the crop was directly correlated with nitrogen fertilizer levels as the pest population inhanced as fertilizer level increased **(Fig. 1)**. Grain yield was found statistically significant **(Table 1 and 2)** for all nitrogen fertilizer levels. Significantly higher grain yield (2758.75 ± 60.82 kg/ha and 2673.79 ± 61.88 kg/ha) was recorded at 100 kg/ha nitrogen fertilizer level in both years 2020 and 2021 respectively.The lowest grain yield was observed at 0 kg/ha nitrogen level in both years which was 1819.18 ± 50.04 kg/ha in 2020 and 1671.97 ± 74.89 kg/ha in 2021.

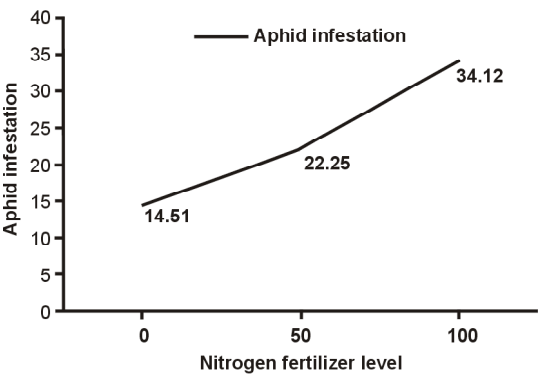

Fig. 1. Correlation of N fertilizer and crop aphid infestation

Results of our study are consistent with the previous workers who reported peak infestation of aphid during the month of February(Akhtar and Perveen, 2002; Ali *et al*., 2012).

Aphid infestation was recorded highest atahigher level of nitrogen fertilizer (34.12 ± 0.81 aphids per tiller in 2020 and 28.65 ± 0.17 aphids per tiller in 2021 respectively). Results of our study are in line with the Ramzan *et al.* (1992) who found that theapplication of nitrogenous fertilizers attract the pest infestation. We observed significantly low aphid density at 0 kg/ha nitrogen level which is in line with Ponder *et al.* (2000) who observed feweraphids (*R. padi*) on the plants with inadequate nitrogen.

We found higher grain protein (%) at higher level of nitrogen application (100 kg/ha). Our results are comparablewith the Franzen *et al*. (2007) who reported thenon-significant difference in total protein contents in aphid-infested plants as compared to control plants. However, contrary to our study Basky and Fónagy (2003) reported low protein contents in wheat flour made from aphid infested wheat.The possible explanation is that loss of grain protein (%) by aphid infestation at higher level of nitrogen was not thesame as compared to resource allocation of grain protein (%) and increased protein (%) production by increasing the level of nitrogen fertilizer application. Similar to our results, Triboi and Triboi-Blondel (2002) reportedthat an increase in grain protein content may come from either through greater nitrogen supply to the grains. We recorded non-significantly different 1000-grain weight (g)in all nitrogen fertilizer levels.

Results of our study are in accordance with the Calhoum (1991) who observed areduction in 1000-grain weight(g) in aphid-infested wheat plots. The non-significant difference of 1000-grain weight (g) at 100 kg/ha nitrogen fertilizer level might be due to the higher infestation of the aphid at grain formation, that blocked phloem pathways of food translocation.

In the present study,thehigher yield of barley was recorded at 100 kg/ha nitrogenfertilizer level. Our results are in conformity to the Moreno *et al.* (2003) who reported the higher yield of barley at 100 kg/ha nitrogen fertilizer level in abarley crop. They observed more secondary tiller formation, higher ears per m^2 and more kernels per ear that resulted in higher grain yield at 100 kg ha^{-1} nitrogenfertilizer level. Results of the present study are at par with the Calhoum *et al.* (1991) who revealed that aphid infestation may reduce the barley yield upto 10-59%. Our results are in line with Miles (2009) who reported that aphids affect cereal plants by direct feeding, creating nitrogen sink, and thus diverting nitrogen away from the seed developing and grain filling. Aphids use the nitrogen for their growth and reproduction. For foliar insecticide application against aphids (only at label rates) on cereal crops, a spray threshold of 10 aphids/tiller is suggested, but caution is required that spraying should made only to increasing aphid population and where beneficial insect activity is limited (NGA, 2010). It is quite better and highly recommended to opt for pre-sowing seed treatment with label rates of insecticidesin cereal crop.

CONCLUSION

The nitrogen fertilizer level at 100 kg ha^{-1} can be recommended as the optimum field rate for barley cropproduction. Although significantly higher population of aphid was recorded at 100 kg ha^{-1} nitrogen fertilizer level, but aphid density on crop plantsdid not giveeconomic damage and barleyplants gave the higher grain yield.

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2.	Qurban Ali	Supervised the execution of the experiment	
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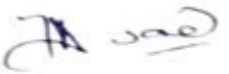
4.	Muhammad Faheem Akhtar	Provided the technical guidance	
5.	Asad Aslam	Analysed the data and helped in write-up	
6.	Najuf Awais Anjum	Designed the structure of manuscript	
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