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POPULATION DYNAMICS OF WHEAT APHIDS IN RESPONSE TO DIFFERENT DOSES OF NITROGEN APPLICATION

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ABSTRACT

Attaining optimal crop production demands vigilant fertilizer application, stressing balanced fertilization to ensure vigorous foliage development and to increase crop yield. A field study was carried out in 2021 to assess the effect of different doses of nitrogen application (90, 100, 110, 120, and 130 kg acre^{-1}) on the population dynamics of aphids in wheat crop. It was observed that excessive nitrogen fertilization can lead to increased aphid infestations. In the study, nitrogen was applied in two split dosages: the first at sowing and the second at the time of the first irrigation *i.e.* 45 days after sowing. The population of wheat aphids was monitored weekly up to seven weeks. During the study period, numerous phases of aphids, including nymphs and adults, as well as the occurrence of ladybird beetles were found in wheat field. There was a direct correspondence between the amount of nitrogen fertilizer applied and the number of pests per plant. Aphid population was increased exponentially with the application of 130 kg acre^{-1} of nitrogen. An amount of N at 90 kg acre^{-1} indicated reduced pest and predator attack throughout the growing season. Nitrogen applications in the range of 120-130 kg per acre increased aphid infestations, besides an upsurge in the activity of the natural enemy, the ladybird beetle. This study underscores the importance of balanced and timely nitrogen fertilizer application in regulating pest populations and optimizing wheat yields. The findings suggest that judicious nitrogen management can mitigate aphid infestations, promoting resilient and sustainable wheat production systems.

Keywords: Ntrogen fertilizer, wheat aphid, wheat yield, aphid population.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a matter of life and death for more than 35 percent of the worldwide human population (Khakwani *et al.,* 2012). More than 70% of the total population of Pakistan consumes wheat as a staple food; hence, procurement of high grain yield is mandatory to meet the speedily demanding population. Undoubtedly, the average wheat yield in our country is not as high as that of advanced countries in the world. Numerous aspects are involved in wheat yield reduction, including using substandard wheat varieties, improper implementation of irrigation and fertilizer, sowing at the wrong time, and invasion of weeds and pests (Akbar and Javaid, 2010; John *et al.,* 2017). Various insect pests affect wheat crops, and among these, aphids are more accountable for considerable economic losses because they actively feed on plants and transfer diseases (Bukvayova *et al.,* 2006; Ahmad *et al.,* 2023). In Pakistan, aphid species commonly observed on wheat crops include *Rhopalosiphum padi*, *Sitobion avenae*, and *Schizaphis graminum* (Shah *et al.,* 2006). Aphids suck sap from shoots and leaves and transmit several kinds of plant diseases. Sap extraction leads to a considerable decrease in yield, with direct reductions ranging from 35–40% and indirect losses of 20–80% due to the transmission of diseases (Carvalho, 2006). *R. padi* inflicts harm by extracting sap from plants starting at the two-leaf stage, resulting in 40–60% yield losses. For *S. graminum,* yield reductions of up to 30% have been documented in experimental fields where no spraying has occurred. Likewise, outbreaks of *S. avenae* resulted in yield losses ranging from 20–30%. In cereal crops, especially wheat, insecticides are utilized to control aphid infestations (Tanguy and Dedryver, 2009). However, many aphid species have developed resistance to commonly used pesticides. This restricted accessibility of operational pesticides for wheat cultivation eventually leads to declined wheat production (Foster *et al.,* 2014). Furthermore, climatic fluctuations are predicted to aggravate aphid infestations, posing a significant threat to wheat yields and theoretically bringing about contrary influences on the global economy (Carvalho, 2006; Pickett *et al.,* 2013). Keeping in mind these challenges, there's a persuasive necessity to discover unconventional tactics for

handling aphids to maintain wheat production and certify forthcoming food security (Simon *et al.,* 2021). Nitrogen plays a noticeable part in plant metabolism, being a decisive constituent of proteins, which are fundamental to all vibrant plant developments (Leghari *et al.,* 2016). Consequently, applying nitrogen, stereotypically in the form of chemical fertilizer, is crucial for improving crop production. Nitrogen fertilizer has been witnessed to influence several features of plant progression, such as tiller density, spikelet count per spike, grain yield per spike, spike length, and 1000-grain weight. The existing study aimed to explore nitrogen fertilizer's impact on aphids' population dynamics.

MATERIALS AND METHODS

Experimental site

A field experiment was conducted at the research area of the Institute of Agricultural Sciences, University of Punjab, Lahore (latitude 31.4790° N, longitude 74.2662° E) during the 2021-22 growing season of wheat.

Experimentation and crop husbandry

The experiment was arranged in a randomized complete block design (RCBD) with quadruplicate sets. The primary objective was to assess the impact of varying nitrogen doses on aphid populations, their natural predators, and the resultant quality and quantity of wheat grain. Local wheat seed varieties were sown using the line drilling method, spaced 20 cm apart at a rate of 90 kg acre^{-1} on November 18, 2021, across three contiguous farms. Nitrogen fertilizer, a combination of urea and di-ammonium phosphate (DAP), was applied at the time of sowing at a rate of 90 kg acre^{-1} across all fields. Subsequent applications of 100, 110, 120, and 130 kg acre^{-1} were administered 45 days after sowing (DAS) during the second irrigation. Irrigation was carried out using groundwater from tube wells at 30, 45, and 60 DAS intervals.

Data recording

A field experiment was conducted at the experimental area of Faculty of Agricultural Sciences, University of the Punjab, Lahore during December 2021. Wheat was grown using all the agronomic practices recommended by Agricultural Department of Punjab. The experiment was conducted in triplicate. Aphid data collection was started 45 days after sowing (DAS). The data were collected weekly for seven weeks. During each sampling, the population dynamics of wheat aphids were assessed at five randomly selected spots within each plot. The study involved perceiving all phases of aphids on five tillers and calculating the average. Furthermore, ladybird beetle larvae and adult phases were also recorded at each selected spot.

Statistical analysis

The study employed a complete randomized block design and directed a two-way analysis of variance (ANOVA) to assess the effect of diverse nitrogen dosages on aphid population activity. The least significant difference test (LSD 0.05) was used to determine the statistical significance of these effects. The analysis was done by using Statistics 8, version 8.1. Before the analysis, the data were tested for normal distribution (Shapiro-Wilk test: $P>0.05$) and homogeneity of variance (Levene test: $P>0.05$) to certify the legitimacy of the outcomes.

RESULTS

The results of this study indicate that higher doses of urea fertilizer led to increased populations of aphid pests compared to lower doses. Throughout the seven-week duration of the experiment, data were recorded from one control group and 24 experimental plots, each receiving one of five different nitrogen doses. Data were collected from five tagged plants within each plot for recording purposes.

90 kg acre^{-1} urea application

The plots treated with the lowest dose of Urea application exhibited the lowest aphid infestation levels consistently throughout the developmental season. The lowest pest population density, recorded at 1.25 aphids per plant, was observed during the initial week of data collection at 45 days after sowing. Conversely, the highest infestation level, reaching 12.0 aphids per plant, was documented during the fifth week of data recording (Fig. 1A).

100 kg acre^{-1} urea application

In these plots, the maximum aphid infestation occurred during the fifth week of data recording, reaching 15 aphids per plant. Conversely, the lowest pest population density, recorded at 2.25 aphids per plant, was observed during the first week of data collection. (Fig. 1B).

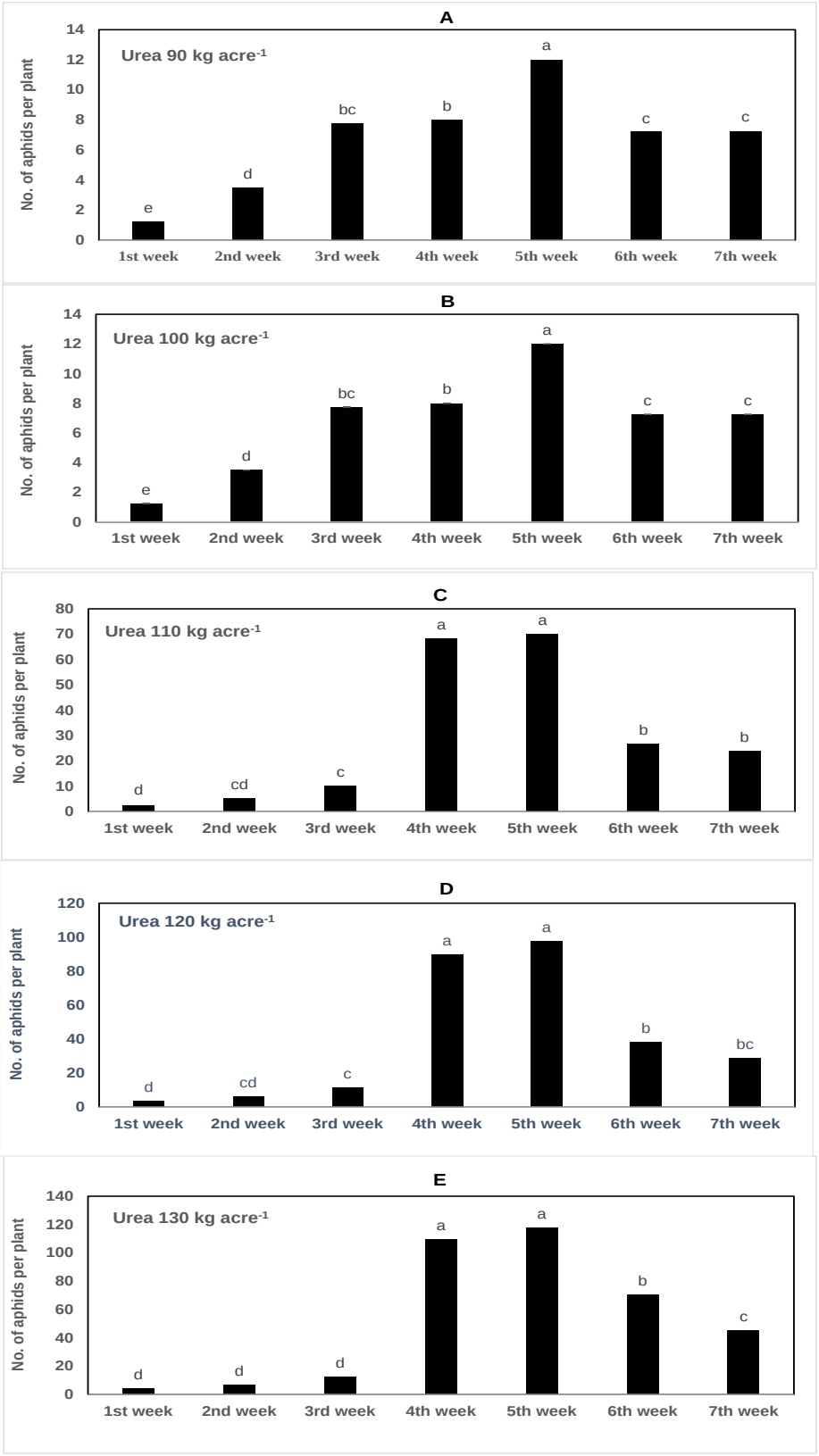

Fig. 1. Effect of rate of N fertilizer on population dynamics of aphids on wheat. Values with different letters show significant difference (P≤0.05).

110 kg acre^{-1} urea application

The incidence of wheat aphids in the plots treated with the lowest urea application rate remained consistently low throughout the growing season, potentially posing a threat equivalent to the economic threshold level. The lowest population density of pests, recorded at 2.5 aphids per plant, was observed during the initial week of recording at 50 days after sowing (DAS). However, the highest invasion, reaching 68.2 aphids per plant, was documented during the fifth week of recording. (Fig. 1C).

120 kg acre^{-1} urea application

Extraordinary figures detected aphid infiltration throughout all recording days. The lowest infiltration (3.5/plant) was verified in the first week of recording. Still, later on, subsequently 2^{nd,} application of urea fertilizer foliar became more greenish in color, and the pest infiltration was amplified up to 97.5 insects per plant found in 5th week of exploration (Fig. 1D).

130 kg acre^{-1} urea application

Throughout the whole study period of the crop, the treatment with a high dose of urea application was found to be heavily infested; the highest population size of 117.75/plant was determined within the fifth week of research, and the smallest populations of 4.5/plant were reported within the first week of recording (Fig. 1E).

Natural enemies of aphids

The findings indicated a notable correlation between aphids and their natural predator, the ladybird beetle. Each plant's ladybird beetle count demonstrated a positive trend, escalating with heightened wheat aphid infestations.

The apex of the ladybird beetle population was observed in the fifth week, reaching 2.31 individuals per location under 130 kg acre^{-1} urea application. At the same time, the nadir occurred during the initial week of urea application at 90kg/acre, with only 0.14 individuals per location. Both adult ladybird beetles and their nymphs contributed to pest population management.

DISCUSSION

Wheat is paramount as a grain crop cultivated in Pakistan during the Rabi season. In the pursuit of maximizing yields, farmers often resort to excessive applications of nitrogenous fertilizers. However, this tradition has its shortcomings. Crops unveil lush greenery when urea fertilizer is disproportionately consumed, which appeals to an accumulation of insect species. Accordingly, grains' quality and weight fade, leading to reduced whole crop yield.

The outcomes of the research designate that there is a correlation between lower pest populations and the lowest fertilizer application rates. On the other hand, an increase in the amount of urea applied per acre is accompanied by an upsurge in pest populations. These outcomes are dependable with preceding studies, such as those by Ramzan *et al*. (1992), who found a direct association between augmented insect infestations and nitrogen-based fertilizers. They endorsed the vigilant application of split nitrogen treatments merely when needed as an operative and standard pest management approach. Sohail *et al*. (2007) emphasized that overemployment of nitrogen fertilizers endorses extreme vegetative growth, which can attract pests. Moreover, higher fertilizer concentrations can distress crop maturity and worsen infestations by sucking insect pests. In their study, Wagan *et al*. (2015) witnessed that pest populations were significantly lower when nitrogen was applied at lower rates than when higher amounts of urea-containing fertilizers were used. This highlights the precarious role of balanced nitrogen application in monitoring pest invasions. Excessive application of nitrogen can result in an upsurge in aphid populations; however, more modest nitrogen levels can commendably control aphid numbers and lessen their impact on both the yield and quality of wheat crops. Subsequently, a balanced nitrogen fertilization approach is critical for upholding wheat health and production while reducing pest-related problems.

Current studies have shown that nitrogen concentrations significantly influence the population dynamics of wheat aphids. An increase in nitrogen application generally leads to a rise in the populations of aphids such as *Rhopalosiphum padi* and *Sitobion avenae*, as the enhanced nutritional value of the wheat supports their growth and reproduction. Additionally, higher nitrogen levels can worsen competition among wheat aphid species, subsidizing increased aphid densities. Nitrogen applications also affect wheat's antioxidant activity and phenolic content, which influences aphid populations. Plants with higher nitrogen levels provide more favorable conditions for aphid survival and reproduction. Hosseini *et al*. (2010) revealed that the interface between nitrogen fertilization levels and sampling dates significantly prejudiced aphids' profusion and population growth rate (r). Their exploration also designated that the incidence of aphids notably impacted plant yield, with this outcome being influenced by the interaction between nitrogen fertilization rates and aphid incidence. Wagan *et al*. (2015) expanded on this

knowledge by noticing that the lowest pest populations followed at lower nitrogen dosages associated with higher urea-containing fertilizers. This accentuates the importance of balanced fertilizer application to reduce pest pressures and optimize crop yield and quality.

Wang *et al*. (2019) additionally supported these results, signifying that augmented nitrogen levels can augment interspecific competition among different species of wheat aphid, leading to complex inclusive aphid densities. This is because nitrogen-rich plants provide additional resources for aphids, causing noteworthy population growth.

Conclusion

The conclusions of this research demonstrate a strong and noteworthy association between aphid invasion per plant and the dosage of urea fertilizer applied. Elevated urea fertilizer levels paralleled extreme aphid invasion, although lower levels resulted in a minimum infestation. Moreover, the research perceived that a split and balanced application of nitrogen commendably alleviated aphid invasion, subsequently leading to higher-quality wheat yields.

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