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# POPULATION OF WHEAT APHID (RHOPALOSIPHUM PADI L.) AND IT'S ASSOCIATED NATURAL ENEMIES

*Original Article*

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## ABSTRACT

**Background:** Wheat (Triticum aestivum L.) is a globally significant cereal crop, frequently threatened by pest infestations that limit yield potential. Among these, aphids are considered major pests, directly damaging plant tissues and indirectly transmitting viral pathogens. Biological control through natural predators offers an ecologically sound alternative to chemical management. However, varietal tolerance and predator abundance across different wheat genotypes remain underexplored, particularly in local agro-climatic conditions.

**Objective:** To assess aphid population dynamics, the abundance of natural enemies, and yield performance across fourteen wheat genotypes under natural field conditions during the 2019 growing season.

**Methods:** The experiment was conducted using a Randomized Complete Block Design (RCBD) with three replications at the Agriculture Research Institute, Tarnab, Peshawar. Fourteen wheat genotypes were monitored weekly for aphid infestation and populations of natural predators including Coccinellids, Syrphid flies, and Lacewings. Aphid counts were recorded per leaf on randomly selected tillers, while natural enemies were counted per plant. Yield data were collected at harvest and expressed in kg $ha^{-1}$. Statistical analysis was performed using ANOVA followed by LSD at a 5% significance level.

**Results:** Aphid infestation varied significantly among genotypes, ranging from 0.01 to 11.9 aphids $leaf^{-1}$. PS-13 recorded the lowest mean aphid density (4.09), while Pakhtunkhwa-15 showed the highest (5.48). Coccinellids ranged from 0.00 to 1.49 $plant^{-1}$, peaking in the third week of March. Syrphid flies were most abundant in the fourth week of February, with values between 0.25 and 0.84 $plant^{-1}$. Lacewings peaked at 2.07 $plant^{-1}$ during the second week of February. PS-13 also achieved the highest yield (3412.55 kg $ha^{-1}$).

**Conclusion:** Wheat genotypes exhibit differential susceptibility to aphids and support varying levels of natural enemies. PS-13 showed resistance to aphid infestation and produced the highest yield, indicating its suitability for integrated pest management strategies.

**Keywords:** Aphid Infestation, Biological Control, Coccinellidae, Lacewing, Syrphidae, Wheat Genotypes, Yield Analysis.

## INTRODUCTION

Wheat (Triticum aestivum L.), a staple cereal crop belonging to the family Graminae and genus Triticeae, holds a central position in global agriculture due to its high nutritional value and widespread consumption. Commonly referred to as the “king of cereals,” wheat contributes approximately 72% of the daily caloric and protein intake in many populations (1). Its dietary significance stems from its richness in essential nutrients including dietary fiber, thiamine, niacin, riboflavin, vitamin E, magnesium, phosphorus, zinc, copper, and easily digestible proteins (2). With its versatility, wheat serves as a raw material for numerous food products such as bread, chapatti, pasta, macaroni, and rolls (1,2). Globally, wheat was cultivated on an estimated 215.90 million hectares, achieving an average yield of 3.57 tons per hectare by 2020. China, India, Russia, the USA, Canada, Ukraine, and Pakistan remain the top producers, with Pakistan accounting for 26 million metric tons annually (3). Locally, Pakistan cultivated wheat over 9.1 million hectares with a yield of 2.7 tons per hectare, while the Khyber Pakhtunkhwa province recorded comparatively lower productivity at 1.9 tons per hectare across 0.75 million hectares (4). As the global population continues to rise, there is a mounting pressure to increase wheat yield. However, wheat production is frequently threatened by a spectrum of biological and environmental stressors, among which insect pests play a pivotal role. In Pakistan, aphids have emerged as one of the most damaging insect pests affecting wheat. These phloem-sucking insects not only directly extract plant sap, causing chlorosis and deformation, but also serve as vectors for viral and fungal diseases, accounting for 35–40% direct and up to 80% indirect yield losses (5,6). The most predominant species attacking wheat is Rhopalosiphum padi L., known for its global distribution and destructive impact, especially during the flowering stage when it can reduce yield by up to 15% (7). The aphid’s mode of action includes injecting phytotoxic saliva into the plant and secreting honeydew, which fosters the growth of sooty mold and disrupts photosynthesis (8). Their rapid reproduction and host-seeking behavior exacerbate the challenge of controlling infestations (9). Severe infestations during early growth stages can lead to stunted root development, reduced tillering, diminished grain quality, and in extreme cases, plant death. Research also indicates that delayed sowing can intensify aphid-related damage, whereas early sowing acts as a mitigating factor (10).

Integrated pest management strategies encompassing biological, cultural, mechanical, and chemical methods have been deployed to control aphid populations. However, biological control stands out as a sustainable and environmentally favorable alternative. Natural enemies such as Coccinellid beetles, Syrphid flies, spiders, lacewings, and parasitoids have shown promise in suppressing aphid populations below economic threshold levels (11). Among these, parasitoids are particularly significant due to their internal feeding behavior during the larval stage and free-living adult stage, offering a natural means of regulating aphid density (12). In recent years, host plant resistance has gained recognition as a strategic approach in reducing aphid infestation. Resistant genotypes can impair aphid feeding behavior and survival, thereby preserving beneficial insect populations and reducing reliance on chemical pesticides (13). Given the substantial role aphids play in diminishing wheat yield and the differential varietal responses observed in their tolerance levels, it becomes imperative to evaluate the resistance potential of wheat genotypes under field conditions. The present study was therefore designed to assess the varietal response of wheat to aphid infestation with a view to identifying resistant genotypes that may contribute to integrated pest management strategies and sustained wheat productivity.

## METHODS

The present study was carried out during the 2018–2019 wheat growing season at the Agriculture Research Institute (ARI), Tarnab, Peshawar, Pakistan, with the aim of evaluating the response of different wheat genotypes to aphid infestation and their associated natural enemies under field conditions. A total of fourteen wheat genotypes were selected based on their agronomic relevance and availability, without prior exposure to chemical or biological stress in the preceding season. Genotypes exhibiting extreme susceptibility to pests or suboptimal germination in prior field trials were excluded to ensure data reliability and generalizability. The experimental layout followed a Randomized Complete Block Design (RCBD) with three replications to minimize environmental variation and improve statistical precision. Sowing was conducted in the second week of November. Each genotype was planted in an individual plot measuring 2.4 m², composed of two rows with 30 cm row-to-row spacing and a row length of two meters. All agronomic practices, including land preparation, fertilization, and irrigation, were uniformly applied throughout the experimental field to eliminate extraneous influences. Environmental data including weekly mean temperature, relative humidity, and rainfall were recorded using a digital agro-meteorological station positioned adjacent to the trial plots. These parameters were monitored from the date of sowing to harvest to provide a contextual basis for interpreting variations in pest dynamics (13,14).

Data were collected weekly from the first visible sign of aphid infestation until crop maturity. Three plants were randomly selected from each row of every plot, and three tillers per plant were examined. Aphid density was quantified as the average number of aphids per leaf, while the population of natural enemies, including Syrphid flies, lacewings, and Coccinellid beetles, was recorded as the average number per plant. These observations were made consistently under comparable daylight conditions to reduce measurement bias. Grain yield was determined by harvesting each plot at maturity and converting the weight to kilograms per hectare using standard agronomic procedures. The entire dataset was statistically analyzed using STATISTIX version 8.1 software. An analysis of variance (ANOVA) was conducted to assess treatment effects, and genotype means were separated using the Least Significant Difference (LSD) test at a significance threshold of $p < 0.05$ (14). The study protocol was reviewed and approved by the Institutional Ethical Review Committee of the Agriculture Research Institute, Peshawar. As the research did not involve human or animal subjects, informed consent procedures were not applicable.

## RESULTS

Highly significant differences ($P \leq 0.01$) were observed among wheat genotypes in terms of aphid infestation measured as the mean number of aphids per leaf. The infestation ranged from 4.09 to 5.48 aphids per leaf across genotypes. The lowest aphid density was recorded in variety PS-13 (4.09), followed by Khaista-17 (4.23) and NIFA-Insaf-15 (4.27), whereas Pakhtunkhwa-15 exhibited the highest mean density (5.48), followed by Pakistan-13 (5.05) and KT-2017 (4.98). Weekly data revealed fluctuations in aphid population dynamics, with the lowest infestation observed during the third and fourth weeks of January (1.24 and 1.28 aphids per leaf, respectively), and the peak infestation recorded in the third week of February (10.2 aphids per leaf). A significant genotype × week interaction ($P \leq 0.01$) was noted, indicating variable resistance patterns across temporal intervals. The minimum aphid load (0.01 aphids per leaf) was observed in PS-5 during the third week of January, while the highest infestation (11.90 aphids per leaf) was recorded simultaneously in Pakistan-13 and Shahkaar-13. With respect to the population of Coccinellid beetles (ladybird beetles), genotype-based differences were statistically non-significant, with values ranging from 0.37 to 1.00 beetles per plant. The lowest mean was recorded in PS-13 (0.37), while Khaista-17 had the highest population (1.00). However, the weekly effect was highly significant ($P \leq 0.01$), with the lowest Coccinellid count reported in the third week of January (0.06), and the highest in the third week of March (0.97). No significant interaction was observed between genotype and week for Coccinellid population, suggesting a uniform impact across varieties.

Analysis of Syrphid fly population showed significant differences among genotypes ($P \leq 0.01$), with mean values ranging from 0.25 to 0.84 flies per plant. PS-13 showed the lowest Syrphid count (0.25), while Paseene-17 exhibited the highest (0.84). Week-wise data also showed significant variation ($P \leq 0.01$), with the lowest count during the third week of January (0.13) and the highest during the fourth week of February (0.75). The genotype × week interaction was also significant ($P \leq 0.01$), with maximum Syrphid abundance recorded in Paseene-17 (1.50 flies per plant) during the third week of February. For Lacewings, significant variation was noted among genotypes ($P \leq 0.01$), with a range of 0.20 to 0.81 lacewings per plant. The lowest number was observed in PS-13, while the highest was found in Pakhtunkhwa-15. Weekly effects were also highly significant, with the lowest count in the third week of January (0.08) and the highest in the second week of February (0.78). A significant interaction ($P \leq 0.01$) between genotypes and weeks was observed, with a maximum lacewing population (2.07) recorded in Ghaneemat during the second week of February.

In terms of yield, statistically significant differences ($P \leq 0.01$) were recorded among the studied wheat genotypes. Yields ranged from 2844.89 to 3412.55 kg/ha. The minimum yield was recorded in NIFA-Insaf-15 (2844.89 kg/ha), followed by NIFA-Aman-15 (2944.89 kg/ha) and PS-5 (2947.16 kg/ha). The highest yield was reported in PS-13 (3412.55 kg/ha), followed by Wadaan-17 (3322.65 kg/ha) and KT-2017 (3242.40 kg/ha). Correlational analysis revealed strong inverse associations between the population densities of aphids and their natural enemies. Specifically, a notable negative correlation was observed between aphid density and syrphid fly population (Spearman's $\rho = -0.69$), suggesting a robust potential of syrphid flies in suppressing aphid numbers. Similarly, lacewings demonstrated a significant suppressive relationship (Spearman's $\rho = -0.81$), indicating their critical role as biocontrol agents during peak aphid activity. Coccinellid beetles also showed a strong inverse correlation (Spearman's $\rho = -0.71$) with aphid population trends, reinforcing their predatory impact on aphid suppression. These findings collectively highlight the ecological significance of natural enemies in regulating aphid infestations under field conditions and support their integration into environmentally sustainable pest management strategies.

**Table 1: Mean number of Aphids leaf$^{-1}$ recorded on different wheat genotypes/cultivars during 2019.**

| January | | February | | | | March | | | | Means |
|---|---|---|---|---|---|---|---|---|---|---|
| 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week | |
| 1.39f-p | 2.83s-f | 4.00j-u | 7.00o-y | 11.0a-d | 9.00f-l | 5.10z-k | 4.00j-t | 2.00x-m | 1.00j-p | 4.73 bcd |
| 0.93k-p | 2.22w-l | 4.71c-n | 6.72q-y | 9.78c-h | 7.89k-s | 7.77k-u | 3.21o-b | 2.06x-m | 1.17i-p | 4.64 be |
| 1.00j-p | 3.22n-a | 3.71k-w | 3.28n-a | 8.28i-p | 7.78k-t | 6.77q-y | 3.77j-v | 2.00x-m | 1.17i-p | 4.23 ef |
| 1.54d-o | 2.22w-l | 4.43g-r | 6.28u-b | 9.56d-i | 6.83p-y | 5.83y-g | 4.87b-l | 1.83z-n | 0.72m-p | 4.41 c-f |
| 1.25g-p | 2.44v-j | 2.44v-j | 5.61y-i | 11.2abc | 9.44e-j | 5.93x-f | 3.10q-c | 2.93s-e | 1.94x-n | 4.62 be |
| 1.67c-n | 4.61d-o | 6.10v-d | 7.50m-w | 10.4a-f | 8.89g-m | 7.89k-s | 4.99a-k | 1.87y-n | 0.94k-p | 5.48 a |
| 0.50nop | 3.11p-c | 4.60e-p | 5.60y-i | 9.89c-h | 7.83k-t | 6.38t-a | 5.21z-j | 2.89s-e | 1.11i-p | 4.71 bcd |
| 0.89l-p | 1.83z-n | 4.32h-s | 7.94k-r | 8.44h-o | 7.56l-v | 5.93x-f | 3.43k-w | 1.22h-p | 1.17i-p | 4.27 def |
| 1.33f-p | 2.50u-i | 3.99j-u | 6.44s-a | 10.9a-e | 9.11f-k | 7.38n-x | 2.93s-e | 1.06i-p | 0.61m-p | 4.62 be |
| 0.17op | 3.33l-x | 4.82b-m | 6.78q-y | 11.9a | 8.72g-n | 6.38ta | 4.27i-s | 2.31v-l | 1.83z-n | 5.05 ab |
| 1.72b-n | 2.67t-h | 4.16i-t | 6.17v-c | 8.78g-n | 6.06w-e | 4.27i-s | 4.66d-o | 2.39v-k | 1.44e-p | 4.09 e |
| 1.56d-o | 3.67k-w | 4.10j-t | 7.83k-t | 11.4ab | 9.17f-k | 5.88y-g | 3.32n-z | 1.33g-p | 1.56d-o | 4.98 b |
| 0.01p | 3.28n-z | 5.77y-h | 6.50r-z | 11.1abc | 8.00j-q | 9.60d-i | 2.99r-d | 1.00j-p | 0.11o-p | 4.83 bc |
| 1.78a-n | 2.22w-l | 4.71c-n | 7.39n-x | 10.0b-g | 9.02f-k | 6.49r-z | 4.49f-q | 2.72t-g | 1.02i-p | 4.98 b |

**Table 2: Mean number of Lady Bird beetle (Coccinelid spp) plants-1 recorded on different wheat genotypes/cultivars during 2019.**

| January | | February | | | | March | | | | Means |
|---|---|---|---|---|---|---|---|---|---|---|
| 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week | |
| 0.00 | 0.02 | 0.15 | 0.50 | 0.76 | 0.80 | 0.70 | 0.60 | 0.50 | 0.35 | 0.46 cd |
| 0.01 | 0.05 | 0.10 | 1.17 | 0.93 | 0.79 | 0.75 | 1.01 | 0.89 | 1.22 | 0.69 a-d |
| 0.00 | 0.00 | 1.26 | 0.71 | 1.17 | 0.64 | 1.20 | 1.35 | 1.41 | 1.26 | 1.00 a |
| 0.00 | 0.03 | 0.86 | 0.84 | 0.95 | 0.66 | 1.41 | 1.17 | 0.86 | 0.86 | 0.84 abc |
| 0.06 | 0.80 | 0.90 | 1.46 | 1.29 | 1.07 | 1.00 | 0.96 | 0.89 | 1.04 | 0.94 ab |

 

| **January** | | **February** | | | | **March** | | | | **Means** |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.40 | 0.64 | 0.66 | 0.72 | 1.41 | 0.59 | 0.42 | 1.04 | 1.27 | 0.72 a-d |
| 0.05 | 0.00 | 0.70 | 0.80 | 0.49 | 0.50 | 0.60 | 0.70 | 0.84 | 0.72 | 0.59 bcd |
| 0.00 | 0.87 | 1.00 | 1.32 | 0.79 | 0.95 | 1.23 | 0.90 | 1.34 | 0.72 | 0.92 ab |
| 0.00 | 0.20 | 0.40 | 0.66 | 0.70 | 0.80 | 0.90 | 1.00 | 0.78 | 0.60 | 0.60 a-d |
| 0.00 | 0.00 | 0.29 | 1.00 | 1.19 | 0.85 | 0.67 | 1.28 | 0.79 | 1.36 | 0.74 a-d |
| 0.05 | 0.00 | 0.00 | 0.00 | 0.65 | 0.75 | 0.85 | 0.60 | 0.50 | 0.30 | 0.37 d |
| 0.08 | 0.60 | 0.71 | 0.67 | 0.58 | 0.28 | 0.48 | 0.82 | 1.36 | 0.62 | 0.75 a-d |
| 0.00 | 0.55 | 0.57 | 1.13 | 0.71 | 1.49 | 1.01 | 0.71 | 1.32 | 0.97 | 0.85 abc |
| 0.17 | 0.10 | 0.30 | 0.70 | 1.05 | 1.00 | 0.76 | 0.86 | 1.00 | 1.07 | 0.68 a-d |

**Table 3: Mean number of Syrphid fly plants$^{-1}$ recorded on different wheat genotypes/cultivars during 2019.**

| **January** | | **February** | | | | **March** | | | | **Means** |
|---|---|---|---|---|---|---|---|---|---|---|
| **3rd week** | **4th week** | **1st week** | **2nd week** | **3rd week** | **4th week** | **1st week** | **2nd week** | **3rd week** | **4th week** | |
| 0.00g | 0.41j-f | 0.15a-g | 0.30p-g | 0.64c-t | 0.51f-b | 0.56e-i | 0.11d-g | 0.64c-t | 0.79c-k | 0.41cd |
| 0.00g | 0.21w-g | 0.68c-p | 0.75c-n | 2.00a | 1.50b | 1.00b | 0.80c-m | 0.79c-i | 0.69c-o | 0.84a |
| 0.00g | 0.26s-g | 0.43i-f | 0.19x-g | 0.44i-f | 0.88c-g | 0.69c-o | 0.54f-b | 0.57e-i | 0.68c-q | 0.47c |
| 0.40k-f | 0.29p-g | 0.75c-n | 0.95cde | 1.00c | 1.50b | 0.90c-f | 0.80c-m | 0.78c-m | 0.67c-q | 0.80a |
| 0.00g | 0.15b-g | 0.48h-d | 0.57e-i | 0.41i-f | 0.62c-v | 0.47h-e | 0.53f-b | 0.64c-t | 0.39m-g | 0.43cd |
| 0.31p-g | 0.10e-g | 0.58e-w | 0.78c-l | 0.85c-h | 1.00b | 0.90c-f | 0.75c-n | 0.50g-c | 0.27r-g | 0.60c |
| 0.21w-g | 0.00g | 0.61d-v | 0.44i-f | 0.51f-b | 0.41j-f | 0.58e-w | 0.44i-f | 0.52f-b | 0.37n-g | 0.41cd |
| 0.00g | 0.00g | 0.63c-u | 0.39l-f | 0.34o-g | 0.36n-g | 0.46h-e | 0.36n-g | 0.45i-e | 0.24u-g | 0.32d |
| 0.12c-g | 0.00g | 0.51f-b | 0.26s-g | 0.39m-g | 0.29p-g | 0.61d-v | 0.20w-g | 0.67c-q | 0.75c-n | 0.38cd |
| 0.34o-g | 0.38n-g | 0.55f-z | 0.60d-v | 0.80c-m | 0.98cd | 1.00c | 0.90c-f | 0.85c-h | 0.75c-n | 0.72b |
| 0.00g | 0.09fg | 0.17z-g | 0.20w-g | 0.40k-f | 0.50g-c | 0.45i-e | 0.35o-g | 0.25t-g | 0.10e-g | 0.25f |

| **January** | | **February** | | | | **March** | | | | **Means** |
|---|---|---|---|---|---|---|---|---|---|---|
| **3rd week** | **4th week** | **1st week** | **2nd week** | **3rd week** | **4th week** | **1st week** | **2nd week** | **3rd week** | **4th week** | |
| 0.27r-g | 0.24u-g | 0.66c-r | 0.50g-c | 0.67c-q | 0.58e-w | 0.15a-g | 0.46h-e | 0.15a-g | 0.33o-g | 0.40de |
| 0.05fg | 0.30p-g | 0.45i-e | 0.55f-z | 0.65c-s | 0.47h-e | 0.37n-g | 0.29q-g | 0.19x-g | 0.08fg | 0.34ef |

**Table 4: Correlation Matrix: Natural Enemies vs Aphid Density**

| | **Aphids** | **Syrphid Flies** | **Lacewings** | **Coccinellids** |
|---|---|---|---|---|
| Aphids | 1 | 0.693 | 0.806 | 0.709 |
| Syrphid Flies | 0.693 | 1 | 0.863 | 0.9 |
| Lacewings | 0.806 | 0.863 | 1 | 0.806 |
| Coccinellids | 0.709 | 0.9 | 0.806 | 1 |

**Table 5: Mean number of Lacewings plants$^{-1}$ recorded on different wheat genotypes/cultivars during 2019.**

| **January** | | **February** | | | | **March** | | | | **Means** |
|---|---|---|---|---|---|---|---|---|---|---|
| 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week | |
| 0.00j | 0.03j | 0.49m-c | 0.62f-u | 0.41q-h | 0.62f-u | 0.54j-z | 0.72c-q | 0.65f-u | 0.45o-f | 0.45bc |
| 0.00j | 0.02j | 0.60g-w | 0.70c-r | 0.80c-m | 0.65f-u | 0.07j | 0.70c-r | 0.26x-j | 0.52l-b | 0.43c |
| 0.15f-j | 0.07j | 0.72c-q | 0.88c-h | 0.98cde | 0.85c-j | 0.87c-i | 0.78c-n | 0.67e-t | 0.57h-x | 0.65ab |
| 0.03j | 0.06j | 0.21b-j | 2.07a | 0.90c-f | 0.43q-f | 0.44p-f | 0.38s-i | 0.71c-r | 0.56i-i | 0.58bc |
| 0.04j | 0.23z-j | 0.93cf | 0.99cd | 1.00c | 1.50b | 0.89c-g | 0.62f-u | 0.42q-f | 0.20c-j | 0.68ab |
| 0.20c-j | 0.45o-f | 0.99cd | 2.00a | 0.50l-c | 1.00c | 0.99cd | 1.00c | 0.50l-c | 0.48n-d | 0.81a |
| 0.01j | 0.28w-j | 0.47n-d | 0.64f-u | 0.15f-j | 0.35u-i | 0.48n-d | 0.55j-y | 0.29w-j | 0.46n-d | 0.37cd |
| 0.13hij | 0.02j | 0.55j-y | 0.36t-i | 0.35u-i | 0.36t-i | 0.23z-j | 0.50l-c | 0.17d-j | 0.52l-c | 0.32d |
| 0.00j | 0.01j | 0.30w-j | 0.10hij | 0.42q-f | 0.76c-o | 0.22a-j | 0.43q-f | 0.40r-h | 0.50m-c | 0.31d |
| 0.45o-f | 0.07j | 0.63f-u | 0.81c-l | 0.23z-j | 0.37s-i | 0.23z-j | 0.42q-g | 0.45o-f | 0.30w-j | 0.40c |
| 0.01j | 0.00j | 0.29w-j | 0.35u-i | 0.41q-h | 0.40r-h | 0.22a-j | 0.10h-j | 0.26x-j | 0.00j | 0.20f |
| 0.00j | 0.41q-g | 0.11hij | 0.29w-j | 0.48n-d | 0.64f-u | 0.73c-q | 0.53k-a | 0.60g-w | 0.78c-n | 0.46bc |
| 0.05j | 0.00j | 0.21b-j | 0.40r-h | 0.42q-f | 0.20b-j | 0.71c-r | 0.65f-u | 0.70c-r | 0.49m-c | 0.38c |
| 0.04j | 0.25 | 0.45o-f | 0.64f-u | 0.90c-f | 0.90c-f | 0.62f-u | 0.50l-c | 0.49m-c | 0.35u-i | 0.51b |

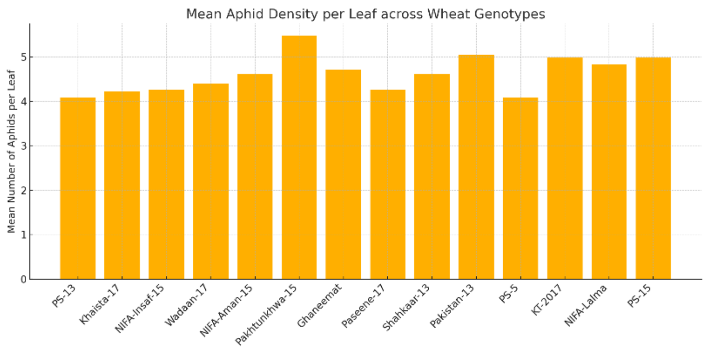


*Figure 1 Mean Aphid Density Per Leaf Across Wheat Genotypes*

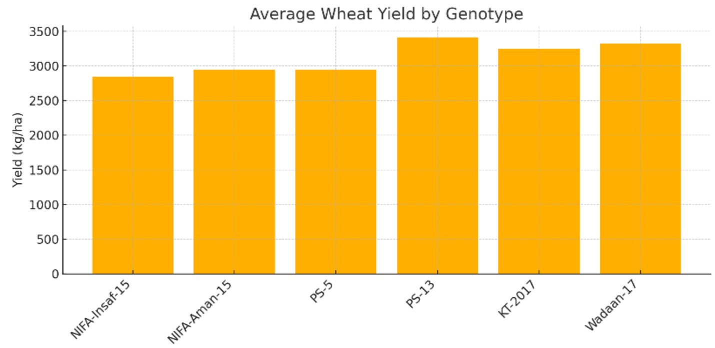


*Figure 2 Average Wheat Yield by Genotypes*

# DISCUSSION

The present study elucidated distinct varietal responses of wheat genotypes to aphid infestation and demonstrated the role of natural enemies in modulating aphid population dynamics. The data confirmed that aphid infestation was significantly influenced by both genotype and temporal variation. Peak aphid populations were consistently observed during the third week of February, a pattern corroborated by previous reports that have identified late winter to early spring as the critical window for aphid proliferation under field conditions (15,16). This temporal increase in aphid density coincided with the early grain filling stages of wheat, highlighting a vulnerability period in the crop's lifecycle. Among the genotypes, Pakhtunkhwa-15 consistently experienced the highest aphid densities throughout the monitoring period. In contrast, PS-13 displayed the lowest aphid infestation, suggesting a relatively higher degree of resistance (17). This genotype not only recorded reduced aphid numbers but also sustained lower populations of natural enemies, yet achieved the highest yield output (3412.5 kg $ha^{-1}$), implying a potential underlying resistance mechanism either biochemical or morphological in nature. Such observations align with earlier findings where wheat lines with reduced aphid colonization also exhibited superior yield performance under natural pest pressure (18,19). This association underscores the importance of host plant resistance as a component of integrated pest management (IPM).

Natural enemy populations—specifically Coccinellids, Syrphid flies, and Lacewings—exhibited a distinct temporal surge that inversely correlated with aphid densities. Notably, Coccinellids reached their highest population in the third week of March, whereas Syrphid flies and Lacewings peaked in the fourth and second weeks of February, respectively (20). These trends suggest a lag in predator buildup relative to aphid emergence, a common ecological delay in predator-prey systems. The significant negative correlations between aphid densities and natural enemy abundance further validated the suppressive role of these biocontrol agents, advocating for their conservation and inclusion in wheat pest management frameworks (21,22). The study's design offered multiple strengths. The use of a randomized complete block design minimized experimental error, and the weekly sampling across ten weeks provided a robust temporal profile of pest and predator dynamics. Moreover, the inclusion of a diverse panel of wheat genotypes enhanced the study's external validity, allowing for generalizable conclusions on varietal tolerance. However, certain limitations must be acknowledged. The absence of controlled environmental data, such as temperature and humidity recordings, limits the ability to model the precise abiotic factors influencing insect behavior. Additionally, while correlations between aphids and their natural enemies were established, causative predator-prey relationships were not experimentally validated. Future studies should consider incorporating exclusion experiments or sentinel prey models to substantiate predation effects.

Furthermore, the biochemical or anatomical traits conferring resistance in PS-13 were not investigated. Understanding the specific resistance mechanisms could provide a foundation for breeding programs aimed at enhancing pest tolerance in wheat. Moreover, longitudinal studies across multiple growing seasons would be instrumental in validating the stability of resistance and predator dynamics under fluctuating environmental conditions (23). In conclusion, the study successfully identified PS-13 as a promising genotype exhibiting reduced aphid infestation and superior yield, reinforcing its potential role in integrated pest management strategies. The findings also highlighted the ecological relevance of natural enemies in regulating pest populations and the need to align sowing dates and agronomic practices with peak predator activity to optimize pest suppression.

 

## CONCLUSION

This study demonstrated that wheat genotypes exhibit varied responses to aphid infestation and that natural enemies play a crucial role in suppressing aphid populations over time. Among the evaluated genotypes, some showed greater tolerance to aphid attack, while others attracted higher densities of natural predators. The gradual decline in aphid population aligned with the increase in beneficial insect activity, underscoring the ecological importance of natural enemies in integrated pest management. The findings highlight the potential of selecting resistant genotypes alongside promoting biological control agents as a sustainable strategy to manage aphid infestations in wheat crops.

**Author Contribution**

| Author | Contribution |
|---|---|
| Madieha Ambreen* | Substantial Contribution to study design, analysis, acquisition of Data<br>Manuscript Writing<br>Has given Final Approval of the version to be published |
| Fawad Khan* | Substantial Contribution to study design, acquisition and interpretation of Data<br>Critical Review and Manuscript Writing<br>Has given Final Approval of the version to be published |
| Samina Yasmin | Substantial Contribution to acquisition and interpretation of Data<br>Has given Final Approval of the version to be published |
| Imtiaz Ali Khan | Contributed to Data Collection and Analysis<br>Has given Final Approval of the version to be published |
| Farhanda Manzoor | Contributed to Data Collection and Analysis<br>Has given Final Approval of the version to be published |
| Inam Ullah | Substantial Contribution to study design and Data Analysis<br>Has given Final Approval of the version to be published |

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