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## Research Article

### Field evaluation of different biopesticides for Aphid Pest Management in Wheat

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#### ABSTRACT

Wheat yield losses are caused by insect infestations. Aphids are important wheat pests that reduce economic production. Increasing wheat yields requires aphid management. Cherry oat aphid, *Rhopalosiphum padi* Linnaeus, green bug, *Schizaphis graminum* Rondani, and corn leaf aphid, *Rhopalosiphum maidis*. Fitch have all been known to damage wheat crops. Pests are controlled only by insecticides. Increased synthetic insecticide use has led to pest resistance and reappearance. Alternatively, botanicals and pesticides can alter aphid activity. The current research considers the importance of aphid management. Neem, *Azadirachta indica* A. Juss, Kortuma, *Citrullus colocynthis* Linnaeus, Tobacco, *Nicotiana tabacum* Linnaeus, silver nanoparticle spray, S1 bacteria, *Bacillus wiedmanni* (S1B), Biopesticide (Bio-N), one insecticide Advantage, and Control were tested against wheat aphid and their biological control, ladybird beetles. Field wheat trials were conducted at MNS University of Agriculture, Multan. Randomised whole block design under factorial was replicated three times. Before and after 24, 48, 72, and 168 hours were recorded. Aphid population dynamics showed substantial variations between kortuma, Ag nanoparticle, and Bio-N treatments. Significant ladybird beetle/plant populations were seen in kortuma and silver nanoparticle treatments during the second week of spraying ( $p < 0.05$ ). Due to less resistance, biopesticides such as Ag nanoparticle, Bio-N, S1B, and kortuma performed better than all other treatments. Aphid populations were higher in the control and biopesticide treatments like neem and tobacco after certain hours. We found that biopesticides worked better than conventional treatments due to lower resistance and natural production.

**Keywords:** Aphid, biological control, biopesticides, botanicals extract, pest management, wheat.



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#### INTRODUCTION

The global wheat market has grown dynamically over the last two decades. Since 2000, the global wheat export volume has increased by 98 million tons (t), amounting to 203 million t in 2020, whereas between 1980 and 2000, wheat exports increased by 23 million t only (USDA, 2021). Pakistan's agriculture zone plays a vital role in establishing the country's economy by putting contributing 18.9% GDP and providing 42.3% employment (Sayal and Khan, 2020). Wheat, *Triticum aestivum* L., is a staple crop of Pakistan. It accounts for 9.2% of value added in agriculture and 1.8% of the Gross Domestic Product (GDP) in Pakistan. During 2020-21, the area under wheat cultivation was 9178 thousand hectares (GOP, 2020-21). A number of factors contribute to low wheat production and yields. Arthropod pests, which harm wheat all over the world, are one of these reasons (Hatchett et al., 1987). Wheat is vulnerable to damage from a diverse range of insect pests, including termites (Termitidae: Isoptera), armyworms and

cutworms (Noctuidae: Lepidoptera), wheat weevils and beetles (Curculionidae, Carabidae, Chrysomelidae), thrips (Phlaeothripidae, Thripidae), Sunn pest (Scutelleridae), Hessian fly (Cecidomyiidae) and aphids (Hemiptera: Aphididae) (El-Wakeil and Volkmar, 2013; Miller and Pike, 2002). Wheat aphids (Hemiptera: Aphididae) are economically important pest species affecting wheat and barley yield in dry regions (Burger and Botha, 2017). There is a wide host range of Russian wheat aphids belonging to 43 genera and about 140 species of cultivated and wild grasses like barley and wheat (Yazdani et al., 2018). The cherry-oat aphid, *Rhopalosiphum padi* Linnaeus, green bug, *Schizaphis graminum* Rondani, and corn leaf aphid, *Rhopalosiphum maidis* Fitch (Hemiptera: Aphididae) are all recorded to damage the wheat crop.

Biological control (parasitoids, predators) is a key component of any integrated management of pests. The *Coccinella* spp., *Ischiodon* spp., *Episyrphus* spp., *Cheilomenes* spp., *Chrysoperla* spp., and several parasitoids are among the most important possible biological control agents. However, the management of chemicals is becoming increasingly significant as it represents the most straightforward and effective approach to regulating aphid populations. A variety of insecticides, including organochlorines, pyrethroids, and organophosphates, have been utilised to regulate aphid populations on agricultural crops. However, numerous studies have associated these substances with several negative characteristics, including ineffective aphid control, persistence in the environment, and oil deposition, alongside their role in the development of insecticide resistance (Bakhetia et al., 1986). The extensive application of insecticides has led to the emergence of resistance in specific aphid species towards pyrethroids, organophosphates, and carbamates. To address resistance, a range of integrated pest management models are employed.

Biopesticides could be the ideal substitutes for synthetic chemicals when food safety requirements improve (Matthews et al., 2022). Insecticidal properties are found in some botanicals. There is less risk of resistance development to these botanicals due to their complex nature (Lowery and Isman, 1995). They are employed as direct sprays, intercropping with the main crop, plant parts soil additives, grain protectants, and synergists Ali et al. (2018). Keeping in view the importance of biopesticides in aphid management, this research was focused on the microbial and botanical efficacy against wheat aphids and their biological control agents under field conditions.

## MATERIALS AND METHODS

### Study Area

The preliminary trial was conducted on the canola crop for evaluation of different biopesticides. Afterwards, the trial was carried out in wheat-crop in the experimental areas of MNS-University of Agriculture, Multan, to determine the efficacy of biopesticides, insecticides, and nanoparticles on wheat aphid.

### Experiment Layout

Data was recorded in during wheat cropping year 2022. The trial was conducted in the area of 198m width and 220m lengths (43,560 sq ft) in wheat crop. The randomized complete block design (RCBD) with factorial design was used with three replications and 7 treatments with one control. Each experimental plot area was 30m×45m and divided into three blocks (replications). Individual blocks were split into experimental units. Each replication was divided into 3 sub-plots, and data were recorded from 5 plants.

### Preparation of Biopesticides (Neem, Kortuma, Tobacco)

Fresh green neem leaves and tobacco leaves were collected from the neem tree and tobacco plant, respectively, at MNS-University of Agriculture. Following a thorough rinsing with tap water to eliminate any particulate matter, the leaves were permitted to air dry at ambient temperature prior to weighing. Following desiccation by ambient air, the leaves underwent a crushing process and were subsequently combined with water at a proportion of 500g of dried leaves to 2 litres of water, allowing for a 24-hour infusion in the ecological laboratory. Subsequently, the saturated leaves underwent mechanical disruption, allowing for the extraction of the liquid phase, which was then agitated for a duration of 30 minutes, culminating in the filtration of the resultant solution through filter paper. For the spray application, a total of 250 ml of the stock solution were diluted with 10L of water. Similarly, the same procedure was done for kortuma fruits (Biswas, 2013).

### Ag Nanoparticles and S1 Bacteria

Pre-synthesized Ag nanoparticles were obtained from the University local lab. The S1 bacteria, *Bacillus wiedmannii*, was also obtained from the University epidemiology lab.

### Treatments Application

The purpose of this study was to evaluate the effectiveness of several botanical extracts, as shown in the table, i.e., tobacco (*Nicotiana tabacum*), kortuma (*Citrullis colocynthis*), neem (*Azadirachta indica*), silver nanoparticles, S1

bacteria (*Bacillus wiedmanni*), and carbosulfan (advantage@20EC) by FMC, for the control and management of aphid in canola and wheat crops.

All of the above-mentioned treatments were applied at intervals of 7 days with a knapsack sprayer equipped with a hollow cone nozzle to check the effectiveness of aphids on canola and wheat (Biswas, 2013) in the concentrations as mentioned in table 1.

Table 1. Treatments and dose.

Sr#	Treatments	Dose
1	Neem leaf extract spray	250ml in 10L of water
2	Kortuma fruits extract spray	250ml in 10L of water
3	Tobacco leaf extract spray	250ml in 10L of water
4	Neem based silver nanoparticle spray	12.5ml in 10L of water
5	S1 bacteria (S1B)	40µl in 10L of water/Acre
6	Advantage	40ml/Acre
7	Biopesticide (Bio-N)	10ml in 10L of water
8	Control Untreated-no spray	-----

### Data Collection

In order to count the number of aphids in each plot, five plants were chosen at random from each plot (Figure 2.2). In every treatment, the adult and nymph populations were documented in situ on the apex of the 10 cm tiller of the plant prior to the spray and following the application, with observations made at intervals of 24 hours, 48 hours, 72 hours, and one week later. The populations of canola and wheat aphids were recorded. The population of aphids was counted and the Blackman and Eastop identification keys were used to identify the aphid species based on their morphology. Data from biological control species such as the ladybird beetle, *Coccinella septempunctata* was also counted (Shah et al., 2017). In the ecological laboratory at the Department of Entomology, MMS-University of Agriculture, Multan, Pakistan, data sheets were kept.

### Statistical Analysis

The collected data were tabulated and statistically analyzed using single factorial randomized complete block design. Data were normalized via Arcsine transformation before it was subjected to analysis of variance (ANOVA) and then analyzed using Statistix 8.1.

## RESULTS AND DISCUSSION

### Effectiveness of Biopesticides on Canola Aphid Population/Tiller

The preliminary trial was conducted on the canola crop to check the efficacy of different biopesticides. Following the application of spray, there were no statistically significant differences observed among the various treatments over a 24-hour period. The observed aphid population exhibited a range of 26.68-74.86% increase in the number of aphids per tiller. The aphid population was significantly different between treatments and the positive control (carbosulfan after 48 hours of treatment). Aphid populations increased by an average of 52.73 %. There was no population observed in AgN treatment. However, the results observed 72 hours after treatment exhibited significant differences across all treatment groups. Aphid population increase to 81.47% was observed in AgN treatment. Meanwhile, a significantly higher increase in the number of aphids (17.74-99.72% aphids per tiller) was observed in tobacco, S1B, and carbosulfan after 168 hours of treatment. The population decreased to 17.74% in Kortuma as shown in Figure 1.

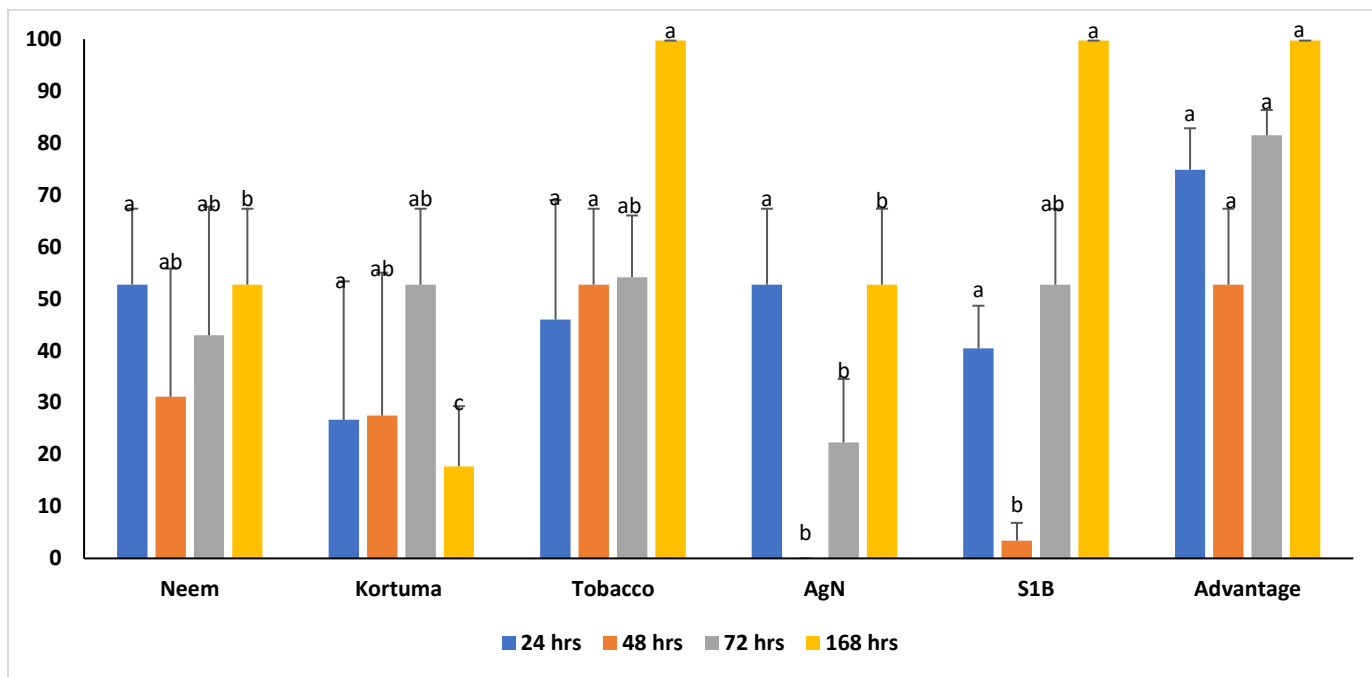


Figure 1. Effectiveness of biopesticides on canola aphid population/tiller (pre-liminary trial).

**Effectiveness of Biopesticides on Wheat Aphid Population/Tiller**

During 1st week of spray, there was no significant differences among the treatments after 24 hours of spray. The increase in number of aphids ranged between 22.46-38.02% aphids per tiller. Similarly, after 48 hours of treatment the aphid population was statistically same in all the treatments along with the positive control (carbosulfan). The increase in aphid population was ranging between 27.87-40.73%. However, 72 hours post-treatment the result was significantly different between the treatments. Where, lower increase in aphid population i.e., 19.97±5.79% aphids per tiller was observed in AgN treatment. Where, higher increase in number of aphids (36.54-37.17% aphids per tiller) were observed in carbosulfan, tobacco and BioN. After 168 hours of treatment population decreased to 0 in tobacco. While, significantly higher increase in the number of aphids (34.40±12.92%) was observed in S1B as shown in Figure 2.

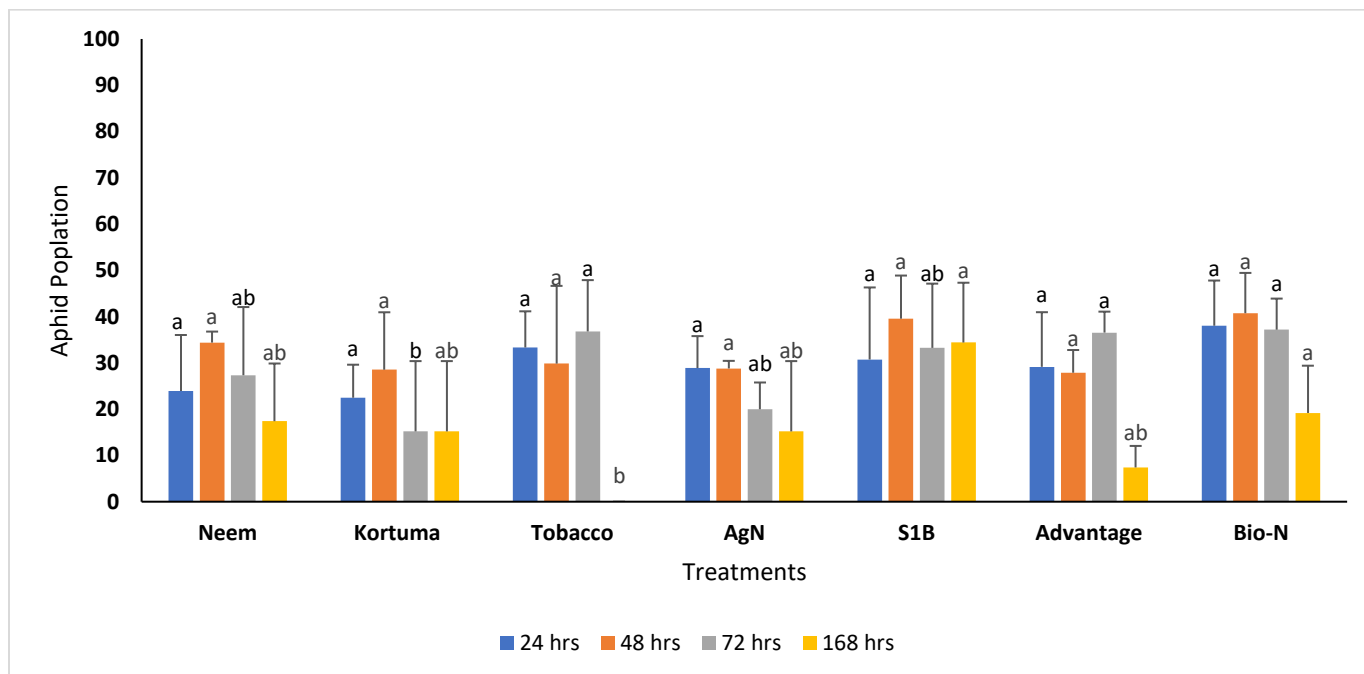


Figure 2. Effectiveness of biopesticides on wheat aphid population/tiller (Week 1).

During 2nd week of spray, there were significant differences among the treatments after 24 hours of spray. The increase in number of aphids ranged between 0.00-51.23% aphids per tiller. Similarly, after 24 hours of treatment the increase in aphid population was significantly higher in BioN, neem, kortuma and carbosulfan treatments (21.74-51.23%). While, there was no population recorded in AgN treatment. After 48 hours of treatment, significantly more increase in aphid population ( $40.94 \pm 11.42\%$  aphids per tiller) was observed in the tobacco treatment. While, there was less increase in aphid population ( $4.73 \pm 4.73\%$  aphids per tiller) was recorded in S1B treatment. The increase in aphid population was ranging between 4.35-48.02% after 72 hours of treatment. However, 72 hours post-treatment the result was significantly different between the treatments. Where, more increase in number of aphids ( $48.02 \pm 24.48\%$  aphids per tiller) were observed in kortuma. While, less increase in aphid population i.e.,  $4.35 \pm 4.35\%$  aphids per tiller was observed in S1B. After 168 hours of treatment population increase was more in tobacco viz.  $47.24 \pm 23.85\%$  in kortuma. While, significantly less increase in the number of aphids ( $8.14 \pm 5.34\%$ ) was observed in S1B as shown in Figure 3.

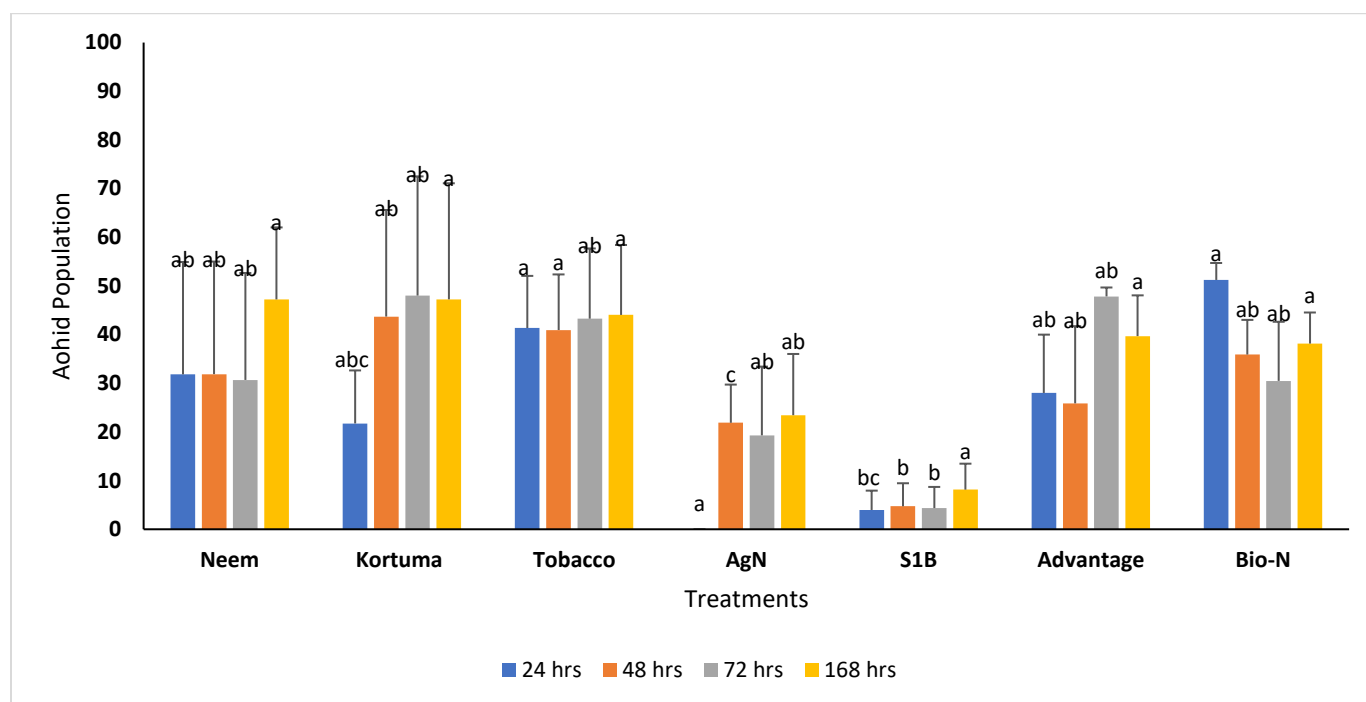


Figure 3. Effectiveness of biopesticides on wheat aphid population/tiller (Week 2).

After 24 hours of spraying, there were significant variations between the treatments during the third week. Aphid populations per tiller increased by an average of 20.01-47.79%. Similarly, after 24 hours of treatment, there were considerably more aphids per tiller in the S1B group ( $47.79 \pm 3.80\%$ ). However, in the case of carbosulfan treatment, the increase was less ( $20.01 \pm 10.30\%$ ). The neem treatment resulted in a much higher rise in the aphid population after 48 hours ( $22.84 \pm 19.78\%$  aphids per tiller). While, the S1B treatment no aphid population was observed. There was a notable difference between treatments after 72 hours. Whereas carbosulfan caused a greater rise in aphids ( $36.84 \pm 14.68\%$  aphids per tiller). However, in the AgN and kortuma-treated groups, there was no sign of an aphid population. The neem treatment group saw a greater percentage increase in their population after 168 hours. In contrast, aphid populations increased by only  $3.50 \pm 3.34\%$  when treated with kortuma as shown in Figure 4.

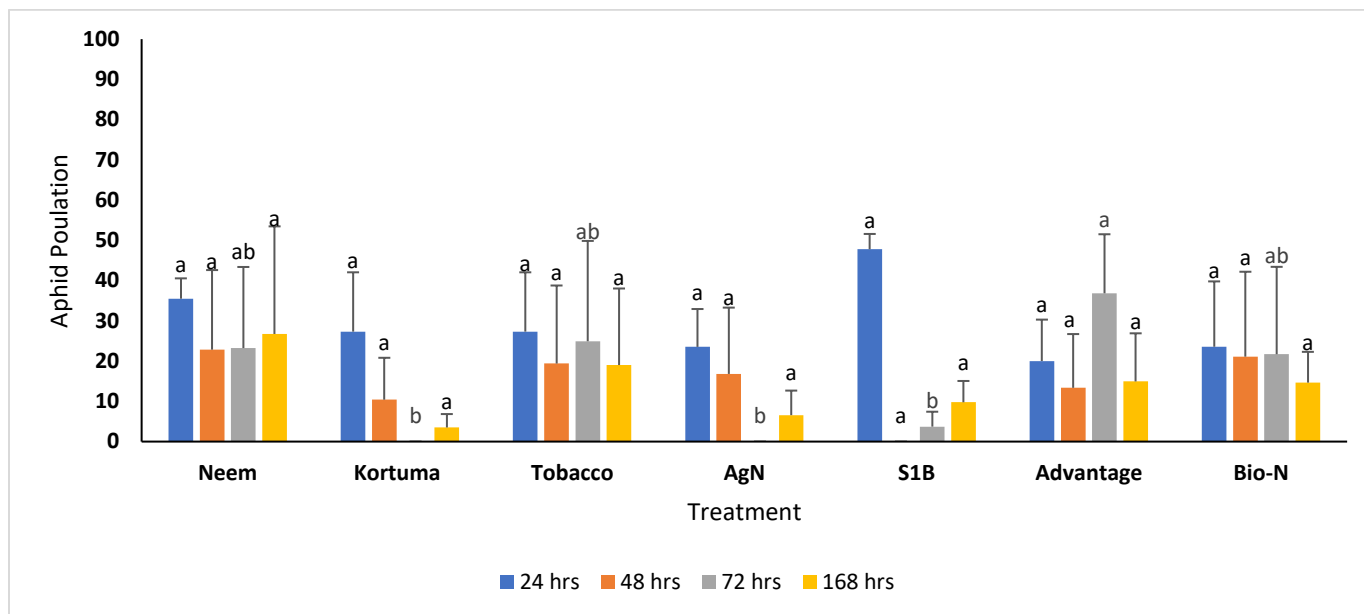


Figure 4. Effectiveness of biopesticides on wheat aphid population/tiller (Week 3).

**Effectiveness of Biopesticides on Ladybird Beetle Population/Plant**

During 1st week of spray, there were no significant differences between the treatments after 24h, 48h, 72h, and 168 hrs. The increase in the number of ladybird beetle populations ranged between 0.00-22.96% per plant after 24 hours. Similarly, after 48 hours of treatment, the ladybird beetle population was statistically same in all the treatments along with the positive control (carbosulfan). The increase in ladybird beetle population was ranging between 28.23-76.70%. After 72 hours of post-treatment, increase in ladybird beetle population i.e., 15.78±48.48% per plant was observed in neem treatment. Lower increase in number of ladybird beetle (44.71-15.78% per plant) were observed in kortuma, tobacco and S1 after 168 hours of treatment as shown in Figure 5.

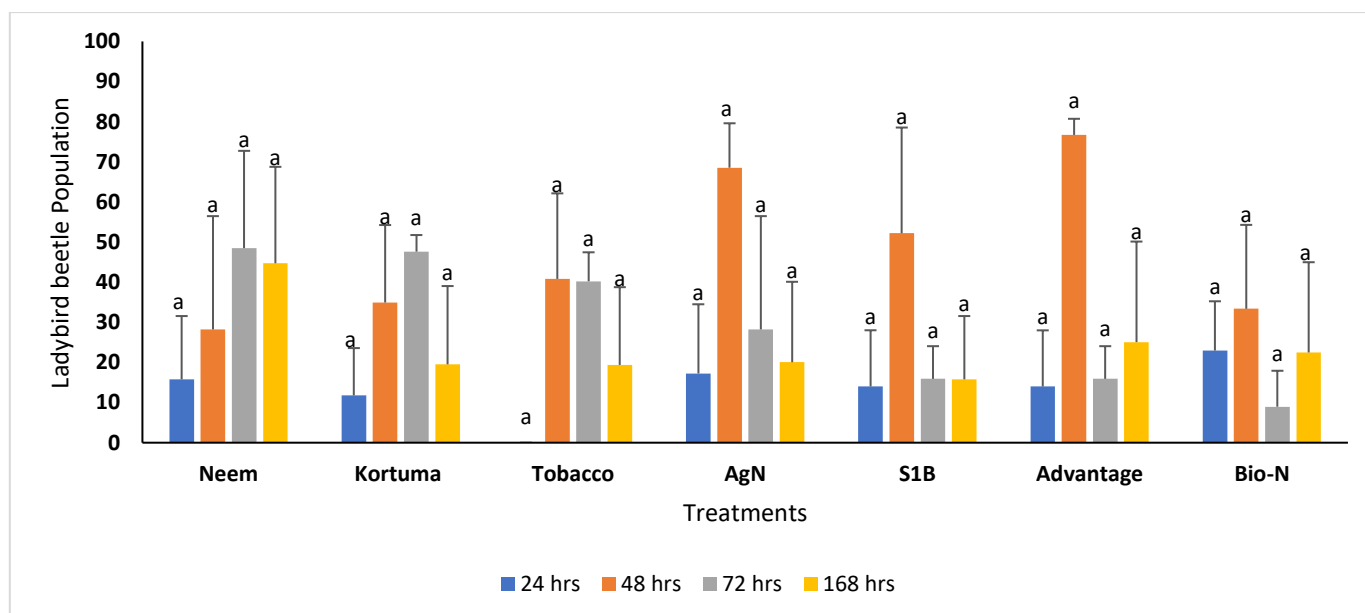


Figure 5. Effectiveness of biopesticides on ladybird beetle population/plant (Week 1).

There were no significant differences among the treatments after 24 hours of spray, during 2nd week of spray. The increase in number of ladybird beetle ranged between 8.96-31.62% population per plant. Similarly, after 24 hours of treatment, the increase in ladybird beetle population was significantly higher in kortuma, tobacco, AgN, and carbosulfan treatments (15.91-43.58%). While there was the lowest population recorded in S1B treatment. After 48 hours of treatment, a significantly more increase in ladybird beetle (15.91± 69.04% population per tiller) was observed

in the AgN treatment. While there was less increase in the ladybird beetle population (18.96±8.96% aphids per tiller) was recorded in tobacco treatment. The increase in ladybird beetle population was ranging between 0.00-48.48% after 72 hours of treatment. However, 72 hours post-treatment the result was significantly varied between the treatments. Where less increase in the number of ladybird beetle (69.04±47.61% population per plant) was observed in AgN. There was no population recorded in advantage. After 168 hours of treatment population increase was more in Bio-N viz. 20.83±26.13% in Bio-N. While a significantly less increase in the number of ladybird beetle population (28.23±9.86%) was observed in kortuma as shown in Figure 6.

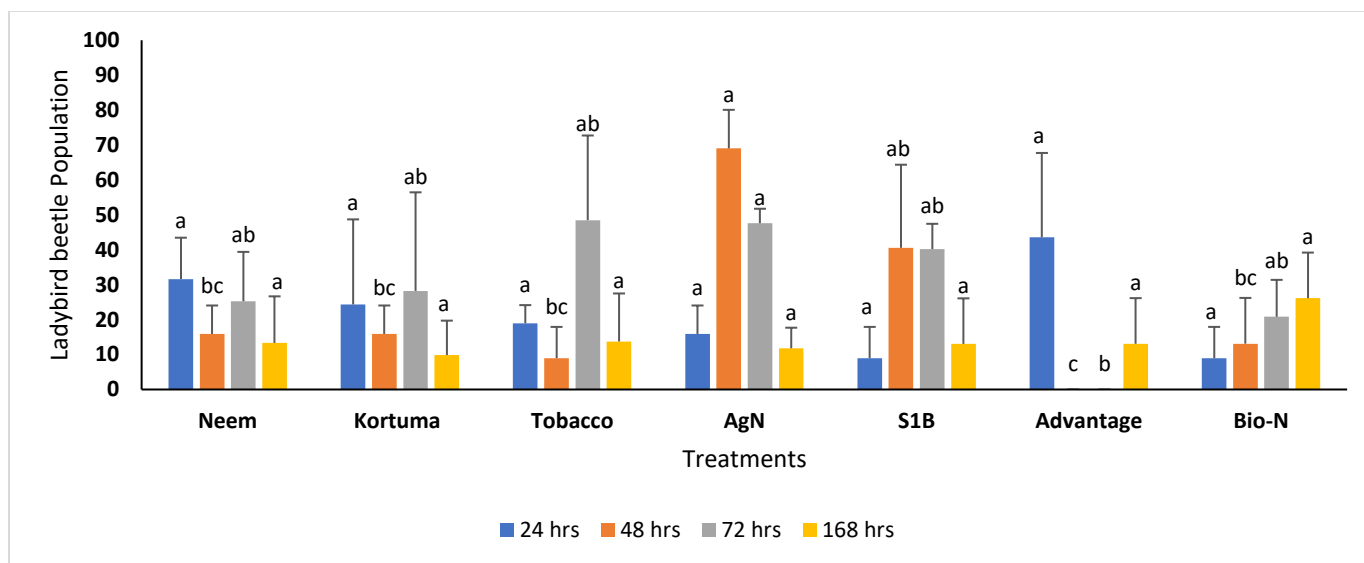


Figure 6. Effectiveness of biopesticides on ladybird beetle population/plant (Week 2)

In the 3rd week of spraying, there were no significant differences between the treatments after 24, 48, 72, and 168 hours. After 24 hours, there was an increase in ladybird beetle populations that ranged from 11.29-30.11% per plant. Similarly, the ladybird beetle population was statistically the same in all treatments, including the positive control (carbosulfan), after 48 hours of treatment. Ladybird beetle populations increased by an average of 19.56-47.58%. The number of ladybird beetles, on average, increased by 47.58% after 72 hours of tobacco treatment. The tobacco treatment had the largest population, at 47.58% per plant. After 168 hours of treatment, carbosulfan showed smaller increases in the number of ladybird beetles (11.29-23.96% per plant) as shown in Figure 7.

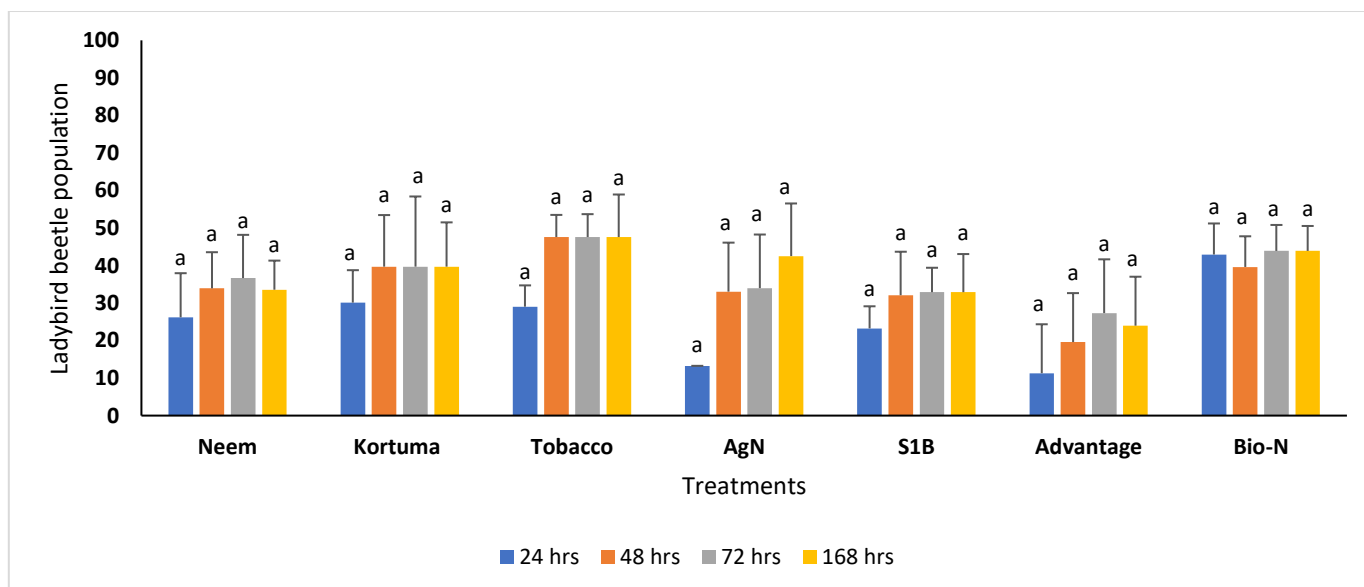


Figure 7. Effectiveness of biopesticides on ladybird beetle population/plant (Week 3).

## DISCUSSION

Research indicates that synthetic insecticides effectively manage wheat aphids, thereby mitigating production losses. However, the presence of toxic substances in the grain makes it an undesirable component for managing aphid populations. This observation holds particularly for wheat, a fundamental crop in Pakistan (Shah et al., 2017). Numerous plant-based compounds made from neem, kortuma, pyrethrum, and tobacco, etc. have been employed as safer pesticides in the management of insect pests (Koul, 2012). These biorational management tools are compatible with natural enemies due to the low residual activity (Xu et al., 2011).

The increase in aphid population (17.74%) was significantly lower in case of kortuma. These results are comparable to the findings of (HYDER et al., 2022) who have reported high toxicity of kortuma against canola aphids. In most cases, the insecticidal activity of *C. colocynthis* extracts might be justified to the presence of several compounds including: saponin, alkaloids and glycosides (Ali et al., 2018).

Because of their importance in traditional farming methods, tobacco plants may also be used as research tools to better understand biological mechanisms. The aphid population was reduced to zero during first week of tobacco spray. It can happen due to the fact that many species of *Nicotiana* include physiologically active chemicals that have been utilized for economic and biological applications (Komori et al., 2007; Poon et al., 2014). Additionally, lower population of aphids was observed in the treatment of neem-based Ag nanoparticle. Similar results of Ag nanoparticles were reported by Kamil et al. (2017) who have found that neem can decrease the aphid population significantly in wheat. Silver nanoparticles (Ag NPs) are one type of metal nanoparticle that has been utilized as an antimicrobial agent for a very long time. This is because Ag NPs can kill many different kinds of insects in many different ways (Kumar et al., 2014). Antimicrobial activity can be exhibited by Ag NPs in a variety of different ways. It has been observed that the toxicity of Ag NPs to microorganisms is higher. Ag NPs can display antimicrobial activity in a wide range. It has been noted that Ag NPs are more harmful to microorganisms (Mandal, 2019).

Following the application of neem, tobacco, and AgNPs, a notable increase in the population of ladybird beetles was recorded after a duration of 168 hours. Abdel-Moniem (2003) and Choudhary et al. (2017) have also provided evidence that neem-based biopesticides exhibit lower toxicity levels towards ladybird beetles. According to Patel (2018), tobacco exhibits a comparatively lower toxicity to ladybird beetles. Therefore, it is advisable to utilise neem, tobacco, and neem-loaded AgNPs for the management of wheat aphids, as they exhibit minimal impact on natural enemies.

## CONCLUSIONS

The results of the current research highlighted that biopesticides had a considerably better effect than conventional treatments because of reduced resistance and the fact that it was produced under natural conditions. Farmers and extension agents are suggested to use these various biopesticides as an informative resource for an economical, ecologically sound, and effective aphid pest management system. This approach may support low-input organic farming and contribute to environmental sustainability. Such research will facilitate the management of aphids in wheat and offer fundamental direction for future researchers.

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## AUTHOR CONTRIBUTIONS

Nimra Batool made significant contribution as a first author and conducted field experiments, literature review, prepared of biopesticides, preparing initial draft of manuscript, and proofread all subsequent drafts of manuscript. Shafqat Saeed created the idea, field survey proforma, financed the field survey, supervised all research, read all drafts of the work, and submitted it for publication as the corresponding author. Muhammad Nadir Naqqash and Fawad Zafar Khan supervised field research, assisted in drafting the results section, edited the final paper versions, prepared graphs, prepared biopesticides in the lab, and analyzed data. Unsar Naeem-Ullah evaluated the initial draft of the paper, revised the literature for the introduction, materials and methods, discussion sections, and proofread the final draft. Muhammad Arslan khan provided S1 bacteria and facilities required for this research. Iqra Kainat and Basit Shahzad conducting field experiments and helped in data collection.

## COMPETING OF INTEREST

The authors have declared no conflict of interest.

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