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Research Article

Biopesticidal Potential of Sericin and Marigold Coated Silver Nanoparticles Against Major Agricultural Pests

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Abstract
The pest outbreaks and the excessive use of synthetic pesticides have become a major concern for agroecosystems globally. Therefore, the current study was designed to characterize and evaluate the bio-pesticidal potential of sericin, and marigold coated silver nanoparticles (AgNps) against three agricultural pests of cotton including cotton thrips *Thrips tabaci*), armyworm (*Spodoptera frugiperda*) and pink bollworm (*Pectinophora gossypiella*). Both the sericin and marigold silver nanoparticles were synthesized separately by using the sonication method and heat method respectively. The nanoparticles were characterized by using UV spectrometry and FTIR. The leaf dip method was used to evaluate the pesticidal activity of nanoparticles. Both the sericin and marigold conjugated AgNps (300mg/L, 200mg/L, 100mg/L and 50mg/L) showed significant bio-pesticidal activity against thrips ($F_{8,18}$=20.015, $P<0.001$) armyworms ($F_{8,18}$=19.097, $P<0.001$) and pink bollworms ($F_{8,18}$=15.786, $P<0.001$). Aforementioned findings of the study concluded that marigold and sericin coated silver nanoparticles solution possess bio-pesticidal activity and can be used for effective control of cotton thrips, armyworms and pink bollworms.

Keywords: Agroecosystem, biogenic nanoparticles, bio-pesticidal activity, agricultural entomology

1. Introduction

Cotton (*Gossypium hirsutum*) is an economically crucial natural fiber crop that is attacked by almost 166 different species of insect pests during its growth cycle [1]. Pink bollworm *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) infestation is found to be a major threat to the cotton crop as it can reduce the final output of the crop by 20 % to 90 % [2]. Pink bollworms can infest various varieties of cotton in Pakistan [3]. Furthermore, the cotton crop is also at risk of attack by cotton thrips, *Thrips tabaci* (Thysanoptera: Thripidae), which primarily cause damage to cotton seedlings [4]. Thrips are the most prevalent early-season pests of cotton [5]. Feeding on cotton crops by thrips can cause losses of up to 30-50% of total yield potential [6]. Moreover, the Armyworms, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), having a diverse range of hosts, are also a destructive secondary pest of the cotton crop. It has been problematic due to its high tolerance against many insecticides [7].

Synthetic pesticides are frequently used in agriculture to enhance crop yield and to protect plants from diseases, weeds, and insects [8]. However, the resistance against synthetic insecticides is increasing day by day and it has become a grave concern all over the [9]. Insect pests develop resistance to synthetic insecticides through multiple mechanisms. These include enhanced detoxification by enzymes such as cytochrome P450 monooxygenases, esterases, and glutathione S-transferases [10, 11]. Target site insensitivity, due to mutations in key proteins like voltage-gated sodium channels or acetylcholinesterase, reduces insecticide binding and efficacy [12]. Additional factors, such as reduced cuticular penetration and behavioral avoidance also contribute to resistance [13].

Thrips and other cotton pests develop pesticide resistance due to high reproduction rates and short generations [14]. Furthermore, these synthetic pesticides are toxic and deteriorate the ecosystem [15]. Therefore, the researchers are looking for new technologies for pest control that are cheap, effective and environmentally friendly. The nano sized biopesticides capped with biomaterials like sericin and secondary plant metabolites could be a better alternative [16].

The nanotechnology techniques are concerned with the preparation and assessment of the potential of particles with sizes ranging from 1-100nm [17]. The use of nanotechnology in agriculture has beneficial impacts on plant growth as well as insect disease management [18]. Nanotechnology based biopesticides can be used for crop protection by the controlled and targeted delivery of pesticides on different cotton pests [19]. Nanotechnology plays a very significant role in the control of cotton bollworms through the biological control of their life cycle [20]. Moreover, it is supposed that soon nanotechnology will revolutionize the agriculture industry by the management of pests.

Several chemicals and reducing agents are being used to produce nanopesticides. Synthetic nanoparticles (NPs) are toxic and expensive [21]; therefore, nanoparticle production by green synthesis by using cheap reducing, capping or stabilizing agents is gaining popularity as they are effective and cheap [22, 23, 24].

Bio-nanopesticides are far better than synthetic pesticides because of their environment-friendly behavior, provision of desired results within a few hours, easy mode of delivery and improved solubility as well as decreased premature degradation and controlled release of the active ingredients [25, 26, 27]. The synthesis of biogenic nanopesticides by incorporation of plant extract as well as biopolymers such as silk sericin has fetched the attention and focus of modern researchers globally [28, 29, 30].

Sericin is a water-soluble globular protein composed mainly of polar amino acids such as aspartic acid and serine [31], which is obtained from the cocoon of the silkworm (*Bombyx mori*). Alongside fibroin, sericin is one of the two natural macromolecular proteins secreted by the silkworm. It is composed of 18 amino acids, with serine being the most abundant (around 30). Due to the presence of multiple hydroxyl groups, sericin exhibits excellent adhesion and water absorption properties. In addition, sericin demonstrates a range of biological activities, including UV protection, antioxidant, antibacterial, and anticancer properties. Silver coated sericin nanoparticles have a variety of potential including antimicrobial and antifungal potentials [32].

Moreover, the insecticidal potential of metal coated nanoparticles of marigold flower extracts has also been reported [33, 34]. In the plant extract, numerous reducing agents are present which can transform the metal ions and atoms into nanoscale materials such as polyphenols, phenolic acids, sugars, terpenoids and flavonoids [35]. The marigold flower is also a rich source of a variety of phytochemicals, including phenolics, flavonoids, xanthophylls (lutein and zeaxanthin) and carotenoids (lutein esters) [36].

Different metals (Pd, Au, Pt, and Ag) can be reduced and converted into nanomaterials [37, 38]. However, silver nanoparticles are preferred over others due to their unique size and high surface to volume ratio [25, 39]. Silver nanoparticles can be synthesized by using extracts from various parts of plants [40]. Additionally, there are very rare chances of resistance development against the silver nanoparticles as these are used in relatively lower concentrations [41, 42]. Resistance development is rare against silver nanoparticles because they act through multiple simultaneous mechanisms, such as disrupting cell membranes, generating reactive oxygen species (ROS), and interfering with DNA and protein function making it difficult for pests to adapt [43]. The insecticidal efficacy of silver-based nanoparticles against the larvae of the cabbage looper, black cutworm and other major lepidopteran insects has been reported [26, 44].

The principal aim of the present study was to develop and evaluate an eco-friendly nanopesticide by synthesizing silver nanoparticles conjugated with sericin and marigold flower extract. The objectives of the study were to synthesize and characterize silver nanoparticles using silk sericin and marigold extract as bioreducing and capping agents, and to evaluate the insecticidal potential of the synthesized nanoparticles against three major cotton pests: cotton thrips (*Thrips tabaci*), armyworms (*Spodoptera frugiperda*), and pink bollworms (*Pectinophora gossypiella*). These pests were selected to evaluate biopesticidal potentials of nanoparticles due to their significant impact on cotton yield at different stages of crop development, their varied modes of feeding (sap-sucking and leaf or boll-damaging), and their increasing resistance to conventional chemical pesticides [6, 7, 14].

The hypothesis of the present study was to synthesize biogenically synthesized silver nanoparticles, stabilized with sericin and marigold extract, would demonstrate significant insecticidal activity against these pests, providing an effective and environmentally sustainable alternative to conventional synthetic pesticides.

2. Materials and methods

2.1. Sample collection

Freshly woven silk cocoons of *Bombyx mori* L. were obtained from the Sericulture Wing of Forestry, Wildlife and Fisheries Department, Lahore, Pakistan. These cocoons were cut into small pieces. The flowers of marigolds (*Tagetes erecta*) were collected from the labeled marigold plants at the Botanical Garden, Government College University Lahore. Healthy and fresh flowers were sorted and rinsed thoroughly with tap water.

2.2. Preparation of extracts

Silk sericin was obtained by using the method described by [45]. Distilled water (100ml) was added to 20g of cocoon pieces (approximate size of 2.5×6 mm) and boiled for 30 minutes at 120 °C. To remove the fibers from the sericin solution, the solution was filtered using a fine cotton mesh (50nm) and the filter cake was squeezed completely to obtain maximum filtration. Fibroin remained on the filter cake while the sericin was passed through the filter paper. To obtain the powder of the sericin solution, the filtrate was lyophilized by using a Labocon Freeze Dryer [46]. Then the sericin powder (0.1g) was added to 100 ml of distilled water to prepare a 0.1% solution.

Fresh marigold flowers were washed two times with tap water, followed by distilled water and then shade dried. The dried flower powder (5g) was added to 100 ml of distilled water and incubated overnight at room temperature (25 ±1 °C). After that, the suspension was boiled for 30 min at 60 °C, and then filtered by using Whatman No. 1 filter paper (125 mm pore size). The obtained filtrate was transferred to reagent bottles (250ml) for further use. Filter cakes of plant material were dried and weighed. The difference in the weight of filtrate was noted down and the percentage of each extract was calculated [47,48,49]. The percentage of the solutions was adjusted to 0.1% through serial dilutions with distilled water.

2.3. Synthesis of silver nanoparticles

For the synthesis of marigold conjugated silver nanoparticles, the method described by [40], was used with slight modifications. The silver nitrate ($AgNO_3$) (0.01M) was added into 100ml of 0.1% marigold solution in a reagent bottle. The mixture was heated in a water bath at 40°C for 30 minutes. Then the solution was placed at room temperature (25°C ±2°C) for 24 h for complete synthesis of silver nanoparticles. After that, the colorless solution of the marigold changed into olive grey.

For the synthesis of sericin conjugated silver nanoparticles, $AgNO_3$ (0.01M) was added to 100ml of 0.1% sericin. Further synthesis was carried out by using an ultrasonic homogenizer/sonicator (CY-500). In the reaction chamber of the sonicator (CY-500), ultrasonic waves of 15:05 pulse rate at 40°C were subjected to the solution [50]. After optimum exposure to ultrasound waves, the color of the solution was changed from colorless to light brown and then dark brown.

2.4. Characterization of silver nanoparticles (AgNPs)

Characteristic absorption peaks of sericin and marigold conjugated AgNPs were studied in the range of 200-800nm using a UV spectrometer (AE-S70-IU) at the Department of Zoology, Government College University Lahore [51]. Chemical bonding in sericin and marigold conjugated AgNPs was evaluated by using Fourier Transform Infrared Spectroscopy (FTIR) (Bruker Alpha platinum ATR) in the Center for Advance Studies in Physics (CASP), Government College University Lahore.

2.5. Collection of insects

Almost the same aged populations of cotton thrips, *Thrips tabaci* (Thysanoptera: Thripidae) and armyworm, *Spodoptera spp.* (J.E. Smith) (Lepidoptera: Noctuidae) were collected from the potted plants at the Cotton Research Institute Khanpur District Rahim Yar Khan (28.4212° N, 165 70.2989° E). Moreover, mass collections of cotton rosette flowers and bolls damaged by pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) were also carried out from the same area. These cotton rosette flowers and bolls (FH-142) infested with pink bollworms were brought to the laboratory at Government College University Lahore and cut open with a knife to obtain pink bollworm larvae that were separated by a fine hairbrush [52]. All the collected larvae were transferred from the field to the laboratory to maintain their colonies for further experiments.

For insect rearing, the nursery of cotton seedlings was raised in 20 inches mud pots. The pots were filled with 2.5 kg of soil and 4-5 de-linted seeds of variety FH-142 were sown in each pot. The nursery pots were kept in an open space for the seasonal sown crop. Nursery seedlings were irrigated with a shower and after 15 days of seedlings emergence, only a single plant was kept in the pot. Plants were shifted to screen greenhouses. Thrips-infested cotton leaves and the masses of armyworms and pink bollworm damaged cotton flowers and bolls that were collected from the field area were used to infest the cotton potted plants at GC University, Lahore. The colonies of these insect pests were maintained and used for pesticidal experiments.

2.6. Bio-pesticidal activity of nanoparticles

The sample larvae were maintained at standard rearing laboratory conditions (27 ±1 °C, 65-75% humidity) for acclimatization [53]. The hunger level of insects was standardized by starving them for 2-3 hours and then they were fed with fresh cotton leaves up to their satiation level before the start of the experiment. For this experiment, Petri plates were divided into twenty-seven groups for each insect pest, making a total of 81 test units across the three pest species. Each set consisted of one control group and eight experimental groups, with all groups replicated three times (n = 3). Fresh cotton leaves (*Gossypium hirsutum* L.) of variety FH-142 were taken, washed and cut into small pieces. A weighed quantity of leaves (4g) was dipped in the distilled water (control) and placed in the petri plates of the control group, serving as a baseline for comparison. The experimental groups were treated with cotton leaves (4g) coated with different concentrations (50 mg/L, 100 mg/L, 200 mg/L, and 300 mg/L) of synthesized silver nanoparticles, using two nanoparticle types: sericin-based and marigold-based formulations. This resulted in four concentration levels × two nanoparticle types = eight experimental groups. Leaves treated with each nanoparticle formulation were placed in their respective Petri plates, and then 2nd or 3rd instar larvae of each pest were introduced into each plate [54, 55].

These insect pests were gently released onto petri plates of each group separately with the help of a camel hairbrush to avoid any injury. Although the pink bollworm, *Pectinophora gossypiella,* usually does not feed on cotton leaves naturally, it has already been reported by Parthiban et al. [51], that it can eat cotton leaves in the 1st and 2nd instar of its life cycle, in case other food is not available. With the help of mesh cloth, petri plates were covered and tightened with a rubber band. The mortality at standard room temperature (25 ±1 °C) was observed in insects for 24 hours. The experiment was replicated thrice, and the cumulative data was taken. The same set of experiments was used to evaluate the biopesticidal potential of all insects (i.e., cotton thrips, pink bollworms and armyworms).

2.7. Statistical Analysis

SPSS software (version 25.0.0.0) was used to conduct One-way ANOVA, followed by Tukey's test to compare the percentage of mortalities at different concentrations.

While the Minitab was used to conduct Probit analysis for the determination of the values of LC_{50}, LC_{95}, 95% Fiducial CI, slope, p and X^2.

3. Results

3.1. Characterization

UV spectrophotometric analysis revealed characterized absorption peaks at 380-400nm for sericin nanoparticles and 400-440nm for marigold nanoparticles (Figure 1a, b). The FTIR absorption peaks of sonicated Se-AgNPs were produced at a wavenumber range of 500-4000 cm^{-1} (Figure 1c). The peak at 3276 cm^{-1} was attributed to the N-H bond of amine. A peak at 1078 cm^{-1} represents the free carboxylate group (COO stretching vibration). Other characteristic absorption peaks were observed at 2926 cm^{-1} (C-H bond stretching). Moreover, two sharp peaks at 1621 and 1517 cm^{-1} were also analyzed. While the FTIR analysis results of marigold coated silver nanoparticles showed a peak at 3293 cm^{-1}, representing the amide stretching (N-H). While the diagnostic peak at 1603 cm^{-1} showed the C-O bond. The peak at 1036 cm^{-1} corresponds to the C-N stretch. Moreover, the peak at 772 cm^{-1} represented the C-H stretching (Figure 1d).

3.2. Bio-pesticidal activity of nanoparticles

The marigold and Sericin conjugated nanoparticles showed significant percentage mortalities against thrips ($F_{8,18}$=20.015, P<0.001), armyworms ($F_{8,18}$=19.097, P<0.001) and pink bollworm ($F_{8,18}$=15.786, P<0.001). The highest percentage of mortalities was observed against 300mg/L of sericin coated silver nanoparticles against thrips (83 ±12.0), pink bollworms (63±6.6) and armyworms (80 ±5.7), respectively.

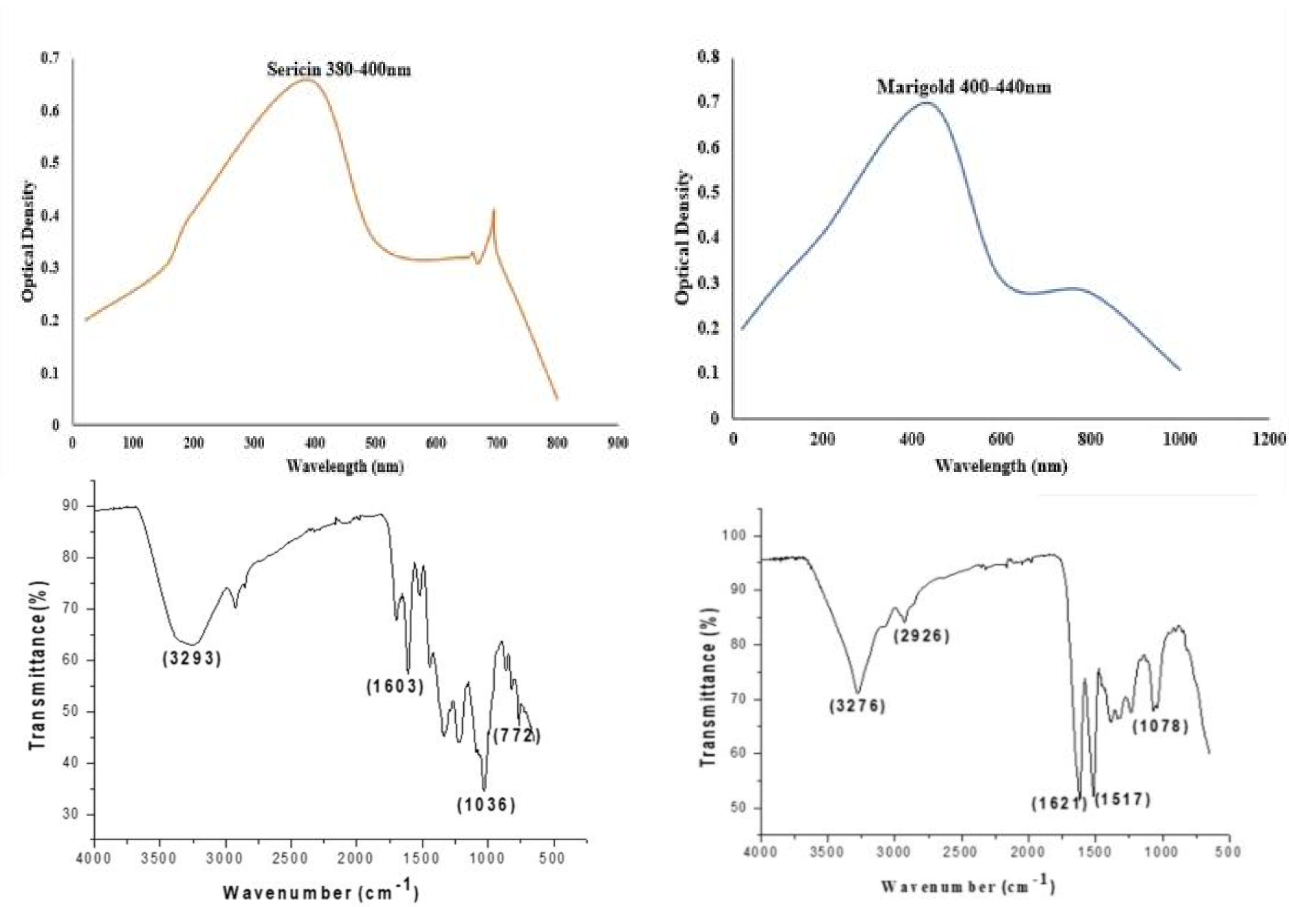

Figure 1. UV spectra of (a) Se-AgNPs and (b) Marigold-AgNPs. (c) Characteristics peaks of FTIR Structural Analysis of Se-AgNPs. and (d) Characteristic peaks of FTIR Structural Analysis of M-AgNPs.

While the 100mg/L and 50mg/L of both marigold and sericin coated silver nanoparticles showed the lowest mortalities against these three cotton pests (Table 1).

The LC_{50}/LC_{95} value of sericin capped silver nanoparticles against thrips was 120.73/397.03 mg/L. It was 157.43/429.24 mg/L against cotton armyworms. While in the case of cotton pink bollworm, it was 217.04/409.435 mg/L. However, the LC_{50} and LC_{95} of marigold-AgNPs against thrips were 106.16 and 400.05 mg/L, while against cotton armyworms, 129.27 and 354.003±mg/L, respectively. It has also been calculated that the LC_{50} and LC_{95} of the marigold-AgNPs against cotton pink bollworm were 202.06 and 392.70 mg/L (Table 2).

4. Discussion

The main aim of the current study was to evaluate the biopesticidal potential of silver nanoparticles (AgNPs) coated with marigold (*Tagetes spp.*) aqueous extracts and with sericin against major agricultural cotton pests, namely thrips, pink bollworms, and armyworms.

Table 1. The percentage mortality of marigold and sericin based silver nanoparticles against thrips, armyworm and pink bollworm.

Nanoparticle	Dose	Percentage Mortality ±SE		
		Thrips	Armyworm	Pink bollworm
Sericin NPs	300mg/L	83±12.0b	80±5.7c	63±6.6d
	200mg/L	66± 5.4b	56±7.2c	50±4.7c,d
	100mg/L	63±5.4b	50±4.7b, c	33±7.2b,c
	50mg/L	20±5.7a	16±3.3a	13.3±3.3a,b
Marigold NPs	300mg/L	80±5.7b	73±3.3c	63±6.6d
	200mg/L	76±2.7b	70±8.1c	60±4.7c,d
	100mg/L	63±3.7b	60±4.7c	33±5.4b,c
	50mg/L	23±5.4a	20±4.7a, b	13±2.7a,b
Control		6±0.33a	6±0.33a	0±0
ANOVA		$F_{8,18}$=20.015; P<0.001	$F_{8,18}$=19.097; P<0.001	$F_{8,18}$=15.786; P<0.001

Note: Values in a column with similar superscripts showed non-significant difference while values with different superscripts showed significant differences ± indicated standard error (SE)

Table 2. Activity of marigold and sericin based silver nanoparticles against thrips, armyworm, and pink bollworm.

Cotton Pest	Nanoparticle	LC_{50}	95% Fiducial CI	LC_{95}	95% Fiducial CI	Slope	p	X^2
Thrips	Marigold NPs	106.16±24.3	38.39-148.9	400.05±63.1	313.18-625.2	0.005	*P<0.001*	6.78
	Sericin NPs	120.73±21.7	65.05-161.1	397.03±59.1	314.49-599.4	0.005	*P<0.001*	6.71
Armyworm	Marigold NPs	129.27 ±25.5	60.044-178.3	465.622±84.2	354.003-797.3	0.004	*P<0.001*	7.25
	Sericin NPs	157.43±20.0	113.50-200.5	429.24±62.3	341.718-638.1	0.006	*P<0.001*	3.85
Pink bollworm	Marigold NPs	202.06±23.6	158.015-264.0	505.26±82.6	392.70-802.7	0.005	*P<0.001*	3.20
	Sericin NPs	217.04±26.0	171.26-291.3	534.023±92.97	409.435-882.9	0.005	*P<0.001*	1.55

Overall, our results demonstrated the significant insecticidal activity ($P<0.001$) of both types of AgNPs, with noticeable mortality in all cotton pests. This study is novel in reporting, for the first time, the biopesticidal activities *of* both types of AgNPs, which were not assessed before against cotton pests, expanding the previous studies, which mainly focused on the antimicrobial or larvicidal activities. Insecticidal activities of volatile compounds from marigolds have already been reported [56]. He et al. [46] used marigold coated silver nanoparticles as an antimicrobial agent. Similarly, Al Masud et al. [57] and Tahir et al. [58] used sericin coated silver nanoparticles as antimicrobial agents. However, their biopesticidal activities were not assessed previously. However, Rehman et al. [59] assessed the pesticidal activity of copper nanoparticles against cotton armyworms and thrips.

The aqueous extract of marigold was used and selected, the main reason is due to its cost-effectiveness, ease of preparation, and adequate phytochemical content, in spite of ethanolic extracts, which are richer in phenolic compounds [60]. This research is in accordance with Vasyliev et al. [40], who also used plant extracts for the synthesis of nanoparticles. Furthermore, Sericin was extracted from the cocoons of silkworms by autoclaving the cocoons in water at 121°C for 30 minutes. Other researchers, such as Munir et al. [45] also used similar methods for the extraction of sericin from the cocoons of *B. mori*. The change in color of the solution from light yellow to olive grey in the case of marigold extracts conjugated silver nanoparticles and dark brown in the case of sericin conjugated silver nanoparticles confirmed the synthesis of nanoparticles. Similar results of change in color to confirm the synthesis of plant extract conjugated silver nanoparticles have already been reported [45, 61].

Moreover, in the current research, UV spectrophotometric analysis of sericin conjugated AgNPs produced an absorption peak at 380-400nm that was very close to the absorption peaks reported by Lamboni et al. [62] and Al Masud et al. [57] at 410nm and 413–424 nm, respectively. The sericin alone usually produces absorption peaks at 220-270 nm, while silver nanoparticles alone at 440-450nm [63]. The reported size of silver nanoparticles prepared by the sonication method is 7.49 nm [64]. However, the UV spectra of the marigold conjugated nanoparticles study produced an absorbance peak at 400-440nm as compared to 387 nm for marigold alone [33], which was in accordance with He et al. [46], who reported the absorption peak of these nanoparticles range from 420nm to 430nm with a particle size ranging from 10 to 90 nm.

In our study, the results of FTIR of sericin based silver nanoparticles showed the characteristic absorption peaks confirming the presence of specific biomolecules, including the NH-OH bond of amine, carboxylate group and C-H bond. Al Masud et al. [57], also reported the presence of NH–OH, C–H, C═O, and C–N containing biomolecules. These biomolecules predominantly act as stabilizing and reducing agents in the synthesis of nanoparticles. The functional groups that are present on the surface also contribute to interactions with the cuticle of the insect and the gut lining, which increase the toxicity through the enzyme inhibition and with the oxidative stress. Furthermore, the results of FTIR analyses of marigold conjugated silver nanoparticles showed specific peaks indicating the presence of the C-O bond, C-N bond and C-H bond. These results are in accordance with the He et al. [46], who also reported similar peaks.

The pesticidal effects of silver nanoparticles conjugated with *Euphorbia hirta* [65], *Prosopis glandulosa* [66] and *Azadirachta indica* [67, 68, 69] extracts used against cotton pests, including the pink bollworm, *Fusarium solani,* whitefly and cotton bug, were already reported. The reason for the increasing rate of mortality might be due to the synergistic effect of the silver ions, which disrupt the DNA replication mechanism and the cellular respiration [70], as well as with phytochemicals from the sericin and marigold silver coated nanoparticles. Moreover, sericin is responsible for instigating the stress responses and disrupting the digestive enzymes in the insect larvae, while marigold comprises flavonoids and terpenoids that can interact with the nervous system of the insect. In addition, the nanoscale size of the AgNPs helps in the penetration through the insect cuticles, triggering cellular damage and increasing their biopesticidal action by producing reactive oxygen species (ROS). Previously, only the antimicrobial and mosquito larvicidal activity of sericin conjugated silver nanoparticles was reported [57,62]. Moreover, the marigold is a phytochemically rich traditional plant with a wide range of pesticidal activities against different insect pests [71].

The present study reflects the fact that the marigold and sericin conjugated silver nanoparticles could be an alternative to synthetic pesticides and these nanoparticles can rectify the limitations associated with synthetic pesticides. The silver nanoparticles are also cheaper and safer [72]. Both silver nanoparticles are effective, environmentally safe, less expensive and easy to apply with minimum care by individuals and communities. However, it is suggested that further research is needed to elucidate the detailed molecular and physiological mechanisms involved in pest mortality.

This is the first report validating their use in agricultural pest management, potentially offering a sustainable and effective alternative to synthetic pesticides. The present findings create a platform for future investigations into oxidative stress responses in the target pests, gene expression changes and detoxification pathways. Overall, both marigold and sericin conjugated silver nanoparticles showed potent biopesticidal activity against the common cotton pests. This is the first report validating their use in agricultural pest management, potentially offering a sustainable and effective alternative to synthetic pesticides.

5. Conclusion

Silver nanoparticles were synthesized by using sericin solution and marigold extract as reducing and capping agents. The two types of nanoparticles were characterized by using UV- spectrophotometry, which ensures the proper confirmation of nanoparticles. FTIR spectra showed the presence of organic constituents in Se-AgNPs and M-AgNPs, which indicates the engagement of organic compounds of sericin and marigold as reducing and capping agents in the synthesis process of AgNPs. Both silver nanoparticles possess bio-pesticidal activity against cotton thrips, cotton armyworm and cotton pink bollworm. These nanoparticles are effective, environmentally safe, less expensive and economical as well as practical in application with minimum care by individuals and communities.

Author Contribution Statements

Syeda Durr E Shahwar Zaidi: Methodology, Project administration and Writing – original draft; Aamir Ali and Muhammad Summer: Project administration and Writing – review & editing; Hafiz Muhammad Tahir: Conceptualization, Supervision and Writing – original draft; Fariha Munir: Methodology and Writing – review & editing; Ayesha Tehreem and Ayesha Muzamil: Data curation, Formal Analyses; Muhammad Adnan and Abdul Khaliq: Investigation, Project administration, Visualization and Validation.

Conflicts of Interest

The authors report no conflict of interest.

Acknowledgment Not applicable (N/A)

Data Availability statement

The data presented in this study are available on request from the corresponding author.

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