Voyage Journal of Scientific Research and Exploration (VJSRE) Vol 2. Issue 1
ISSN (Online): 3007-3898, ISSN (Print): 3007-388X, April to September 2025

Antibacterial activities of chickpea (*Cicer arietinum* L.) leaves used to enhance the growth of ladyfinger (*Abelmoschus esculentus* L.*)* plant

Rayyan Komal[1], Huma Gul[1,2]*

[1] Department of Botany, Women University of Swabi, Khyber Pukhtunkhwa, Pakistan
rayyankomal77@gmail.com
[2] Department of Plant Sciences, Faculty of Biological Sciences, Quaid-i-Azam University, Islamabad, Pakistan
humagul@bs.qau.edu.pk
Corresponding author*: *humagul@bs.qau.edu.pk*

Abstract

This study explores the multiple benefits and management strategies of okra (Abelmoschus esculentus L), a widely cultivated crop in the Indo-Pak subcontinent valued for its medicinal properties, including antidiabetic and antioxidant activities. The research investigates the antibacterial properties of chickpea (Cicer arietium L.) leaf extract against plant pathogens and its potential and its role as a bio stimulant for okra growth. Invitro experiments demonstrated that chickpea leaf extract exhibited antibacterial activities, with the highest inhibition zone (12 mm and 13 mm) against Klebsiella pneumoniae and Pseudomonas aeruginosa, respectively, at higher concentrations. Comparatively standards, antibiotics Gentamicin and Meropenem show greater inhibition, with Gentamicin yielding a 30 mm zone against Pseudomonas aeruginosa. Additionally, Cadmium sulfate nanoparticles were synthesizing using chickpea leaf extract as an eco-friendly antimicrobial agent. A color shifts from yellow to greenish yellow indicated nanoparticles synthesis, confirmed by UV-visible spectroscopy with a peak at 350 nm. Invivo experiments involved the application of chickpea leaf powder as a soil amendment at different concentrations (1g, 3g, and 5g). The treatment significantly enhanced okra growth, with 1% chickpea leaf powder yielding optimal results in root and shoot development. Urea fertilizer was less effective compared with chickpea. These findings suggest that chickpea leaf products offer a sustainable alternative to chemical fertilizers and pesticides, highlighting their potential in plant disease management and sustainable agriculture.

Keywords: Chickpea, Synthesis of Nanoparticles, UV- Spectroscopy, *Abelmoscus esculentus* L., *Cicer arietinum* L., Medicinal activities.

Introduction

Abelmoschus esculentus L Okra is a popular plant in the Indo-Pakistani subcontinent and one of the most widely cultivated and consumed species in the Malvaceae family (Naveed *et al.,* 2009). In older literature, okra was often referred to as *Hibiscus esculentus*, although it actually belongs to the genus Hibiscus. The plant can be grown in a variety of climates, including tropical, subtropical, and warm-temperate climates, making it suitable for a wide range of geographic areas. Therefore, the plant is commercially cultivated and used in many countries (Adiaha *et al.,* 2017).

India accounted for 61.2% of total global okra production, which rise from 1.8 million tons in 1972 to 11.2 million tons in 2022 (Kumar *et al.,* 2013). Okra was originally discovered in what is now Ethiopia and later spread to the Caribbean, South America, North America, Africa, India, and the eastern Mediterranean. Okra has long been a staple food in southern countries but is also becoming increasingly popular in the West (Islam *et al.,* 2019).

India is a focus of a lot of research on okra farming, pest dynamics, and management techniques because it is the world's largest producer of okra. Nigeria, Mali, Pakistan, Sudan, and Iraq are among the other nations that significantly contribute to the world's okra production. While the crop serves a variety of purposes, its main focus is on the green, soft fruits of the plant, which are high in vitamins A, B, and C as well as minerals like iron and iodine. They also contain a substantial amount of protein and oil, about 20.0% of each (Adebooye *et al.,* 1996). This vegetable is said to have low levels of cholesterol, saturated fat, and salt and is a vital source of viscous fiber (Adebooye *et al.,* 1996).

Okra leaves and seeds have been shown to have antibacterial, antioxidant, and antidiabetic properties. Okra has long been used in herbal medicine and offers numerous health benefits, including reducing inflammation, regulating blood sugar levels, and even preventing cancer (Ardestani *et al.,* 2020). Additionally, okra is used medicinally as a blood volume or plasma expander (Kumar *et al.,* 2010).

Additionally, okra is used medicinally as a blood or plasma volume expander (Kumar *et al.,* 2010). By scavenging oxygen free radicals, an alcoholic extract of the leaves has been shown to improve kidney function, reduce proteinuria, and alleviate renal tubular and interstitial disorders (Kumar *et al.,* 2009). The protein- and oil-rich fruits have been used on a small scale for oil production (Çalışır *et al.,* 2005). Furthermore, the coarse fibers of okra fruits and mature stems are used for paper production (Ounis *et al*., 2024). The roots of *Althaea officinalis* have a strong demulcent effect and are extremely rich in mucilage. This mucilage can be used in place of plasma. According to (Tobyn *et al.,* 2010), the roasted seeds have sudorific qualities and are antispasmodic, cordial, and stimulating when infused.

The best fiber from okra (*Abelmoschus esculentus*) is composed of 67.5% a-cellulose, 15.4% hemicellulose, 7.1% lignin, 3.4% pectic matter, 3.9% fatty, waxy matter and 2.7% aqueous extract. It is obvious that a-cellulose, hemicellulose, and lignin are the primary components of okra fiber, with the remaining components being very minor in proportion. The present study's main goals were to: (1) Examine the antibacterial properties of chickpea leaf extract against plant pathogens.(2) To assess the impact on ladyfinger seed of chickpea leaf powder as a soil amendment.(3) Cadmium sulphide nanoparticles (CdS NPs) should be created and characterized. (4) Assessing the antimicrobial efficacy of chickpea leaf extract against Klebsiella pneumonia and Pseudomonas aeruginosa.(5) To investigate the possible advantages of utilizing healthier and more natural substitutes.

Materials and methods

In Vitro Experiment (Preparation of chickpea leaves extract in polar solvent)

Fresh leaves of the chickpea plant (*Cicer arietinum* L.) were collected in December 2024. After washing the leaves with clean water to remove all dust. Spread the leaves on clean paper or cloth for drying. Take 20 grams of dried leaves and grind in a mortar pestle and then put in a clean 500-ml flask. Add 200 ml of acetone shake well and cover the flask. Let the mixture infuse for 2 days in a drying oven at room temperature. Filter the mixture and pour the solvent (solvent extract) into a large Petri dish. Add 10 ml of acetone and place the dish in a fume hood for 6 hours to evaporate the solvent. After 6 hours, the acetone was evaporated and the extract was completely dried and ready for further processing or experiments. It was stored in the refrigerator.

Sample preparation from extract leaves or solution

Take 10 g of dried chickpea leaves extract solution and then add 1 ml of DMSO mix thoroughly to dissolve the solution in DMSO and stored in a tube or vial. The sample was ready for the antibacterial test.

Antibacterial activities (Media preparation and autoclaving)

Three types of media were prepared: nutrient agar, MacConkey agar and nutrient broth for bacterial growth and isolation. First, 4.2 g of nutrient agar was placed in a flask. Added 150 ml distal water shakes well and then covered with a cotton cap. 5.15 g of MacConkey agar was weighed and added 100 ml distal water. Similarly, 0.39 g of nutrient broth was also weighed and added 30 ml of distal water, mixed and shaken three times and then allowed to stand for a few minutes. The mediums were then autoclaved for 15 minutes at 121°C (standard temperature). After the sterilization process, the mediums (nutrient agar, nutrient broth, and MacConkey) were poured into Petri dishes and stored at temperatures between 2°C and 4°C for further use.

Bacterial isolation and purity testing

For bacterial isolation, three different culture media plates (Nutrient Agar NA, Nutrient Broth NB, MacConkey MAC) were prepared and three different bacterial samples were used: E. coli (*Escherichia coli*) PS (*Pseudomonas aeruginosa*) KP (*Klebsiella pneumoniae*). Each bacterial culture was then streaked onto culture media plates (NA, MAC) using an inoculating loop. These plates were incubated for 24 hours at 37°C to allow bacterial growth. Individual colonies grown from the original sample were then selected on NA and MAC plates. On MAC plates, colonies were differentiated based on their color and morphology. Isolated colonies were then streaked or plated onto separate fresh NA and MAC plates to ensure pure culture. But culture appeared only

on nutrient agar which means it is a gram –ve culture**.** Incubate the bacterial culture in the nutrient broth tube. Add 3 ml of nutrient solution to each tube and inoculate the KP and PS bacterial cultures. After two days, the purity of the clinical isolation is checked by Gram staining and microscopic examination.

Gram staining

A sterile, grease-free slide was taken, labeled, and smeared with a drop of physiological saline. A colony was placed on the slide, heat-fixed, and satin-finished according to the following instructions. The slide was immersed in crystal violet for one minute. Excess dye was decanted and gently washed away with tap water. After washing, the smear was treated with iodine for one minute. It was then gently rinsed again with tap water. To decolorize, 75% ethanol + 25% distal water was applied for 15 seconds, followed by rinsing. For decolonization, 90% alcohol was applied for 2–3 seconds. The slide was rinsed again with tap water to stop decolonization. 0.25% safranin was applied as a counterstain for 15–20 seconds, followed by rinsing. After drying, the bacteria were examined under oil immersion. Microscopic examination showed pinkish bacteria.

Antibacterial activity of chickpea leaves extract against *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*

Obtain a pure culture of (KP) *Klebsiella pneumoniae* and (PS) *Pseudomonas aeruginosa*. Grow the bacteria in nutrient broth until they reach a suitable density. Prepared a nutrient agar plate, Pour melted nutrient agar into sterile Petri dishes and allow it to solidify. Using a sterile swab spread a standardized inoculum of the target bacteria (KP and PS) evenly over the surface of each nutrient agar plate. Make four (4) small, round holes in the agar plates. Add a known amount of leaf extract solution to the center of each hole: approximately 40 ml of solution to the first hole, 60 ml to the second, 80 ml to the third and 100 ml to the fourth hole. Incubate the plates for 24 hours at 37°C. After incubation, measure the diameter of each clear zone (inhibition zone) around the hole where bacterial growth is inhibited. A large zone indicates stronger antibacterial activity.

Antibiotic susceptibility testing (AST) or checking antibiotic resistance

Table 1. Shows media or material requirements.

S.No	Material Required
1	Nutrient Agar Plates (NA)
2	Bacterial Cultures: *Pseudomonas aeruginosa* (PS), *Klebsiella pneumoniae* (KP)
3	Antibiotics: Penicillin, Gentamicin, Erythromycin, Meropenem
4	Antibiotic Discs
5	Sterilized equipment (Inoculating Loops, Pipettes, etc.)

Checking antibiotic resistance

Testing for antibiotic resistance (penicillin, gentamicin, erythromycin, meropenem) against bacteria using a disc diffusion test. For this purpose, culture plates were prepared and the bacterial cultures *Pseudomonas aeruginosa* (PS) and *Klebsiella pneumoniae* (KP) were inoculated onto separate culture plates using a sterile loop. A standardized inoculum of the bacterial strain was evenly distributed over the surface of the culture plate. Antibiotic discs (penicillin, gentamicin, erythromycin, meropenem) were applied to the inoculated plates. Both plates were then incubated for 24 hour at 37°C. After that the zone of inhibition (ZOI) around each antibiotic disc was measured. The size of the zone of inhibition was measured and compared with a standardized table to determine bacterial susceptibility to each antibiotic.

Preparation of chickpea leaves extract in nonpolar solvent

Took 82 grams of chickpea leaves, crushed and placed in a 1000-ml flask. Added 200 ml of distal water and maintain the water level for a few days. After 7 days, placed the flask in a 37°C water bath for shaking for 60 minutes and then allowed it to cool to room temperature. After cooling, the mixture was filtered with filter paper and stored in a refrigerator at 5°C for further use in the synthesis of cadmium nanoparticles.

Synthesis of nanoparticles

Cadmium sulfide nanoparticles (CdS NPs) were prepared using a green method using plant leaves extract. To prepare CdS NPs, take 53 gram of cadmium sulfate added 100ml distal water. Put the flask in water bath set at 40°C with shaking speed 100, put the cadmium sulfate solution drop by drop until the light green colour change into brown colour. Hence the colour change the nanoparticles are synthesizing after drying. Take 5 grams of these dried particles into value tube and added 1ml DMSO solution. The purified nanoparticles of cadmium sulfide were then dried in an oven and stored in a clean bottle for further characterization and activity assessments. Further, the CdS NPs formation was confirmed by taking UV-visible spectra.

UV-Visible Spectrophotometry (UV-Vis)

The synthesized CdS NPs were further analyzed using a UV-VIS spectrophotometer (Shimadzu Corporation, Japan). The sample was diluted in distilled water and then analyzed in the UV range from 300 nm to 700 nm.

Vivo experiments (Soil amendments)

Raw soil samples were collected for the experiment it was then cleared from surface debris, such as leaves or twigs *e.t.c*. Soil was prepared added to improve its physical, chemical, or biological properties, ultimately aiming to enhance plant growth and development. The goal was to overcome soil limitations and improve its overall function, such as drainage, aeration, or nutrient availability. Soil was put in a cleaned container and mixed thoroughly to create a uniform sample

and then filled the pots. Total 21 pots containing 250-gram soil each were prepared including three sets of soil. In first set nine pots of three treatments (chickpea leaf powder) T1 (1g), T2 (3 g), T3 (5 g) with three replicates pots of each treatments were prepared. In the 2nd set three treatments of Urea U1 (1 g), U2 (3 g) and U3 (5 g) including three replicates pots of each treatment were prepared. Similarly the 3rd set was control having 3 replicates without treatments were prepared. All pots were left undisturbed for one week to allow the treatment to take effect.

Incubation period

After that following the incubation period, after incubation ladyfinger *(Abelmoschus esculentus*) seed were sow in each pot and the pot were watered regularly with 50ml each. The experiment aimed to compare the effect of different treatment on ladyfinger seed germination and growth, providing valuable insights into the potential benefits of using chickpea leaf powder and urea.

Results

Antibacterial Activities of Chickpea Leaf Extract

The antibacterial activity of chickpea leaf extract was tested against two bacterial strains: *Klebsiella pneumoniae* (KP) and *Pseudomonas aeruginosa* (PS). The results are presented in the table below: Antibacterial activity against both *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*, with varying concentrations showing different levels of inhibition. On *Pseudomonas aeruginosa* showed that the chickpea leaf extract sample gives zone of inhibition only on 80 concentrations the zone diameter is 18mm respectively while on *Klebsiella pneumoniae* the extract sample give zone of inhibition on concentration of 40, 60 and 100% the zone diameter was 11mm, 11mm, and 12nm respectively however, the 12mm, at 100% concentration show the largest on *Klebsiella pneumonia* (Figure 1 & 5, Table 2).

Table 2. Antibacterial activity of chickpea leaves extract.

	Klebsiella pneumonia		***Pseudomonas aeruginosa***	
S.No	**Concentration of extract sample**	**Zone diameter**	**Concentration of extract sample**	**Zone diameter**
1	40	11mm	40	0mm
2	60	11mm	60	0mm
3	80	0mm	80	13mm
4	100	12mm	100	0mm

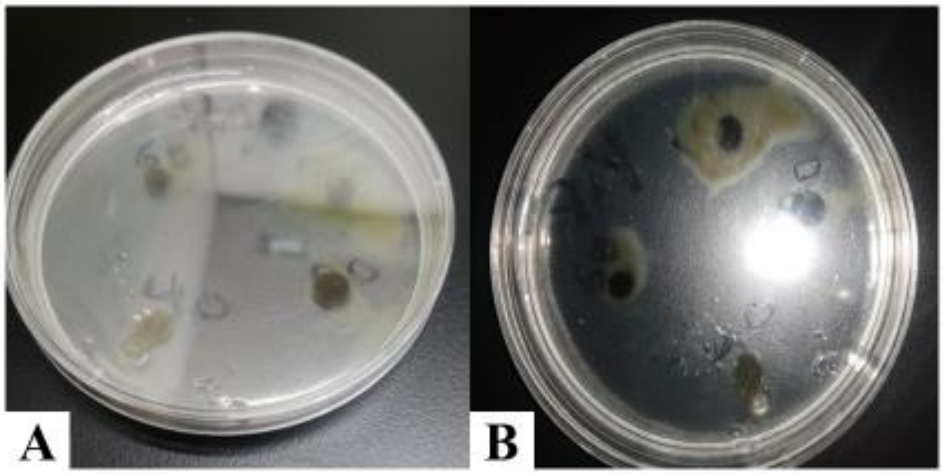

Figure 1. *Pseudomonas aeruginosa* and *Klebsiella pneumonia* plate showing zone of inhibition.

Antibiotic Resistance Testing

The antibiotic resistance testing was performed against *Klebsiella pneumonia* and *Pseudomonas aeruginosa* using four different antibiotics (Figure 3). The results are presented in the table 3. The result is classified as follows: Sensitive (S) Large inhibition zone, meaning the bacteria were killed or their growth was inhibited by the antibiotic. Intermediate (I) Medium inhibition zone, meaning the bacteria were partially sensitive. Resistant (R) no or small inhibition zone, meaning the bacteria was not affected by the antibiotic. That means the bacteria were resistant to the antibiotic. *Pseudomonas aeruginosa* antibiotics resistivity was checked against 4 different antibiotics Penicillin, Gentamicin, Erythromycin and Meropenem. *Pseudomonas aeruginosa* produce zone of inhibition against Gentamicin and Meropenem which is 30mm and 12mm. Erythromycin and Penicillin did not produce any zone. While *Klebsiella pneumonia,* resistivity test produces zone of inhibition against Meropenem which is 10mm while Penicillin, Gentamicin, Erythromycin did not produce zone of inhibition (Figure 2 &Table 3).

Table 3. Antibiotic resistances against *Klebsiella Pneumonia* and *Pseudomonas aeruginosa* bacteria.

S.No	*Pseudomonas aeruginosa*	Zone diameter	*Klebsiella pneumonia*	Zone diameter
1	Penicillin	0mm	Penicillin	0mm
2	Gentamicin	30mm	Gentamicin	0mm
3	Erythromycin	0mm	Erythromycin	0mm
4	Meropenem	12mm	Meropenem	10mm

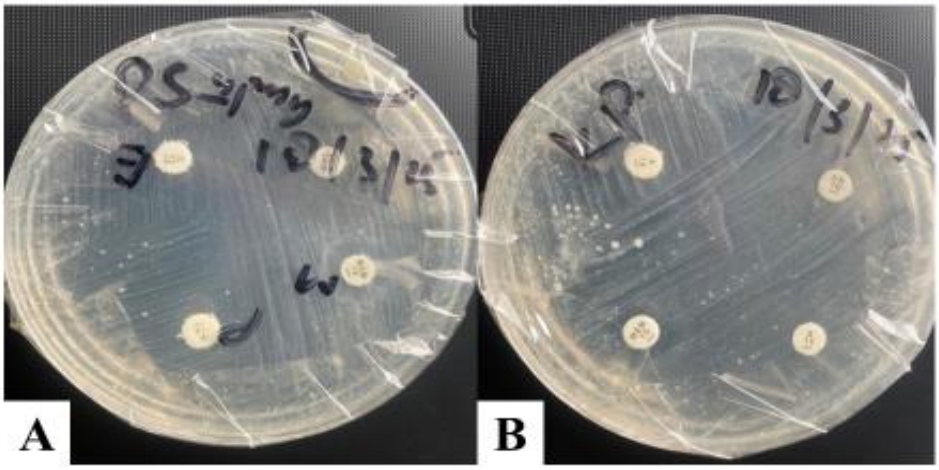

Figure 2. Antibiotic resistances against *Klebsiella Pneumonia* and *Pseudomonas aeruginosa.*

On *Klebsiella Pneumonia* only Meropenem plate showing zone of inhibition, zone diameter was 10nm respectively**,** PS Gentamicin and Meropenem plate showing zone of inhibition, zone diameter is 30nm and 12nm respectively. 30nm zone by Gentamicin on PS showed largest zone.

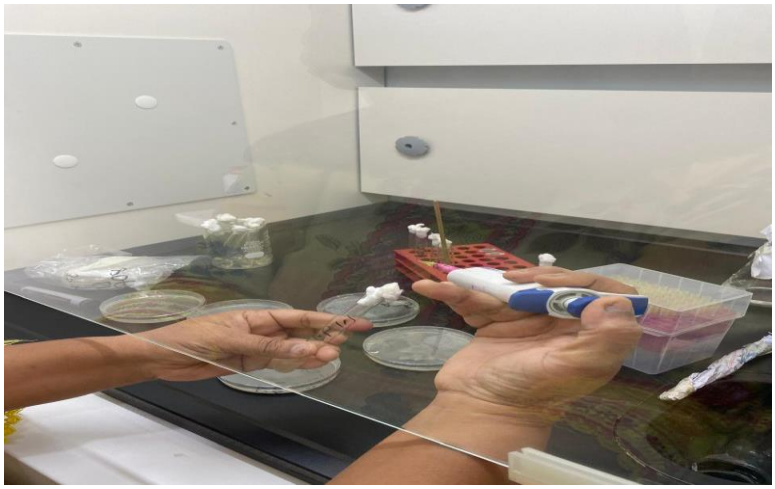

Figure 3. Preparation of nutrient agar for antibacterial resistance test.

Synthesis of Cadmium Sulfide Nanoparticles

The synthesis of CdS NPs was confirmed by UV-visible Spectrophotometry at range 200nm to 700nm showed a color change from light green to brown, indicating the formation of nanoparticles. The UV-Vis absorption spectrum of CdS nanoparticles was shown in the figure. Around λ = 430–500 nm, a noticeable absorption peak was seen, confirming that CdSNPs formed as a result of their quantum confinement effect. Particle size, synthesis circumstances, and surface capping agents could affect the precise peak position. The electronic transition between the valence and conduction bands of CdS was responsible for the presence of that absorption band, indicating the successful synthesis of nanoparticles (Figure 4).

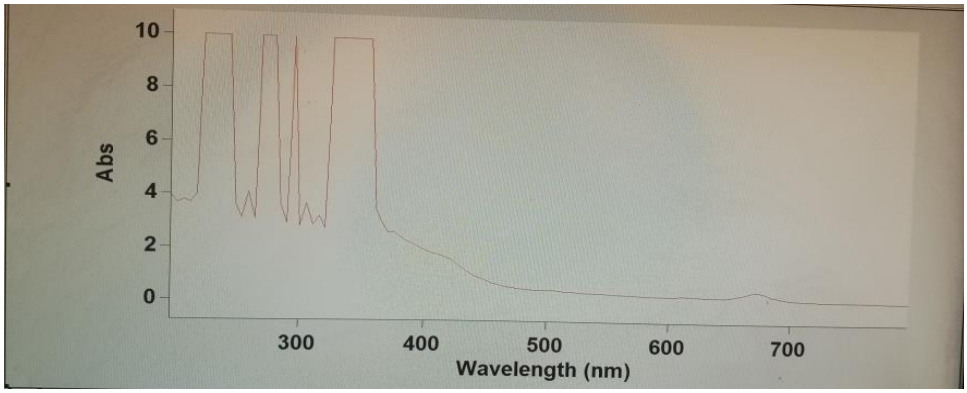

Figure 4.Indicate the synthesis CdSNPs through UV-visible Spectrophotometry.

The growth and health of chickpea (*Abelmoschus esculentus*) leaves can be improved by using chickpea (*Cicer arietinum*) leaf powder as a natural product, as shown in (Figure 5). The image often shows the application technique (foliar spray or soil conditioner) and emphasizes how it affected plant growth. Chickpea leaves, rich in nutrients and bioactive compounds, could help plants become more robust, more resistant to pests, and more productive. The image highlights the benefits of that organic treatment by comparing treated and untreated plants and promoting environmentally friendly and sustainable cultivation methods.

Figure 5. Chickpea *Cicer arietium* leaves powder use as a treatment for ladyfinger *Abelmoschus esculentus* plant.

*Cicer arietinum*is used as an organic treatment to promote the growth and development of ladyfinger (*Abelmoschus esculentus*) as shown in (Figure 6). In that context, chickpeas were likely used as organic matter compost, plant residue, or green manure in addition to fertilizing the soil and stimulating microbial activity to provide the nutrients necessary for okra plant health. The figure illustrates the potential of sustainable agricultural practices that utilize crop rotation to organically enrich the soil and increase crop yields by incorporating nitrogen-fixing legumes like chickpeas.

Figure 6. Chickpea *Cicer arientium* used as treatment for the enhancement of ladyfinger *Abelmoschus esculentus* plant.

Figure 7 illustrated the results of root weight of okra plants among various treatments. The maximum root weight 1.30±0.36g was found in T1 while minimum 0.15±0.03g was observed in treatment U2 however chickpea treatment showed better result than urea as compared to control.

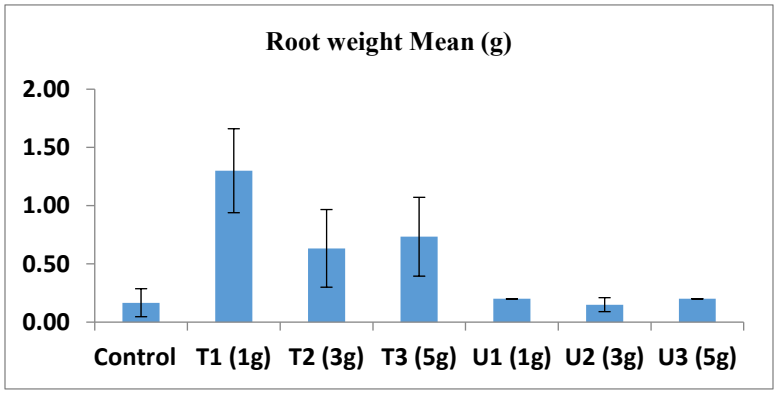

Figure 7. Effect of treatments on root weight of *Abelmoschus esculentus.*

Figure 8 defined the results of root length of okra plants under the influence of various treatments. The highest root length 5.97±1.45cm was observed in (chickpea) T3 showed the positive impact while, lowest 0.2±0.00cm was recorded in treatment U2 however U1 (1g of urea) provided better performance as compared to control.

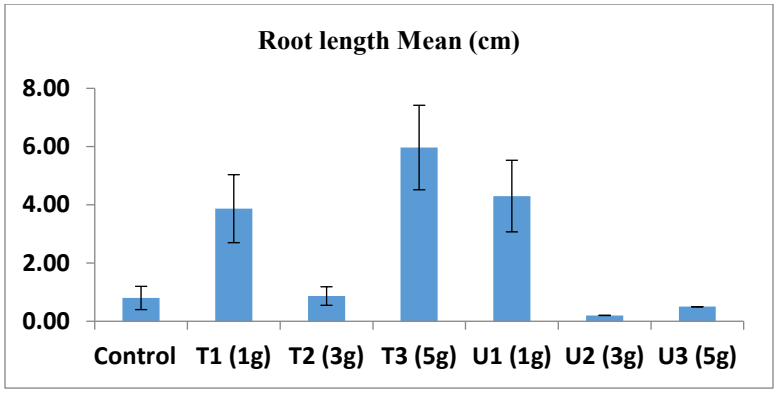

Figure 8. Effect of different treatments on the root length of plant.

Similar results were observed in shoot weight figure 9. The greatest shoot weight 2.57±0.12 g was observed in chickpea treatment T1 (1g) while, treatment T2 (3g) also showed better effect. However the minimum weight 0.15±0.05 g was recorded in U2 compared with control.

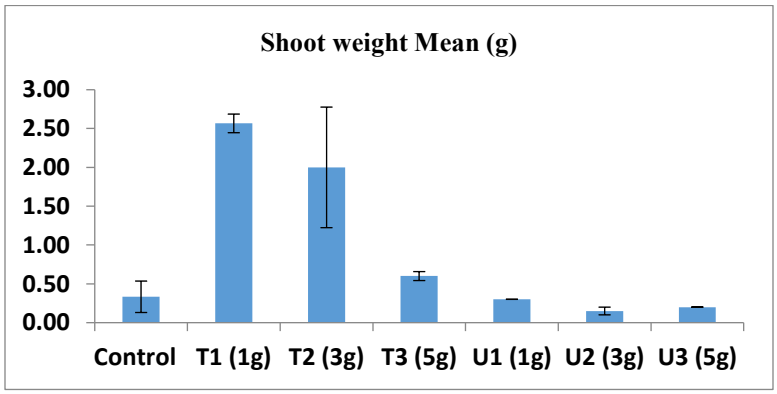

Figure 9. Effect of different treatments on the shoot weight of *Abelmoschus esculentus*.

Figure 10 illustrated the overall better shoot length growth among all treatments except U2 (3g) which suppressed plant shoot length 0.6±0.00cm, however Chickpea treatment provided better effect T1 and T2 both got maximum length 19.73±2.96 cm and 19.73±1.92 cm respectively.

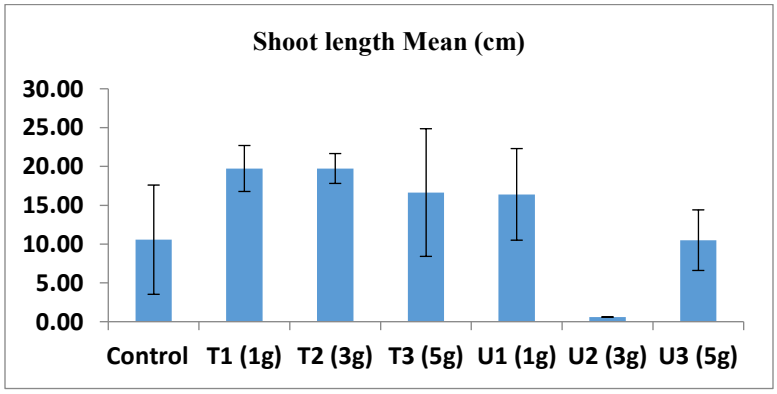

Figure 10. Effect of different treatments on shoot length of *Abelmoschus esculentus*.

The results regarding no. of leaves were expressed in figure 11. It was observes that no. of leaves got almost similar effect of treatments. However, the highest no. of leaves 6±0 was calculated in T1 while, the lowest 2±1 were estimated in U2. Although, the chickpea treatment gave better effect on the overall growth of *Abelmoschus esculentus* plant as compared to other treatments as well as control.

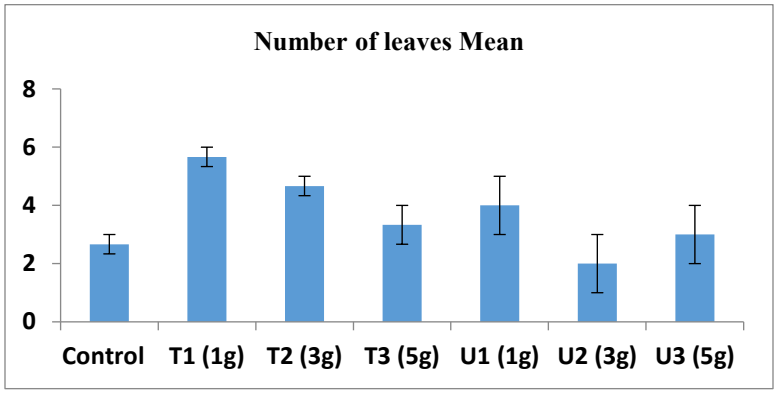

Figure 11. Effect of different treatments on plant leaves.

Discussion

Recent research has shown that chickpea leaf extract can be used as a natural antibacterial agent against plant pathogens, particularly *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*. The extract showed varying levels of inhibition against both bacterial species, with *Klebsiella pneumoniae* showed the largest zone of inhibition at 100 µl. According to (Kan *et al.,* 2010), chickpea leaf extract may be a useful alternative to synthetic pesticides and offer a more sustainable and environmentally friendly approach to controlling plant diseases.

Furthermore, the study showed that using chickpea leaf powder as a soil improver promoted leaf finger growth, with optimal results at certain concentrations. Root weight and length, as well as shoot weight and length, were significantly improved by the treatment with 1% chickpea leaf powder. The growth and productivity of chickpea plants can be improved by using chickpea leaf powder as a soil improver (Kan *et al.,* 2010).

Research showed that legume residues, such as chickpea leaves, can improve soil fertility by adding organic matter, nutrients, and beneficial bacteria (Drinkwater *et al.,* 1998). Ghosh *et al.,* (2007) showed that adding residues and crop rotations based on legumes can increase soil nitrogen levels, which is beneficial for the next chickpea harvest. Adding ground chickpea leaves to the soil improves soil fertility.

The nutrients and organic matter in chickpea leaves can improve soil fertility and structure. Chickpea yields can be increased by improving soil fertility and health. Furthermore, using chickpea leaf extract for the synthesis of cadmium sulfide nanoparticles offers a sustainable and environmentally friendly method for nanoparticles production. This study promotes sustainable agricultural practices by exploring the potential of natural ingredients to promote plant growth and control plant diseases.

Conclusion

The current study showed that chickpea root extract has antibacterial activity against two bacterial pathogens that can infect the okra plant: *Pseudomonas aeruginosa* (PS) and *Klebsiella pneumoniae* (KP). The results suggest that ground chickpea leaves can be an effective bio stimulant for UV-visible absorption spectra between 200 and 700 nm. The results of the study have implications for sustainable farming practice, namely for reducing the use of pesticides. Chickpea leaf powder improved the soil quality. The best results were obtained at specific concentrations of chickpea treatments. According to these results, using chickpea leaf powder as a natural soil amendment can improve plant growth and development while simultaneously reducing the need for artificial fertilizers. By investigating the potential of natural products to combat plant diseases and promote growth, study also contributes to the development of sustainable agricultural practices. This study has important implications for reducing the negative environmental impact of synthetic chemicals in agriculture and promoting environmentally friendly alternatives for crop protection and growth promotion.

Author's contributions

RK conceptualized the research, conducted analysis, HG Supervised the manuscript, RK and HG wrote the original manuscript. The authors approved the current version for publication.

Conflict of interest

The authors declared that there is no conflict of interest.

References

Adebooye, O. C., & Oputa, C. O. (1996). Effects of galex (r) on growth and fruit nutrient composition of okra (*Abelmoschus esculentus* (L.) Moench). *Life J. Agricul.*, *18*(1), 1-9.

Adiaha, M. S. (2017). Effect of Okra (*Abelmoschus esculentus* L. Moench) on human development and its impact on the economy of farmers in Obubra Rainforest Zone of Nigeria. *World News of Natural Sciences*, *10*.

Ardestani, S. T., Khodaparast, S. A., Moghaddam, A. A., Ghanavati, F., & Darsaraei, H. (2020). First report of powdery mildew caused by Golovinomyces bolayi on okra (*Abelmoschus esculentus*). *Australasian Plant Disease Notes*, *15*(1), 26.

Çalışır, S., Özcan, M., Hacıseferoğulları, H., & Yıldız, M. U. (2005). A study on some physico-chemical properties of Turkey okra (*Hibiscus esculenta* L.) seeds. *Journal of Food Engineering*, *68*(1), 73-78.

Drinkwater, L. E., Wagoner, P., & Sarrantonio, M. (1998). Legume-based cropping systems have reduced carbon and nitrogen losses. *Nature*, *396*(6708), 262-265.

Ghosh, P. K., Bandyopadhyay, K. K., Wanjari, R. H., Manna, M. C., Misra, A. K., Mohanty, M., & Rao, A. S. (2007). Legume effect on soil health and productivity of rainfed maize-chickpea rotation in eastern India. *Journal of Agricultural Science*, 145(3), 239-249.

Islam, M. T. (2019). Phytochemical information and pharmacological activities of Okra (*Abelmoschus esculentus*): A literature-based review. *Phytotherapy research*, *33*(1), 72-80.

Kumar, D. S., Tony, D. E., Kumar, A. P., Kumar, K. A., Rao, D. B. S., & Nadendla, R. (2013). A review on: *Abelmoschus esculentus* (Okra). *International Research Journal of Pharmaceutical and Applied Sciences*, *3*(4), 129-132.

Kumar, R., Patil, M. B., Patil, S. R., & Paschapur, M. S. (2009). Evaluation of Abelmoschus esculentus mucilage as suspending agent in paracetamol suspension. *International Journal of PharmTech Research*, *1*(3), 658-665.

Kumar, S., Dagnoko, S., Haougui, A., Ratnadass, A., Pasternak, N., & Kouame, C. (2010). Okra (*Abelmoschus spp*.) in West and Central Africa: Potential and progress on its improvement.

Kan, A., Özçelik, B., Kartal, M. U. R. A. T., Özdemir, Z. A., & Özgen, S. (2010). In vitro antimicrobial activities of Cicer arietinum L (Chickpea). *Tropical Journal of Pharmaceutical Research*, *9*(5).

Naveed, A., Khan, A. A., & Khan, I. A. (2009). Generation mean analysis of water stress tolerance in okra (*Abelmoschus esculentus* L.). *Pak. J. Bot*, *41*(1), 195-205.

Ounis, S., Turóczi, G., & Kiss, J. (2024). Arthropod pests, nematodes, and microbial pathogens of okra (Abelmoschus esculentus) and their management—A review. *Agronomy*, *14*(12), 2841.

Tobyn, G., Denham, A., & Whitelegg, M. (2010). *The Western Herbal Tradition E-Book: The Western Herbal Tradition E-Book*. Elsevier Health Sciences.