



Article

Eco-friendly control of fusarium root rot disease infecting cucumber in Iraq

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Abstract

The activity of chemical compounds to induce systemic resistance against fusarium root rot disease was assessed in cucumber plants. Ascorbic acid and Beltanol fungicide treatments inhibited fungal growth up to 100% on PDA medium at concentration of 1000 mg/L and 2000 mg / L, respectively. Potassium phosphate, coumaric acid and ascorbic acid combination treatment decreased disease incidence and severity up to 0.00 and 0.00%, respectively. compared to control treatment which scored 83.33 and 81.33%, respectively. Straight. In addition, it caused an increase. The wet and dry weight of the plant was significant compared to the other treatments. All factors tested could induce systemic resistance through increasing total phenol content, 15 days of the pathogen treatment. Ascorbic + K₂HPO₄ + coumaric + *F. solani* combination treatment scored the highest phenol content after 15 days, scoring 1.367 mg / g, compared to the control treatment (pathogenic fungus alone), which was 1.200 mg / g. This combination could increase total protein content in plants to 22.33% compared to the 15.00% in control treatment. Data obtained suggests the combination ascorbic + K₂HPO₄ + coumaric is highly effective against fusarium root rot disease infecting cucumber in Iraqi environment.

Keywords: Cucumber; *F. solani*; K₂HPO₄; Coumaric; Ascorbic; control.

Received: 22/7/2026

Revised: 15/9/2026

Accepted: 20/9/2026

Published: 30/9/2026

Citation: Hassan A, Al-Luhaiby A, Al-Mayahi S. Eco-friendly control of fusarium root rot disease infecting cucumber in Iraq. JSPPB. 2026; 1: 17-25.

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المكافحة الصديقة للبيئة لمرض تعفن الجذور الفيوزاريومي الذي يصيب الخيار في العراق

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المستخلص

تم تقييم فعالية بعض المركبات الكيميائية في تحفيز المقاومة الجهازية ضد مرض تعفن الجذور الناجم عن فطر الفيوزاريومي *Fusarium* في نباتات الخيار. أدت المعاملة بحمض الأسكوربيك ومبيد الفطريات "بيلتانول" (Beltanol) إلى تثبيط النمو الفطري بنسبة تصل إلى 100% على وسط "PDA" الغذائي عند تركيزي 1000 ملغ/لتر و 2000 ملغ/لتر على التوالي. كما أدت المعاملة المشتركة المكونة من فوسفات البوتاسيوم وحمض الكوماريك وحمض الأسكوربيك إلى خفض نسبة الإصابة بالمرض وشدة تصل إلى 0.00% و 0.00% على التوالي، مقارنة بمعاملة المقارنة التي سجلت 83.33% و 81.33% على التوالي. وبالإضافة إلى ذلك، تسببت هذه المعاملة في زيادة معنوية في الوزن الرطب والجاف للنبات مقارنة بالمعاملات الأخرى.

وقد أظهرت جميع العوامل المختبرة قدرة على تحفيز المقاومة الجهازية من خلال زيادة المحتوى الكلي للفينولات بعد 15 يوماً من المعاملة بالعامل الممرض؛ حيث سجلت المعاملة المشتركة (حمض الأسكوربيك + K_2HPO_4 + حمض الكوماريك + فطر *F. solani*) أعلى محتوى من الفينولات بعد 15 يوماً، إذ بلغت 1.367 ملغ/غرام، مقارنة بمعاملة المقارنة (الفطر الممرض وحده) التي سجلت 1.200 ملغ/غرام. كما ساهمت هذه المعاملة المشتركة في رفع المحتوى الكلي للبروتين في النباتات إلى 22.33% مقارنة بـ 15.00% في معاملة المقارنة. وتشير البيانات المستخلصة إلى أن الخليط المكون من حمض الأسكوربيك و K_2HPO_4 وحمض الكوماريك يتمتع بفعالية عالية في مكافحة مرض تعفن الجذور الناجم عن الفيوزاريوم والذي يصيب الخيار في البيئة العراقية.

1. Introduction

Cucumber, *Cucumis sativus* L. is one of the major vegetable crops in Iraq as it is grown both in open and protected cultures (1). Based on the latest statistics, the Iraqi growing area and fruit production of cucumber scored 84155 dunums and 185484 tonnes, respectively (2). Several diseases infect cucumber plants, including those caused by soil-borne fungi (3). The fungus *Fusarium solani* is a soil born pathogen impacting a wide range of hosts causing severe losses (4). This pathogen can destroy the plant root system and diminish the foliar system (5). Due to the significant damage caused by the extensive use of chemical pesticides to human health and the ecosystem, recent efforts have been directed toward developing eco-friendly pesticide alternatives to manage plant diseases (6, 7), including those used to induce disease resistance in plants (8). In Iraq, chemicals were used to induce resistance against fungal pathogens, including potassium phosphate (K_2HPO_4) (9), coumaric acid (10) and ascorbic acids (11). This study therefore aimed to assess the efficacy of some resistance-inducing agents against *F. solani* infection and their growth-promoting effects on cucumber plants.

2. Materials and Methods

2.1. Isolation, identification and pathogenicity of *F. solani*

A local isolate of the pathogenic fungus *F. solani* (acc. No. MN857748), previously described, was used. The pathogenic fungus inoculum was prepared using local millet *Panicum miliaceum* seeds method described by Dewan and Sivasithamparam (12). *F. solani* pathogenicity was confirmed on cucumber plants grown in pots.

2.2. The activity of K_2HPO_4 and organic compounds against the pathogenic fungus growth on PDA medium

The poisoned food technique was performed to test the inhibitory activity of K_2HPO_4 , coumaric acid, and ascorbic acid. Concentrations (400, 600, 800 and 1000) mg/L. of each compound were prepared, passed through a 0.45 μ m Millipore filter using vacuum filtration, mixed well in PDA medium before solidification, and added to 9 mL disposable plates. Beltanol (Probelte, Spain) (containing 50%Chinosol active ingredient) was tested as described above. Beltanol concentrations (500, 1000, 1500 and 2000) mg/L were prepared based on the active ingredient concentration. Four plates of each treatment and control were inoculated in the middle with 0.5 ml discs sliced from the edge of *F. solani* culture at 5th day of growth stage and incubated at 25 ($\pm$ 2) °C. Inhibition percent was calculated as follows:

$$\text{Inhibition\%} = \frac{\text{mean of radial growth in control} - \text{mean of radial growth in treatment}}{\text{mean of radial growth in control}} \times 100$$

2.3. Efficacy assessment of K_2HPO_4 and organic compounds to induce systemic resistance and promote growth of cucumber plants against the pathogenic fungus

This experiment was performed in a greenhouse at the Abu-Ghraib Research Station, Ministry of Agriculture. A mixture of sandy soil and peatmoss (2:1) was prepared, autoclaved, and added to plastic pots at a rate of 3 Kg per pot. Cucumber seeds were surface-sterilized with sodium hypochlorite for 2 min, washed for 2 min with sterile distilled water, and sown at 5 seeds per pot. Soil in pots was contaminated with pathogenic fungal inoculum (grown on millet) at 30 g/pot 15 days before sowing. Millet-free fungus was added to pots as a control treatment. Treatments used as follows:

1. Control
2. *F. solani*
3. Coumaric acid
4. K_2HPO_4
5. Ascorbic acid
6. Coumaric + *F. solani*
7. *F. solani* + K_2HPO_4
8. Ascorbic + *F. solani*
9. Coumaric + K_2HPO_4 + *F. solani*
10. Coumaric + K_2HPO_4
11. Coumaric + Ascorbic + *F. solani*
12. Coumaric + Ascorbic
13. Ascorbic + K_2HPO_4 + *F. solani*
14. Ascorbic + K_2HPO_4
15. Ascorbic + K_2HPO_4 + Coumaric + *F. solani*
16. Ascorbic + K_2HPO_4 + Coumaric
17. Beltanol + *F. solani*

All treatments were added at sowing. K_2HPO_4 and Coumaric acid were added to the soil at a rate of 50 ml/pot and a concentration of 800 mg/L. Ascorbic acid was added at a rate of 50 ml/pot and a concentration of 1000 mg/L. Beltanol was added at 1 ml/L and 50 ml per pot, respectively.

Half of each concentration was used in combination treatments. The experiment was designed based on a completely randomized design (CRD) using 17 treatments in 3 replicates. Data were analyzed using least significant difference (LSD) at a probability level (0.05%). Data were recorded 4 days of pathogen inoculation based on wilt symptoms, up to 45 days. Seedling mortality percent was calculated using the equation as follows:

$$\text{Seedling mortality\%} = \frac{\text{No. of dead plants}}{\text{Total plant No.}} \times 100$$

Plants were collected 60 days of planting and disease severity was assessed the following disease index described by Alwan (13):

- 0= Healthy plants
- 1= 1- 25 of root is rotten
- 2= more than 25-50% of root is rotten
- 3= more than 50-75% of root is rotten
- 4= more than 75-100% of root is rotten or plant death

Disease severity percent was calculated based on McKinney (14) as follows:

$$\text{Disease severity\%} = \frac{(\text{plant of 0 scale} \times 0) + \dots + (\text{plant of 4 scale} \times 4)}{\text{total plants} \times 4} \times 100$$

Whole plant was collected, washed to remove soil debris and fresh weight was estimated. For dry weight estimation, plants were placed in paper bags and dried at 40 °C up

to weight stabilization. Biochemical properties related to systemic induced resistance were measured. Total phenol and protein contents were estimated 15 and 30 days of pathogen inoculation, respectively.

3. Results

3.1. Antifungal activity of K_2HPO_4 , ascorbic and cumaric acids against *F. solani* on PDA medium

K_2HPO_4 treatment could inhibit the fungal growth on PDA at all concentration scoring 83.70-100% compared to 0% inhibition in K_2HPO_4 free control (Table 1). Both ascorbic and cumaric acids showed inhibitory effects against the pathogenic fungus growth, varied based on concentration used (Fig. 1). Cumaric acid scored 100% highest growth inhibition at concentrations 800 and 1000 mg/L. Whereas, ascorbic acid scored 100% growth inhibition at 1000 mg/L.

Table 1. Antifungal activity of K_2HPO_4 against *F. solani* on PDA.

Concentration (mg/L.)	Fungal radial growth rate	Concentration (mg/L.)
0	9.00	0.00
400	1.46	83.70
600	0.00	100.00
800	0.00	100.00
1000	0.00	100.00
L.S.D 0.05	0.59	6.66

¹ Each value represents an average of 3 replicates.

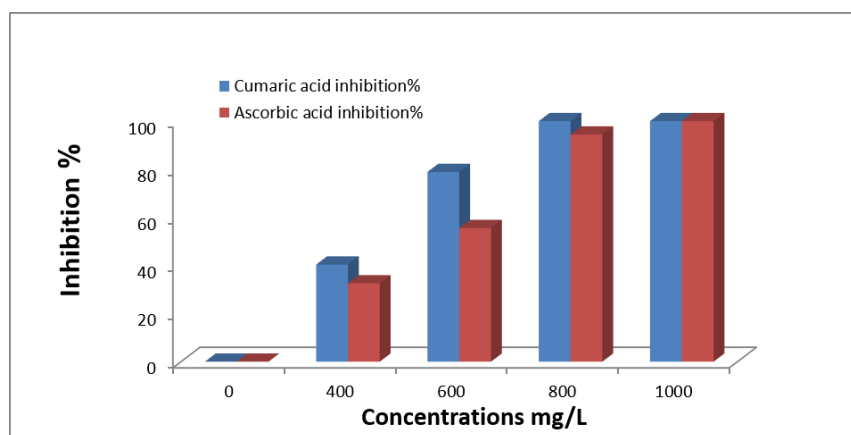


Figure 1. The inhibitory activity of organic compounds tested against *F. solani* growth on PDA medium. Each value represents an average of 3 replicates. L.S.D_{0.05} of cumaric acid inhibition=4.89, L.S.D_{0.05} of ascorbic acid inhibition= 4.97 .

3.2. Toxic activity of Beltanol pesticide against *F. solani* on PDA medium

Beltanol inhibited pathogenic fungal growth at all concentrations tested, achieving 100% inhibition at 2000 mg/L (Table 2).

3.3. The activity of bio- and chemical inducers against *F. solani* on cucumber plants under greenhouse conditions

Among the treatments, the combination ascorbic + K_2HPO_4 + cumaric acid scored 0.00 and 0.00% for disease incidence and severity, respectively (Table 3). Similarly, cucumber plants treated with this combination scored 11.600, 11.700, and 4.033, 3.967 g/plant, the highest fresh and dry weight rates, with or without fungus treatment, respectively (Fig. 2).

Cucumber plants treated with the combination ascorbic + K_2HPO_4 + cumaric scored 22.33 mg/g maximum protein content compared to other treatments (Fig. 2). Similarly, the combination ascorbic + K_2HPO_4 + cumaric scored 1.367 mg/gm maximum phenol content 15 days of treatment (Fig. 4).

Table 2. Antifungal activity of Beltanol against *F. solani*.

Concentration (mg/L)	Fungal radial growth rate (cm)	Concentration (mg/L)
0	9.00	0.00
500	7.06	21.48
1000	4.50	50.00
1500	1.13	87.40
2000	0.00	100.00
L.S.D 0.05	0.44	6.92

¹ Each value represents an average of 3 replicates.

Table 3. Activity of bio- and chemical compounds against disease incidence and severity percent of *F. solani* under greenhouse conditions.

Treatments	Incidence%	% Severity
Control	0.00	0.00
<i>F. solani</i>	83.33	81.33
Cumaric acid	0.00	0.00
K_2HPO_4	0.00	0.00
Ascorbic acid	0.00	0.00
Cumaric + <i>F. solani</i>	16.67	14.67
K_2HPO_4 + <i>F. solani</i>	6.67	2.67
Ascorbic + <i>F. solani</i>	23.33	21.33
Cumaric + K_2HPO_4 + <i>F. solani</i>	3.33	1.33
Cumaric + K_2HPO_4	0.00	0.00
Cumaric + Ascorbic + <i>F. solani</i>	6.67	4.00
Cumaric + Ascorbic	0.00	0.00
Ascorbic + K_2HPO_4 + <i>F. solani</i>	3.33	1.33
Ascorbic + K_2HPO_4	0.00	0.00
Cumaric + Ascorbic + K_2HPO_4 + <i>F. solani</i>	0.00	0.00
Cumaric + Ascorbic + K_2HPO_4	0.00	0.00
Beltanol + <i>F. solani</i>	43.44	36.67
L.S.D0.05	6.57	5.69

¹ Each value represents an average of 3 replicates.

4. Discussion

Data from this study showed that the use of K_2HPO_4 , cumaric acid, and ascorbic acid can provide an efficient control method against *F. solani*. A combination of these materials can offer an eco-friendly pesticide alternative for root rot disease management and enhance plant growth as well.

K_2HPO_4 can damage fungal hyphae and spores, directly preventing their spread (15). Due to its inhibitory activity, this chemical was used effectively to control many fungal pathogens, including *F. solani*, *F. oxysporum* f.sp. *melonis*, *Rhizoctonia solani* and *Sclerotinia rolfsii* (9, 16, 17). The antimicrobial activity of K_2HPO_4 may be related to its role in controlling cellular osmotic pressure and carbohydrate accumulation, resulting in reduced

fungal infections and increased plant resistance to fungal pathogens (18). Hence, K_2HPO_4 could decrease disease incidence and severity of many fungal pathogens including *F. oxysporum*, *F. solani* and *R. solani*, in addition to increase plant growth parameters as well (17, 19).

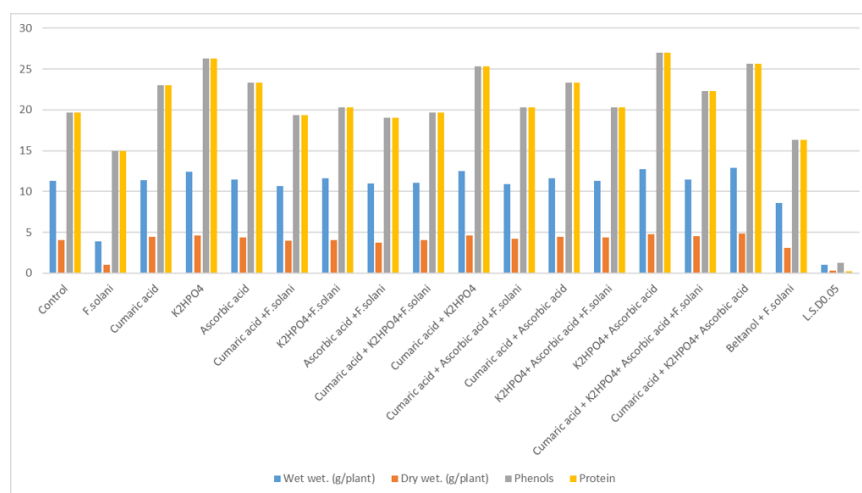


Figure 2. Effectiveness of bio- and chemical compounds on fresh and dry weights, total protein and phenol contents of cucumber plants grown in pots. Each number represents the average of three replicates.

Similarly, organic compounds were used successfully to inhibit *R. solani* growth infecting beans in Iraq (10). The inhibitory activity of cumaric acid may be related to increased concentration, which increased phenolic compounds. These compounds inhibited fungal growth through damaging cell membranes or modifying protein synthesis through binding the active sites of fungal enzymes (20, 21). Ascorbic acid may have a direct inhibitory activity against pathogen growth metabolites, resulting in growth suppression and death (22). Many studies have reported that these compounds have antimicrobial activity against many plant pathogens (9, 10, 11, 22).

Cumaric acid activity against disease incidence and severity may be involved in its role to induce systemic resistance in plant. This activity is resulting in the accumulation of pathogenicity related proteins at the infection site, including B-1, 3-glucanase and chitinase degrading the fungus cell walls, and peroxidases, ascorbate oxidase, polyphenol oxidase and phytoalexins (23). Besides, cumaric acid may decrease the soil pH around the rhizosphere and improve the nutrient supply, as the pH of Iraqi soil is higher than 7 (24). Ascorbic acid activity against pathogens could be through decrease the action of oxidation, harmful to cell metabolisms, resulted from the pathogen activity (11, 16). Hence, ascorbic acid could increase resistance against pests and enhance plant growth by increasing the antioxidant activity of enzymes, including peroxidase and catalase, and inducing chitinase and glucanase related to induced resistance (22). Additionally, ascorbic acid can enhance plant growth through increasing root efficiency in nutrient uptake and photosynthesis (25). It also increases nitrogen and chlorophyll concentration in leaves, contributes chlorophyll synthesis and components and acts as a chlorophyll antioxidant (26). The increase in the plant fresh and dry weights in plants treated with ascorbic acid may be related to it acted as a growth regulator homologous (27, 28), in addition to its role to decrease heat stress and improve photosynthesis (11, 29, 30).

In this study, the high fungicidal activity of Beltanol against *F. solani* may be related to its active ingredient, Chinosol, which binds heavy elements and forms complex compounds that the pathogen cannot easily absorb. Besides, Chinosol comprises chelating compounds with copper in the host tissues, enabling these compounds to pass and be

released through the pathogen cells, resulting in the death of the pathogen (31). Beltanol inhibited the growth of *F. solani* causing root rot and wilt disease on soybean, pepper and Madagascar periwinkle *Catharanthus roseus* on PDA medium up to 100% at concentration 2000 mg/L (9, 32, 33). Phenols can inhibit enzymes produced by pathogens prior plant infection, including cellulases, pectinases, laccase and xylanase. Besides, they inhibit oxidative phosphorylation in the fungus and restrict it from element, protein and antioxidant uptake (34, 35, 36). The accumulation of phenol produced by cells in infected plants enhances plant defense mechanisms against fungal bacterial and viral pathogens (37).

5. Conclusions

The current study suggests that the biochemical combinations can offer an effective, eco-friendly control method against *Fusarium* root rot disease. They can be used alone or combined with bio-fertilizers to enrich poor soils and promote the growth of beneficial micro-organisms in agricultural ecosystems.

Author Contributions: Conceptualization, A.H. and S.A.; methodology, A.A.; validation, A.H., A.A. and S.A.; formal analysis, S.A.; investigation, A.A.; resources, A.H.; data curation, S.A.; writing—original draft preparation, A.A. and S.A.; writing—review and editing, A.H.; visualization, A.H.; supervision, A.H.; project administration, A.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: Authors acknowledge Prof. Dr. T. A. Kareem for technical assistance.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Farhan OK, Ibade KW, Kareem TA. Diagnosis the *Pseudoperonospora cubensis* causes downy mildew in cucumbers and its resistance to potassium silicate and extract eggplant wild. IOP Conference Series: Earth and Environmental Science. 2023; 1225, (ICASE-2022).
2. CSO. Statistical group part3, Agricultural statistics. 2023; <https://cosit.gov.iq/documents/AAS2023/3.pdf>
3. Kareem T, Mutar S, Karim E, Al-Kuwaiti N. Protective effect of olive polyphenols on watermelon against *Fusarium oxysporum* f.sp. *niveum* infection. Pak. J. Phytopathol. 2020; 32(1), 7-31.
4. Al-Fadhal FA, AL-Abedy AN, Alkhafije DA. Isolation and molecular identification of *Rhizoctonia solani* and *Fusarium solani* isolated from cucumber (*Cucumis sativus* L.) and their control feasibility by *Pseudomonas fluorescens* and *Bacillus subtilis*. Egypt. J. Biol. Pest Control. 2019; 29, 47.
5. Zheng N, Zheng LP, Ge FY, Huang WK, Kong LA, Peng DL, Liu SM. Conidia of one *Fusarium solani* isolate from a soybean-production field enable to be virulent to soybean and make soybean seedlings wilted. J. Integr. Agric. 2018; 17(9), 2042-2053.
6. Aboutorabi M. A Review on the Biological Control of Plant Diseases using Various Microorganisms. J. Res. Med. Dent. Sci. 2018; 6(4), 30-35.
7. Adesemoye AO, Kloepper JW. Plant-microbes interactions in enhanced fertilizer-use efficiency. Appl. Microbiol. Biotechnol. 2009; 85(1), 1-12.
8. Liorens E, Agustín PG, Lapena L. Advances in induced resistance by natural compounds: towards new options for woody crop protection. Scientia Agricola. 2016; 74, 90-100.
9. Al-Mayahi SH, Hassan AK. Induction of systemic resistance in soybean using some eco-friendly materials against infection of *F. solani* and its effect on germination and biochemical characteristics. Plant Archives. 2021; 21, 1274-1280.
10. Al-Luhaiby AA, Hassan AK. Evaluation the ability of some organic compounds is protecting bean seedling against infection with *Rhizoctonia solani*. Plant Archives. 2020; 20(1), 86-90.
11. Hassan AK, Abdelmagith OM, Abdul Karim RR. Evaluation of the efficiency of some organic acids in the control rhizoctonia rot root disease caused by *Rhizoctonia solani* in cucumber plant. ARID Int. J. Sci. Technol. 2019; 2(4), 23-38.

12. Dewan MM, Sivasithamparam K. A plant-growth-promoting sterile fungus from wheat and rye-grass roots with potential for suppressing take-all. *Trans. British Mycol. Soc.* 1988; 91(4), 687-692.
13. Alwan KF. Activity of some biocontrol agents against *Fusarium solani* and *Macrophomina phaseolina* caused cucumber root rot disease in Babylon Province. *J. Al-Muthanna Agric. Sci.* 2014; 2(2), 1-22.
14. Mckinney HH. Biological control of nematode pests by natural enemies. *Annu. Rev. Phytopathol.* 1923; 18, 415-440.
15. Orober M, Siegrist J, Buchenauer H. Mechanisms of Phosphate-induced Disease Resistance in Cucumber. *European Journal of Plant Pathology.* 2002; 108, 345–353.
16. Abdel-Kader MM, El-Mougy NS, Aly MDE, Lashin SM. Integration of biological and fungicidal alternatives for controlling foliar diseases of vegetables under greenhouse conditions. *Int. J. Agric. For.* 2012; 2(2), 38-48.
17. Jabnoun-Khiareddine H, Abdallah R, El-Mohamedy R, Abdel-Kareem F, Gueddes-Chahed M, Hajlaoui A, Daami-Remadi M. Comparative efficacy of potassium salts against soil-borne and air-borne fungi and their ability to suppress tomato wilt and fruit rots. *J. Microb. Biochem. Technol.* 2016; 8(2), 45-55.
18. Atef MN, Haikel N. Efficacy of Seed Treatment with Microbial Agents And/or Waste Products for the control of Cucumber Damping-off. *Aust. J. Basic Appl. Sci.* 2008; 2(4), 1404-1410.
19. Abdel-Monaim MF, Atwa MAM, Morsy KM. Induce Systemic Resistance against Root Rot and Wilt Diseases in Fodder Beet (*Beta vulgaris* L. var. *rapacea* Koch.) by Using Potassium Salts. *J. Plant Patho. Microbiol.* 2015; 6 (315), 2.
20. Abdel-Monam MF, Ismail ME. The use of antioxidants to control root rot and wilt diseases of pepper. *Not. Scientia Biologicae.* 2010; 2(2), 46-55.
21. Wu M, Song M, Liu M, Jiang C, Li Z. Fungicidal activities of soil humic/fulvic acid as related to their chemical structures in green house vegetable fields with cultivation chrono sequence. *Sci. Rep.* 2016; 6, 22558
22. Ahmed SM. Effects of salicylic acid, ascorbic acid and two fungicides in control of early blight disease and some physiological components of two varieties of potatoes. *J. Agric. Res. Kafer El-Sheikh Univ.* 2010; 36(2), 220-236.
23. Abdel-Monaim MF, Abdel-gaid MA, Armanions HAH. Effect of chemical inducers on root rot and wilt diseases, yield and quality of tomato. *Int. J. Agric. Sci.* 2012; 2 (7), 210 – 220.
24. Pei K, Ou J, Huang J, Ou S. P- Coumaric acid and its conjugates: Dietary sources, pharmacokinetic properties and biological activities. *Phytochem.* 2016; 69, 1250 – 1260.
25. Traber MG, Stevens JF. Vitamins C and E: Beneficial effects from a mechanistic perspective. *Free Radic. Biol, Med.* 2011; 51(5), 1000-1013.
26. Aboleila B, Eid RA. Improving gladiolus growth, flower keeping quality by using some vitamins application. *J. Amer. Sci.* 2011; 7(3), 10 – 17.
27. Johnson JR, Fahy D, Gish N, Andrews PK. Influence of ascorbic acid spray on apple sunburn. *Good Fruit Grow.* 1999; 50(13), 81-83.
28. Katay G, Tyihak E, Katay E. Effect of ascorbigen and 1-methylascorbigen on disease resistance of bean plants to *Uromyces phaseoli*. *Natl. Prod. Commun.* 2011; .6(5), 611-615.
29. Oertli JJ. Exogenous application of vitamins as regulators for growth and development of plant. *J. Plant Nutr. Soil Sci.* 1987; 150, 375-391.
30. Pavet V, Olmos E, Kiddle G, Mowla S, Kumar S, Antoniw J, Alvarez ME, Foyer CH. Ascorbic acid deficiency activates cell death and disease resistance responses in arabidopsis. *Plant Physiol.* 2005; 139, 1291-1303.
31. Meister RT. *Farm Chemical Handbook.* Willoughby, Ohio. 2000.
32. Mousa AR, Hassan AK. Inducing systemic acquired resistance in pepper against *Rhizoctonia solani*. *Iraqi J. Mark. Res. Consum. Prot.* 2023; 15(1), 92-105.
33. Yasir LB, Almaliky BS. Integrated control of root rot and wilt disease on *Catharanthus roseus* using biological and chemical control. *Iraqi J. Mark. Res. Consum. Prot.* 2023; 15(1), 132–146.
34. Shafique HA, Sultana V, Ara J, Haque SE, Athar M. Role of antagonistic micro-organisms and organic amendment in stimulating the defense system of okra against root rotting fungi. *Pol. J. Microbiol.* 2015; 64(2), 157–162.
35. Adandonon A, Regnier T, Theresa AS. Phenolic content as an indicator of tolerance of cowpea seedlings to *Sclerotium rolfsii*. *Eur. J. Plant Pathol.* 2017; 9, 58- 78.
36. Ali MB, Haridy AG, Mahmoud AF. Evaluation of faba bean genotypes for yield and resistance to *Fusarium* root rot under greenhouse and field conditions. *Int. J. Biosciences.* 2019; 14, 374-385.
37. Zaynab M, Fatima M, Abbas S, Sharif Y, Umair M, Zafar MH, Bahadar K. Role of secondary metabolites in plant defense against pathogens. *Microb. Pathog.* 2018; 124, 198-202.

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