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Biodiversity and host range of *Rhizoctonia solani* isolates from the al-shariʿa region, Karbala province, Iraq

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Abstract

This research aimed to investigate the biodiversity of *Rhizoctonia solani* in the Al-Sharia area of Karbala Governorate and to study the host range of high-pathogenicity fungal isolates. It also aimed to determine their Anastomosis groups. The isolation and identification results showed the presence of several pathogenic fungi belonging to six genera of fungi associated with plant roots and stem bases: *Rhizoctonia sp., Alternaria sp., Aspergillus spp., Fusarium spp., Macrophomina sp.*, and *Colletotrichum spp. Rhizoctonia sp.* was the dominant species, with an incidence rate of 85% and a frequency of 47.3%. The results showed that all tested *Rhizoctonia spp*. isolates exhibited high pathogenicity, reducing seed germination rates. The germination inhibition percentage rangedfrom 12% to 100%, while in the control treatment it was 0.00%. Isolates R2K1, R2K12, R1K13, and R2K15 completely prevented germination, with 0.0% germination in their respective treatments. Meanwhile, an isolate of *R. solani from cucurbit plants* was characterized by high virulence and a broad host range. It infected various plant species, including tomatoes, cucumbers, radishes, basil, grapes, alfalfa, onions, spinach, barley, celery, and chard, with a 100% infection rate.

Keywords: *Biodiversity*, Root rot diseases, *Rhizoctonia solani, Karbala*

Introduction

The fungus *Rhizoctonia solani* is one of the most important causal agents of seed rot and damping-off diseases. It is widespread throughout the world, and its importance and danger are amplified by its broad host range, encompassing more than 142 plant species belonging to 125 genera from various plant families, including Solanaceae, Legumes, Asteraceae, Poaceae, and Brassicaceae, as well as ornamental plants and trees [1] R. solani is a major cause of seed rot and damping-off diseases in Iraq, and it is highly prevalent on vegetable crops such as tomatoes and cucumbers. It causes significant losses due to germination failure and the loss of numerous seedlings following infection. It also causes diseases at various stages of plant growth, including root rot and decay, and stem canker [2].

This fungus is considered a soil-borne pathogen and is widespread worldwide. This fungus lives in the soil as mycelium on organic matter or as dormant sclerotia. *Rhizoctonia solani* is a soil fungus that attacks seeds, causing them to rot. It also attacks the lower stem after germination, causing lesions and reddish-brown spots, leading to seedling mortality [3].

Many plants in open-field and greenhouse cultivation are susceptible to various diseases and pests that cause significant damage during the growing season. One such disease is Rhizoctonia root rot disease, a common problem in nurseries and greenhouses caused by the fungus *Rhizoctonia solani*, which is widespread globally [4]. Rhizoctonia root rot is one of the most important and widespread soil diseases, and the extent of loss from this disease is largely determined by the density of pathogenic fungal inoculum in the soil and the growing season. Agriculture and the presence of biotic factors. The fungus *R. solani* is one of the most aggressive pathogens. It is characterized by the production of numerous enzymes and toxins that are pathogenic to plants and contribute to their pathogenicity. These are responsible for the development of characteristic disease symptoms. This pathogenicity has been studied under laboratory conditions, where it was found that a group of enzymes that help break down cell walls, such as pectinase and pectin methyl esterase, are associated with the fungus. It also secretes toxic substances, some of which have phenolic or glycosidic properties. It is also believed that additional compounds are associated with the fungus, such as phenylacetic acid [5]. *R. solani* is classified into several strains that differ morphologically and physiologically, including 14 groups known as Anastomosis Groups [AGs]. These groups differ genetically, as some isolates ear highly pathogenic traits and others non-pathogenic traits due to mutations [6]. The fungus Rhizoctonia is considered one of the important fungi that attack plants, causing many diseases. This fungus mainly lives on roots and other plant parts below the soil surface [6]. Among the most important diseases caused by this fungus are seedling damping-off, leaf blight or spots, stem canker in young plants, root lesions, root and stem rot, and other diseases that affect plants in the field. It also attacks plant parts, causing them to rot during storage, resulting in significant crop losses [7].

This fungus is facultatively parasitic and non-specialized in its asexual stage, *R. solani*, belongs to the sterile fungi group that grows by mycelium without producing spores. In contrast, its sexual stage, Thanatephorus cucumeris, belongs to the basidiomycetes of the family Ceratobasidiaceae [8]. This final stage is rare in nature and is exceptionally absent from the fungus's life cycle. The fungus is characterized by the formation of thick, brown mycelium that branches at almost right angles, with constriction near the branching point and a transverse septum. Another distinctive feature is the formation of sclerotia of varying sizes [9], enabling it to persist for several years under unfavorable environmental conditions [10]. The fungus lives in the soil as mycelium within a wide temperature range of 8-36°C and 20-75% humidity [11]. It attacks plants at various stages of growth when suitable environmental conditions are present. The likelihood of infection increases with the presence of stressors such as drought, insect infestations, nematodes, and exposure to chemical fertilizers and pesticides. It penetrates the host directly through natural plant openings or wounds, forming

infection cushions and appressoria [12]. The fungus comprises numerous strains, identified by cytoplasmic anastomosis groups and molecular genetic techniques [13]. It secretes enzymes and toxins that degrade host cell walls, such as cellulase, pectinase, and Phosphatase [14]. Therefore, this research aimed to investigate the biodiversity of the fungus *Rhizoctonia solani* in the Al-Sharia area of Karbala Governorate and to study the host range of isolated fungal isolates with high pathogenicity.

Materials and Methods

Sample Collection

Samples were collected from numerous plants belonging to different plant families infected with root and stem base rot from several farms in the Al-Sharia area of Karbala Governorate. Plants were considered infected based on the observed symptoms, which included wilting and yellowing of leaves, seedling death, and lesions on the crown [lower stem] in the form of slightly sunken brown or black spots. The samples were collected and placed in polyethylene bags for preservation, with the location and date of collection, plant species, and plant family recorded (Table 1). They were then refrigerated at 4°C in the laboratory for isolation and identification of the pathogenic fungi.

Table (1): The sample name and code, as well as all collection specifications.

T	Sample collection location	Sample code	Date of collection 2024	plant family	Plant type
1	Karbala / Sharia	K 1	10/19	The lottery	The choice
2	Karbala / Sharia	2K	21/10	oral	Mint and basil
3	Karbala / Sharia	3K	10/22	bakery	Okra
4	Karbala / Sharia	4K	10/27	Palm trees	palm seedlings
5	Karbala / Sharia	5K	11/1	pomegranate	pomegranate
6	Karbala / Sharia	6K	11/1	Citrus	bitter orange
7	Karbala / Sharia	7K	11/1	almond	Rose enamel
8	Karbala / Sharia	8K	11/9	mulberry	figs
9	Karbala / Sharia	9K	11/9	Vineyards	grapes
10	Karbala / Sharia	10K	11/14	eggplant	Tomato
11	Karbala / Sharia	11K	11/14	legumes	Alfalfa and broad beans
12	Karbala / Sharia	12K	11/15	Crusader	Radish
13	Karbala / Sharia	13K	11/15	grass	barley
14	Karbala / Sharia	14K	11/15	tent	celery
15	Karbala / Sharia	15K	11/15	lily	onions and garlic
16	Karbala / Sharia	16K	11/15	Qatifiyah	Chard

Isolation and Diagnosis

Isolation of the fungus *R. solani* from infected plants

Pathogenic fungi associated with root diseases were isolated from plant parts (roots, stem bases) that showed symptoms on the day after harvesting. Small pieces, 0.5 cm in diameter, were taken from each infected root and stem base and surface-sterilized with a 1% sodium hypochlorite solution for 2 minutes. The pieces were then washed with sterile distilled water for two minutes to remove any remaining disinfectant and dried with sterile paper towels. Five pieces were inoculated into each 9 cm- diameter Petri dish containing potato dextrose agar culture medium. Potato Dextrose Agar (PDA) (200 g potatoes, 20 g dextrose, 20 g agar, and 1 L of water). The plates were incubated at 25 ± 2°C. After 3-5 days, the fungal isolates were purified by culturing them on potato sucrose agar[PSA] [200 g potatoes, 10 g sucrose sugar, 20 g agar and 1 liter of water] and incubated at 25 ± 2 °C for seven days and diagnosed based on the shape of the colony, the branching of the fungal hyphae, the the ability to form pigments in the culture medium, and using the standard taxonomic keys.

Occurrence and frequency percentages were calculated. Frequency of fungal isolates according to Krebs (1978) as follows:

Percentage of isolates appearing in the Innate Percentage frequency of fungal isolates

Diagnosis of the fungus *R. solani*

R. solani fungal isolates were grown on water agar and agar medium 2 % and incubated at 25 1 ±° C for three days, after which the isolates were identified. Based on the characteristics mentioned previously [15], including the color of the fungal colony, the branching pattern of the young mycelium, the ability to form *sclerotia* that are not differentiated into rind and medulla, the shape of the hyphal cells, and the presence of septa with dolipore septa.

Preservation of fungal isolates associated with plant roots

After purification and identification of the fungal isolates, they were stored in sealed test tubes containing a soil mixture medium and a small amount of millet seeds. The tubes were sterilized in an autoclave at 121°C and 1.5 kg/cm² for 1 hour, twice consecutively at 24-hour intervals. The sterilized soil was then inoculated by adding three 5 mm diameter discs taken from near the edges of 5-day-old fungal isolate colonies grown on PSA medium. Subsequently, the test tubes were placed in the incubator at 25 ± 1°C for 15 days with continuous stirring, then placed in the refrigerator at 4°C until subsequent tests were carried out.

Preparation of fungal inoculum for pathogenic fungal isolates

Each fungal isolate was grown by placing a small amount of contaminated soil from the preservation process in the center of a plate containing PSA culture medium , with three replicates for each isolate. The plates were incubated at 25 ± 1°C for 7 days. During this period, the white maize seeds were sterilized by placing 100 g of cleaned seeds in a 500 ml flask with 50 ml of water to moisten them. They were sterilized by autoclaving at 121°C and 1.5 kg/cm2 for 20 minutes, twice consecutively within 24

hours. The flasks were inoculated after cooling with the fungal inoculum at a rate of 5 five 5-mm-diameter discs per flask, with three replicates. The flasks were incubated at a temperature of 25 ± 1°C for 14 days. The flasks were shaken once every 3-5 days to ensure aeration and distribution of the fungal inoculum to all the seeds.

Susceptibility Tests

Detection of pathogenic isolates of the fungus *R. solani* using seeds of different plants in plastic pots

The pathogenicity of 36 *R. solani* isolates collected in the autumn of 2024 was tested. These isolates belong to twelve plant families, as indicated in Table 1 . Isolated from the samples referred to in Table 2. The soil mixture was sterilized with ethyl alcohol at 10 ml/kg and left to stand for 15 minutes before use. The following day, the soil was distributed into 15 cm-diameter pots, with 1 kg of soil per pot. Inoculum for each *R. solani* isolate was added to sterile soil at a rate of 1 % (w/w), and each treatment was repeated three times, with a control treatment (treatment with sterile, uncontaminated sorghum seeds). Three days after adding the fungal inoculum to the soil, the pots were planted with seeds of the plant species from which the fungi were isolated. Ten seeds were sown per pot, carefully watered, and results were recorded after germination was complete in the control treatments.

Table (2): Identifying and coding fungal isolates within the pathogenicity test

T	Sample code	Fungal isolate symbol	plant family	Plant type
1	1K	R3K1 ,R2K1 and ,R1K1	lottery	The choice
2	2K	R3K2 ,R2K2 and ,R1K2	oral	basil
3	3K	R3K3 ,R2K3 and ,R1K3	bakery	Okra
4	7K	R3K7 ,R2K7 and ,R1K7	almond	Rose enamel
5	9K	R3K9 ,R2K9 and ,R1K9	Vineyards	grapes
6	10K	R3K10 ,R2K10 and R1K10	eggplant	Tomato
7	11K	R3K11 ,R2K11 and ,R1K11	legumes	The jet
8	12K	R3K12 ,R2K12 and ,R1K12	Crusader	Radish
9	13K	R3K13 ,R2K13 and ,R1K13	grass	barley
10	14K	R3K1 ,R2K1 and ,R1K1	tent	celery
11	15K	R3K15 ,R2K15 and R1K15	lily	onions
12	16K	R3K16 ,R2K16 and ,R1K16	Qatifiyah	Chard

Studying the host range of fungal isolates *R. solani* using different plant families and the possibility of diagnosing anastomosis groups

To study the family scale For *R. solani* isolates. The isolated solani, which were confirmed to be pathogenic in initial Tests, was cultured in the greenhouse of the Plant Protection Department, College of Agriculture, University of Kerbala . R2K1 , R1K2 , R1K9 , R3K10 , R3K11 , R2K12 , R1K13 , R1K14 , R2K15 , and R2K16 were inoculated onto sorghum seeds as shown in Table 3. The soil mixture was sterilized with 10 ml/kg of ethyl alcohol and left to stand for 15 minutes before use. The following day, the soil was distributed into 15 cm diameter pots, with 1 kg of soil per pot. Inoculum for each *R. solani* isolate was added to sterile soil at a rate of 1 % (w/w), and each treatment was repeated three times, with a control treatment (sterile, uncontaminated sorghum seeds). Three days after adding the fungal inoculum to the soil, the pots were planted with seeds of host plantsrepresenting different anastomosis groups. These included tomato, cucumber, radish, basil, grape, alfalfa, onion, spinach, barley, celery, and chard, with 5 seeds per pot (a total of 330 pots). They were carefully watered and placed under shade in a completely randomized design (CRD). The results were taken based on the appearance of disease symptoms or their absence.

Table(3): Identification of fungal isolates for detection of cytoplasmic fusion aggregates of the fungus*R. solani*Using dispersed families

T	Sample code	Code for the most pathogenic fungal isolates	plant family	Plant type
1	1K	R2K1	The lottery	The choice
2	2K	R1K2	oral	basil
3	9K	R1K9	Vineyards	grapes
4	10K	R3K10	eggplant	Tomato
5	11K	R3K11	legumes	The jet
6	12K	R2K12	Crusader	Radish
7	13K	R1K13	grass	barley
8	14K	R1K14	tent	celery
9	15K	R2K15	lily	onions
10	16K	R2K16	Qatifiyah	Chard

Results and Discussion

Isolation and identification of fungi associated with plant roots

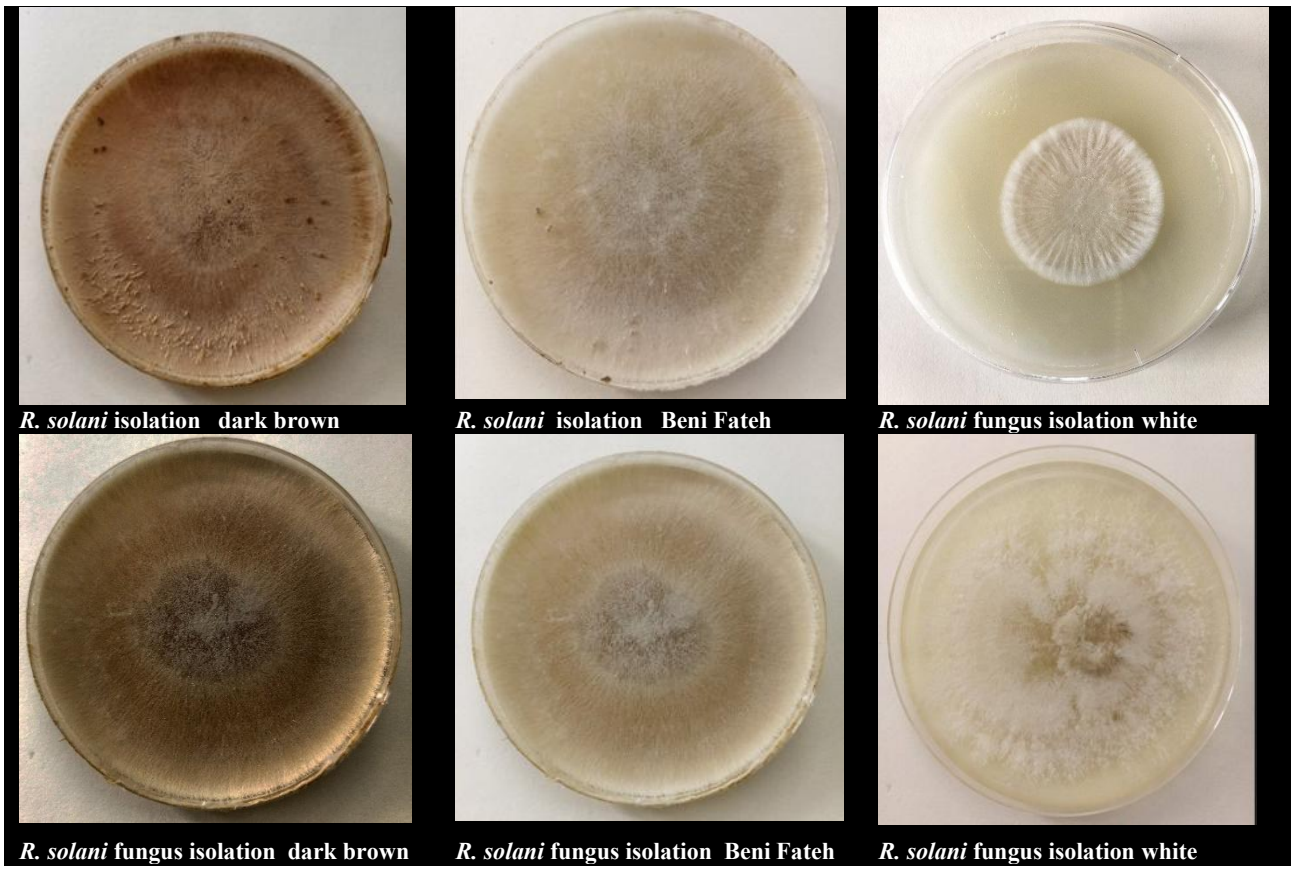
The results of isolation and diagnosis, as shown in Table 4, indicate the presence of several pathogenic fungi. Several fungal species were isolated and identified . The following six genera were isolated from roots and stem bases of plants. These included *Rhizoctonia sp Alternaria sp , Aspergillus spp , Fusarium spp , Macrophomina sp , Colletotrichum spp* . The dominant species was *Rhizoctonia sp* . Its occurrence rate in the samples reached 85 %, with a frequency of 47.3%. This may be due to the accumulation of fungal structures, such as sclerotia , which remain alive in the soil for years

until the host becomes unavailable, and the failure to follow proper agricultural practices such as, fertilizers, crop rotation, deep plowing, the use of seeds contaminated with fungus, and the failure to use resistant varieties were all contributing factors. These results are in line with what was reported by [16].

Table (4): Isolation and diagnosis of fungi associated with cucumber roots

T	Fungi	Appearance%	Frequency %
1	*Rhizoctonia* sp	85.0	47.13
2	*Fusarium* spp	61.4	32.10
3	*Macrophomina* sp	45.3	8.22
4	*Alternaria* spp	21.6	4.16
5	*Aspergillus* spp	13.4	4.12
6	*Colletotrichum* spp	12.0	1.22

Because *Rhizoctonia solani* is an important fungus that attacks plants across a wide range of families, causing many diseases. This fungus mainly lives on roots and other plant parts below the soil surface. [6]. Most of these other pathogenic fungi. They may possess the ability to produce reproductive units in large numbers and the capacity to withstand unfavorable conditions. [17]



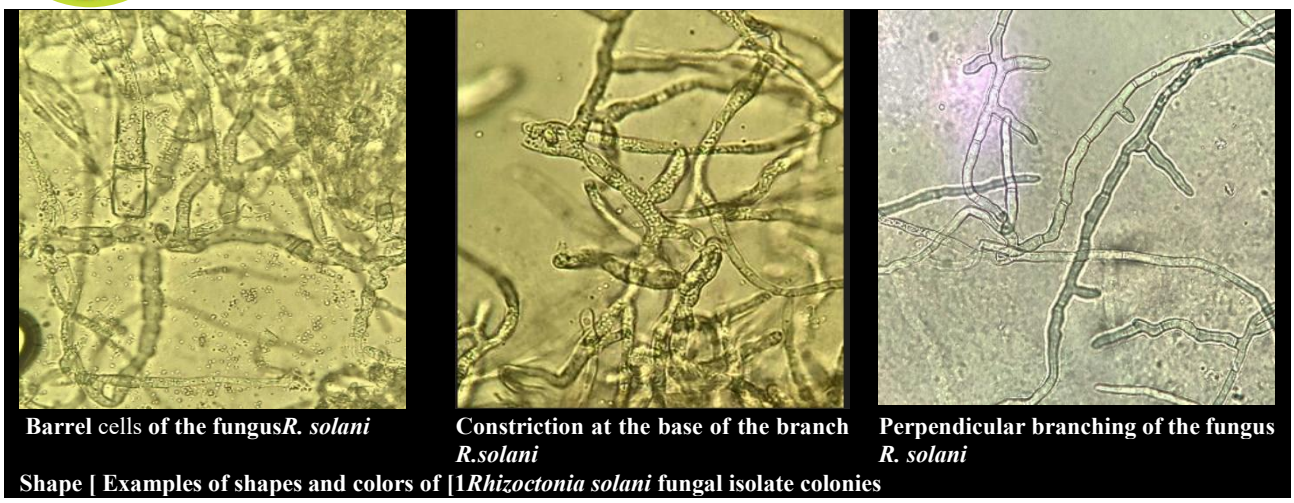


Figure (1): Cultural and microscopic characterizations of *R. solani* isolates

The results of the laboratory examinationv (Figure 1)showed that all 38 isolates
: obtained shared the following characteristics

The results of the laboratory examination Figure 1 showed that all 38 isolates obtained shared the following characteristics :

1 - Branching near the terminal septum of cells in young fungal mycelium.
2 - Branches narrow, and septa form near the point of branch origin.
3 - The appearance of a shade of brown.

These are the basic, constant characteristics that distinguish *R. solani* All isolates were characterized by rapid growth on PDA culture medium and had a color ranging from light to dark brown. All isolates formed thick-walled sclerotia. The sclerotia varied widely in shape and size and were brown in color.

Some isolates also formed barrel cells, with variations in width and length depending on isolate type. The results also showed variation in colony color. Fourteen isolates formed light brown colonies, while 13 formed dark brown colonies, and 11 formed light brown colonies in the early stages of growth, which then turned dark brown.

Detection of pathogenic *R. solani* isolates using plastic pots

The results Table 5 showed that all tested isolates reduced germination percentage. The seeds showed that the percentage of germination inhibition ranged from 12% to 100%, while in the control treatment it was 0.00%. The isolates R2K1 , R2K12, R1K13 , and R2K15 completely prevented germination, and the germination rate in their respective treatments was 0.0%. All isolates were re-isolated from the rotten seeds in pure culture by culturing them on PDA medium under laboratory conditions, in accordance with Koch's postulates. The difference in seed germination percentage between the isolates may be attributed to genetic differences among fungal strains. The samples were collected from different regions, and 10 highly virulent fungal isolates, each representing a specific plant family Table 5, were selected for use in subsequent field experiments. These results agree with those found in [18] . Or perhaps the difference in the isolates ' ability to secrete the enzymes that degrade pectin and cellulose

in the early stages of infection is due to their role in host penetration, including pectinase, pectin methylesterase, pectin lyase, cellulase, and Phosphatase, which has a major effect on fungal pathogenesis [12] .

Table (5) Pathogenicity of *R. solani* isolates

T	Sample code	plant family	Plant type	percentage to inhibit seed % germination		
				First isolation R1	Second isolation R2	Third isolation R3
1	1K	The lottery	The choice	%75	%100	%42
2	2K	oral	basil	%36	%42	%65
3	3K	bakery	Okra	%26	%32	%22
4	7K	almond	Rose enamel	%28	%12	%16
5	9K	Vineyards	grapes	%34	%23	%70
6	10K	eggplant	Tomato	%90	%12	%34
7	11K	legumes	The jet	%93	%45	%65
8	12K	Crusader	Radish	%54	%100	%23
9	13K	grass	barley	%67	%43	%100
10	14K	tent	celery	%54	%43	%75
11	15K	lily	onions	%23	%23	%100
12	16K	Qatifiyah	Chard	%65	%95	%65

Studying the family range of*R. solani* Dispersed families fungal isolates using and the possibility of diagnosing cytoplasmic fusion clusters

The results are shown in Tables 6-7. Figure (2-12)shows the variation in the infection rates of R. solani fungal isolates on different plant hosts. Isolate R2K1, from the family Cucurbitaceae, caused severe infection in all plants, with a 100% inhibition rate and a 100% infection rate. Other isolates varied in their levels of infection across different plant species, such as tomatoes , cucumbers, radishes, basil, grapes, alfalfa, onions, spinach, barley, celery, and chard. Isolates belonging to this group have a severe effect on vegetative shoots, causing root damage and seedling damping - off in many plants. Due to this specialization in infecting or not infecting plant hosts, these isolates belong to different cytoplasmic fusion groups. [12]

Table (6): Percentage of germination under the influence of different pathogenic fungal isolates

T	symbol of isolation	Cucumber initiatives	basil seedlings	grape seedlings	Initiatives Tomato	Jet initiatives	Radish seedlings	barley seedlings	Celery seedlings	Spinach seedlings	Impact rate Isolates on
1	Control Without the nurse	88.88	100.0	60.66	88.88	100.0	80.00	100.0	60.00	100.0	86.49
2	R2K1 The pumpkin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	R1K2 Oral	66.66	60.00	13.33	40.00	46.66	100.0	88.88	46.66	76.66	59.87
4	R1K9 Al Karmiya	66.66	66.66	0.00	53.33	80.00	100.0	88.88	26.66	100.0	64.69
5	R3K10 The Eggplant	77.77	66.66	26.66	13.33	80.00	93.33	77.77	33.33	33.33	55.80
6	R3K11 Legumes	55.55	53.33	26.66	6.66	20.00	88.88	88.88	40.00	63.33	49.25
7	R2K12 Crusades	77.77	30.00	26.66	16.66	80.00	0.00	100.0	0.00	76.66	45.31
8	R1K13 Al Najalia	77.77	63.33	13.33	23.33	86.66	73.33	0.00	0.00	100.0	48.64
9	R1K14 Al Khaymiya	55.55	66.66	13.33	30.00	39.33	100.0	100.0	20.00	96.66	57.95
10	R2K16 Al Qatifiyah	33.33	100.0	13.33	0.00	73.33	73.33	100.0	6.669	6.66	45.18
11	R2K15 The Lily	66.66	76.66	13.33	23.33	86.66	73.33	100.0	6.66	73.33	57.77
Plant species sensitivity rate		60.60	62.12	18.84	26.87	62.97	71.11	76.76	21.82	66.06	

- **... Each number represents the average of three times the number of**

Table (7) Percentage of infection caused by different pathogenic fungal isolates

T	symbol of isolation	Cucumber initiatives	basil seedlings	grape seedlings	Initiatives Tomato	Jet initiatives	Radish seedlings	barley seedlings	Celery seedlings	Spinach seedlings	rate Impact isolation
1	Control Without the nurse	0	0	0	0	0	0	0	0	0	0
2	R2K1 The lottery	100	100	100	100	100	100	100	100	100	100
3	R1K2 Oral	33.33	40	46.66	60	53.33	0	11.22	53.33	23.33	35.69
4	R1K9 Karmiya	33.33	33.33	53.33	46.66	20	0	11.22	73.33	0	30.13
5	R3K10 Eggplant	22.33	33.33	73.33	86.66	20	6.66	22.33	66.66	66.66	44.22
6	R3K11 Legumes	44.44	46.66	33.33	93.33	80	6.33	11.11	60	36.66	45.76
7	R2K12 Crusades	22.22	70	33.33	83.33	20	100	0	100	33.33	51.36
8	R1K13 Grass	22.22	36.66	23.33	76.66	13.33	36.66	100	100	0	45.43
9	R1K14 The tent	44.44	33.33	13.33	70	60.66	0	0	80	3.33	33.90
10	R2K16 Qatifiyah	66.66	0	6.33	100	26.66	26.66	0	3.33	93.33	35.89
11	R2K15 Lily	33.33	23.33	13.33	76.66	13.33	26.66	0	93.33	26.66	34.07
Final rate plant species sensitivity		38.39	37.88	36.03	72.12	37.03	27.54	23.26	66.36	34.85	

The agricultural soils in the Al-Sharia area of Karbala Governorate are contaminated with numerous pathogenic fungi, which are dangerous to crops, as a number of them were isolated and identified, belonging to six genera of roots and stem bases of different plants, namely *Rhizoctonia sp.*, *Alternaria* sp , *Aspergillus* spp , *Fusarium* spp , *Macrophomina* sp , *and Colletotrichum* spp..

It was found that the dominance of the fungus *Rhizoctonia sp* among the isolated fungi Its occurrence rate in the samples reached 85 % , with a frequency rate of 47.3%. % . It was isolated from the roots and stems of a large group of plants belonging to more than ten plant families.

Furthermore, all tested isolates of the fungus Rhizoctonia sp. showed high pathogenicity. This resulted in a decrease in the percentage of seed germination. The percentage of germination inhibition ranged from 12-100%, while in the control treatment it was 0.00%, and some germination was completely prevented.

References

1) Ogoshi , A. (1996). Introduction - the genus Rhizoctonia. In. Rhizoctonia species :taxonomy, molecular biology, ecology, pathology and disease control. Eds .Sneh B, Jabaji -Hare S, Neate S and Dijst G. Kluwer Academic Publishers, The Netherlands . pp. 1-9 .
2) Kareem, TA and Hassan, MS (2013). Molecular characterization of Rhizoctonia solani isolated from pepper plants in Iraq by using PCR. Diyala Agricultural Sciences Journal, 5(2): 45-54 .
3) Rehman,S . ; Rubina, L.; R.; Ebnezer J.; Kumar, E , J , and Badri., Z A., (2012) Comparative efficacy of Trichoderma viride, T. harzianum and Carbendazim Damping-off and Root rot of tomato with Trichoderma spp. and Calcium Chloride or Silicon. Kamphaeng Saen Academy. Journal.3(1),18-2\
4) Yarmeeva , MM, Kokaeva , LY, Chudinova , EM, Kah, MO, Kurchaev , ML, Zeyruk , VN, ... & Elansky , SN (2021). Anastomosis groups and sensitivity to fungicides of Rhizoctonia solani strains isolated from potatoes in Russia. *Journal of Plant Diseases and Protection* , *128* (5), 1253-1261.
5) Woodhall , J. W., Brown, L., Harrington, M., Murdock, M., Pizolotto , C. A., Wharton, P. S., & Duellman, K. (2022). Anastomosis groups of Rhizoctonia solani and binucleate Rhizoctonia associated with potatoes in Idaho. *Plant Disease* , *106* (12), 3127-3132.
6) Rashid , O., Abdullah, S.N.A., Alsultan, W., Misawa, T., Ahmad, K., & Kutawa , A.B. (2021). Characterization of inter and intra anastomosis group of Rhizoctonia spp. isolated from different crops in Peninsular Malaysia. *Tropical Plant Pathology* , *46* (4), 422-434.
7) Naqvi , S.A.H., Abbas, A., Farhan, M., Kiran, R., Hassan, Z., Mehmood, Y., ... & Baloch, F.S. (2024). Unveiling the genetic tapestry: exploring Rhizoctonia solani AG-3 anastomosis groups in potato crops across borders. *Plants* , *13* (5), 715
8) Nasraoui B. (2016). The champignons and pseudochampignons Pathogens of cultivated plants : Biology , New System , Pathological Interaction (Pathogenic fungi

and pseudo-fungi of cultivated plants: Biology, New systematic, Pathological interaction). Editions Universitaires Europe , Germany, 198 pp.

9) Blazier, S. R. and K. E. Conway. (2004). Characterization of Rhizoctonia solani isolates associated with patch diseases on turf grass. Proceeding of the Oklahoma Academy of Science, 84: 41-51 .

10) Howard, F. S. and D. H. Gent. (2007). Damping off and seedling blight. Pages 1-4. Available on internet: https://bugwoodcloud.org/bugwoodwiki / DampingOff SeedlingBlight-EggplantPepperTomato.pdf

11) Nandeesha , C. V., Nandeesha , K. L., & Bhaliya , C. M. (2021). Evolutionary biology and interaction among the anastomosis groups of Rhizoctonia spp. Journal of Pharmacognosy and Phytochemistry , 10 (2), 461-466.

12) López-Corrales , R., Michereff , S. J., García-Estrada, R. S., Correia, K. C., Mora-Romero, G. A., León-Félix, J., & Tovar-Pedraza, J. M. (2024). Diversity and pathogenicity of anastomosis groups of Rhizoctonia solani isolates associated with potato diseases in northern Sinaloa, Mexico. Potato Research , 67 (3), 1011-1026.

13) Carling, D. E., R. E. Baird, R. D. Gitaitis , K. A. Brainard, and S. Kuninaga . (2002). Characterization of AG-13, a newly reported anastomosis group of Rhizoctonia solani . Phytopathology, 92: 893-899.

14) Weinhold, A. R. and J. B. Sinclair. (1996). Rhizoctonia solani : penetration, colonization and host response. Pages 163-175. In: Rhizoctonia Species: Taxonomy, Molecular Biology, Ecology, Pathology and Disease Control. B. Senh , S. Jabaji -Hare, S. Neate and G. Dijst (eds). Kluwer Academic Publishers, Dordrecht.

15) Perl-Treves, R.; Foley, R. C.; Chen, W. and Singh, K. B. (2004). Early induction of the Arabidopsis GSTF 8 promoter by specific strains of the fungal pathogen Rhizoctonia Solani . MPMI. 1(17): 70-80 .

16) Lin, R., Xia, Y., Liu, Y., Zhang, D., Xiang, X., Niu, X., ... & Zheng, A. (2021). Comparative mitogenomic analysis and the evolution of Rhizoctonia solani anastomosis groups. Frontiers in Microbiology , 12 , 707281

17) Johnk JS, Jones RK (2001) Differentiation of three homogeneous groups of rhizoctonia solani anastomosis group 4 by analysis of fatty acids. Phytopathology 91:821–83

18) Aydın, M. H., & Ünal, F. (2021). Anastomosis groups and pathogenicity of Rhizoctonia solani Kühn isolates obtained from pistachio (Pistacia vera L.) saplings in Siirt province, Turkey. Turkey Tarımsal Araştırmalar Dergisi , 8 (1), 18-26 .