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EFFECT OF SELENIUM AND MANGANESE OXIDE AND THEIR COMBINATION IN INDUCING RESISTANCE IN PEPPER PLANTS INFECTED WITH PATHOGENIC FUNGUS *FUSARIUM SPP.*

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ABSTRACT

This experiment was conducted in a greenhouse belonging to the Department of Plant Protection, College of Agricultural Engineering Sciences, University of Baghdad - Jadiriyah during the 2023-2024 growing season. The aim was to study the effect of selenium and manganese oxide in inducing resistance in pepper plants (*Capsicum annuum*) against the pathogenic fungus *Fusarium solani* while enhancing certain growth parameters. The results revealed that applying these elements in combination at the optimal concentration of 200 mg/L inhibited fungal growth in vitro by 77.71% compared to the pathogenic fungus control, which showed 0% inhibition. This treatment also improved growth parameters such as plant height, fresh weight, and dry weight in pot experiments. Moreover, it reduced disease severity and infection rate in both pot and field experiments, in addition to enhancing the activity of enzymes such as peroxidase, Phenylalanine ammonia-layse (PAL), and catalase in pepper plants under field conditions.

Key words: **Se, Mno$_2$, *F. solani*, *Capsicum annuum*.**

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INTRODUCTION

The pepper plant (*Capsicum annuum* L.) is one of the economically significant main crops, rich in various vitamins, minerals, carbohydrates, and other nutrients. It is cultivated in several countries worldwide and belongs to the Solanaceae family (Ismail *et al.,* 2011). Pepper plants are affected by several soil-borne pathogens, the most notable of which are those causing wilt and seedling damping-off (Al-aamel & Al-maliky, 2023). Various factors contribute to wilt in peppers, leading to significant losses, including the pathogen *Fusarium spp.* (Al-Rubaie, 2022). Among the primary causes of wilt and root rot diseases affecting numerous crops are the fungus *Fusarium solani* (Avery *et al.,* 2019). Abiotic elements can be utilized to control certain pathogens and enhance plant resistance, thereby mitigating the negative environmental impacts of chemical pesticides (Hatem & Ali, 2023). Selenium is an essential micronutrient for plants, known to enhance their resistance to various environmental stresses such as drought, salinity, high temperatures, and bacterial and fungal pathogens. It also boosts the activity of antioxidant enzymes in plants (Schiavon *et al.,* 2017). Selenium can be applied to plants through various methods, including soil application (Hussein *et al.*, 2019). Studies have demonstrated that selenium application promotes plant growth and productivity (Bano *et al.,* 2021). Research has shown that selenium at a concentration of 20 mg/kg inhibited the growth of *F. proliferatum* isolated from rice in vitro (Troni *et al.*, 2021). Additionally, a study revealed that selenium in the form of sodium selenate at a concentration of 120 ppm reduced the growth of *Fusarium spp.* by 87.14% (Özer *et al.* 2024). Manganese is an essential element in plant fertilization, enhancing plant nutrition, photosynthetic efficiency, and crop productivity (Mousavi *et*

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al., 2007). A study demonstrated that manganese oxide improved grain production through foliar spraying (3.74 mg ha^{-1}) and seed soaking (3.57 mg ha^{-1}), showing effectiveness in increasing productivity and biological fortification of bread wheat grains in alkaline soils (Ullah *et al.*, 2018). Increasing manganese levels in the soil stimulates plant growth and reduces the impact of root pathogens due to its significant role in enzyme-catalyzed reactions (Schmidt & Husted, 2019). Given the severe damage caused by seed rot and seedling damping-off diseases to pepper seedlings worldwide, this study aimed to induce systemic resistance in plants against damping-off disease using environmentally safe substances to mitigate disease risks and reduce associated losses. This was achieved by applying selenium and manganese oxide individually or in combination to combat the pathogen and enhance certain growth parameters. The study also aimed to analyze the biochemical reactions by measuring the activity of enzymes such as PAL (Phenylalanine ammonia-lyase), peroxidase, and catalase in plants.

MATERIALS AND METHODS

1. Testing the Effect of Selenium and Manganese Oxide at Three Concentrations on the Inhibition of *Fusarium solani* Growth In Vitro: Three concentrations of selenium and manganese oxide (100, 150, and 200 mg/L) were tested, both individually and in combination, against *Fusarium solani*, which had been morphologically and molecularly identified. The optimal concentration was selected for subsequent experiments. These concentrations were applied to PDA (Potato Dextrose Agar) medium in three 9 cm Petri dishes for each treatment. The center of each dish was inoculated with a 0.5 cm diameter disc of *F. solani* mycelium from a 6-day-old culture. The control treatment consisted of PDA medium inoculated with the pathogenic fungus disc without any additives. The plates were incubated at 25 ± 2°C, and after six days, the percentage of fungal inhibition was calculated using the following formula (Kim *et al.*, 2012):

$$\text{Inhibition Percentage} = \frac{\text{Mean Colony Diameter in Control} - \text{Mean Colony Diameter in Treatment}}{\text{Mean Colony Diameter in Control}} \times 100$$

2. Testing the Susceptibility of Pepper Cultivars to *Fusarium solani* Infection:
This experiment was conducted in the greenhouse of the Department of Plant Protection, College of Agricultural Engineering Sciences, University of Baghdad. The susceptibility of three pepper cultivars (Charisma, King Green, and Key Man) to the pathogenic fungus *F. solani* was tested. The cultivars were planted in 2 kg sterilized pots containing a sterile soil mixture combined with peat moss in a 2:1 (w/w) ratio. The pathogenic fungus inoculum was applied to the pots (50 mL per pot) at a concentration of 1×10^6 spores ml^{-1}. Five 40-day-old pepper seedlings were transplanted into each pot. After 30 days, the infection rate was calculated using the following formula:

$$\text{Infection Percentage} = \frac{\text{Number of Infected Plants}}{\text{Total Number of Plants}} \times 100$$

The severity of infection was evaluated using a 5-grade disease index, adapted slightly from Sun et al. (24), as follows:

0 = Healthy plant with no symptoms.
1 = Less than 25% of the roots showing light brown discoloration.
2 = 25–50% of the roots showing dark brown discoloration.
3 = 50–75% of the roots showing dark brown discoloration, including discoloration of the crown area.
4 = 75–100% of the roots showing dark brown discoloration, with crown discoloration and complete plant death.

The percentage of infection severity was calculated using McKinney's formula:

$$\text{Infection Severity Percentage} = \frac{= \sum(\text{Disease Grade} \times \text{Number of Plants in Grade})}{\text{Maximum Disease Grade x Total Number of Examined Plants}} \times 100$$

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3. Evaluation of the efficiency of the optimal concentration of materials in greenhouse pot experiments: This experiment was conducted in the greenhouse of the Department of Plant Protection, College of Agricultural Engineering Sciences, University of Baghdad. A mixture of soil was sterilized using an autoclave at a temperature of 121°C and a pressure of 1.5 kg cm^{-2} for 20 minutes, repeated twice with a 48 hour interval between sterilizations. The sterilized soil was mixed with peat moss in a 2:1 ratio (w/w) and placed in 1 kg pots. The pots were planted with seeds of the pepper cultivar Charisma, which was identified as the most susceptible to infection by the pathogenic fungus *F. solani*. Three seeds were sown per pot. Treatments were applied to the soil, and three days later, the fungal inoculum was added at a concentration of 1×10^6 spores ml^{-1}, except for the control treatments, which received only distilled water without the fungus. The most effective concentration identified in the in vitro inhibition experiments (200 mg L^{-1}) was used. The materials were applied at a volume of 30 ml per pot. After 30 days of adding the fungal inoculum, plant height, fresh weight, dry weight, and the percentage and severity of infection were measured (Table 1).

Table 1. Treatments used in pot experiments and their concentrations

No.	Treatment	Additive material Conc. mg l^{-1}
1	Control (Plant only)	0
2	Control (Pathogenic fungus only)	0
3	Fungus + Selenium	200
4	Fungus + Manganese Oxide	200
5	Fungus + Selenium + Manganese Oxide	100+100
6	Selenium	200
7	Manganese Oxide	200
8	Selenium + Manganese Oxide	100+100
9	Chemical pesticide Uniform	2.5

4. Evaluation of the efficiency of the best treatments in field pot experiments:
Six treatments were selected from the pot experiments that demonstrated effectiveness in controlling *F. solani* infection in pepper plants. The field experiment was conducted in one of the greenhouses of the Plant Protection Department of the College of Agricultural Engineering Sciences, University of Baghdad, Jadiriyah, during the 2023 winter growing season. The land was plowed, finely tilled, and divided into five blocks with furrows, maintaining a distance of 100 cm between each furrow. The experiment followed a randomized complete block design (RCBD) with three replicates per treatment. Pepper seedlings with three true leaves were planted at 40 cm intervals. A 3 cm diameter circle, 10 cm deep, was created around each seedling, into which 100 mL of the treatments were applied, except for the control treatments (with and without the fungus). The treatments were applied at a concentration of 200 mg L^{-1}. Three days after treatment application, fungal inoculum (spore suspension) was added to the circles around the seedlings at a concentration of 1×10^6 spores ml^{-1}, with 50 mL of the suspension applied per seedling. For the control treatment, only sterile distilled water was added without the pathogenic fungus. The treatments used in the experiment are detailed in Table (2).

Table 2. Treatments used in field experiments and their concentrations

No.	Treatment	Conc. mg l^{-1}
1	Control (Plant)	0
2	Control (*Fusarium solani*)	0
3	Se + *F. solani*	200
4	MnO_2 + *F. solani*	200
5	MnO_2 + Se + *F. solani*	100+100
6	Uniform + *F. solani*	2.5

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5. Evaluation of the materials' effectiveness on enzyme activity in plants: The activity of the enzymes PAL (Phenylalanine Ammonia-Lyase), Peroxidase, and Catalase was assessed in the laboratory of the Environmental and Water Directorate, Ministry of Science and Technology. Pepper leaves were collected 7, 14, and 21 days after the treatments were applied. The third leaf from the growing apex of 10 plants per replicate was sampled, placed in polyethylene bags, stored in a cooled container, and transported to the laboratory. The enzymes were analyzed according to standard laboratory procedures. Peroxidase activity was determined following the methods of Al-Sufi (2001) and Hamid (2002). PAL activity was measured using the method described by Al-Jarrah (2011), while catalase activity was assessed based on the method of Kato and Shimizu.

Calculation of infection percentage and severity: Five plants were randomly uprooted from each replicate after 60 days to calculate the infection severity. The roots were thoroughly washed with running water and dried. The infection percentage and severity were calculated as described in section (2).

6. Statistical analysis: Statistical analysis was conducted using GenStat program, using the completely randomized design (CRD) in the laboratory and greenhouse experiment, while using the completely randomized block design (RCBD) in implementing the plastic house experiment. The averages were compared according to the least significant difference (LSD) at the probability level (0.05).

RESULTS AND DISCUSSION

1. The effect of selenium and manganese oxide on the inhibition of *F. solani* growth in vitro: The results, as shown in Table (3), indicate that the combined treatments of selenium and manganese oxide at a concentration of 200 mg L^{-1} provided the best inhibition of the pathogenic fungus *F. solani*. The percentage of inhibition in the combined treatment (Se + MnO_2 + *F. solani*) at the highest concentration was 77.17%. The treatment with manganese oxide (MnO_2 + *F. solani*) resulted in 75.13% inhibition, while selenium treatment (Se + *F. solani*) achieved 76.43%. The chemical fungicide, used as a comparison, showed the highest inhibition rate of 100%. Based on these results, the concentration of 200 mg L^{-1} was selected as the optimal treatment for application in greenhouse and field experiments (Figure 1). These results align with those reported by Mao *et al.*, (2020), who found that ordinary selenium at a concentration of 20 mg/L inhibited *Fusarium graminearum*, the causal agent of wheat blight. Similarly, selenium at the same concentration inhibited *Fusarium proliferatum* in vitro. Eskandari *et al.*, (2020) also demonstrated that ordinary manganese contributed to reducing cotton plant infections caused by *Fusarium spp.*

Table 3. Effect of different concentrations of selenium and manganese oxide on the inhibition of *F. solani* growth in vitro on PDA medium

No.	Treatment	Concentration mg L^{-1}	Fungus inhibition %
1	Control (*Fusarium solani*)	0	0
2	Se + *F. solani*	100	73.67
3	Se + *F. solani*	150	74.4
4	Se + *F. solani*	200	76.43
5	MnO_2 + *F. solani*	100	73.1
6	MnO_2 + *F. solani*	150	74.4
7	MnO_2 + *F. solani*	200	75.13
8	Se + MnO_2 + *F. solani*	100	73.83
9	Se + MnO_2 + *F. solani*	150	74.97
10	Se + MnO_2 + *F. solani*	200	77.17
11	Uniform + *F. solani*	2.5	100
	$LSD_{0.05}$		1.237

Each number in the table represents the mean of 3 replicates.

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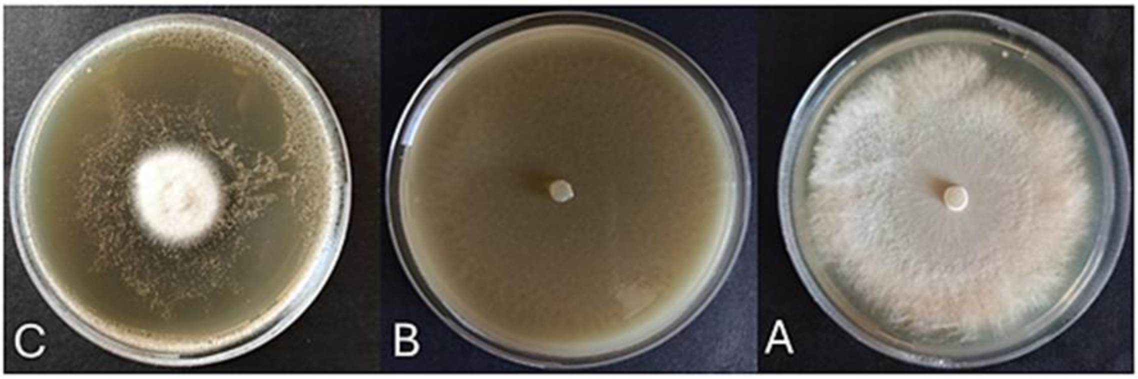

Figure 1. inhibition zone treatment: A: *Fusarium solani*, B: Chemical Fungicide Uniform, C: Combined Treatment at 200 mg/L

2. Testing the Susceptibility of Pepper Cultivars to *F. solani* Infection: The results for the infection percentage and severity caused by the fungal pathogen on three pepper cultivars indicated that the cultivar Charisma was significantly more susceptible than the other cultivars. The infection severity for Charisma was 84.6%, showing a substantial difference. On the other hand, the cultivars Key Man and King Green did not exhibit a significant difference in infection severity, which was 41.7% and 35.4%, respectively. However, the infection percentage was uniform across all cultivars, at 100%, as shown in Table (4). Therefore, the Charisma cultivar was selected for use in subsequent experiments.

Table 4. Susceptibility of some pepper cultivars to the pathogenic fungus *F. solani*

No.	Cultivars	Infection severity	Infection percentage
1	Charisma CA	84.6	100
2	King Green KG	35.4	100
3	Key Man KM	41.7	100
	L.S. $D_{0.05}$	12.49	

Each number in the table represents the mean of 3 replicates

3. Evaluation of the efficiency of the optimal concentration of materials in greenhouse pot experiments: The results of adding the optimal concentration of materials in the pot experiments demonstrated a significant improvement in several growth parameters. The plant height measurements showed that all treatments exhibited significant differences compared to the control treatments (plant and *F. solani* only). The highest average plant height was observed in the combined treatment without the fungal pathogen (MnO_2 + Se), with an average height of 32.61 cm. This was followed by the combined treatment with the pathogen (MnO_2 + Se + *F. solani*) and manganese oxide without the pathogen, both with an average height of 31.13 cm, as detailed in Table (5). For fresh weight, all treatments significantly differed from the control treatments. The highest average fresh weight was recorded for the combined treatment without the fungal pathogen (MnO_2 + Se), with an average fresh weight of 12.32 g. Other treatments followed with close averages, as shown in Table (5). For dry weight, the treatments (MnO_2 + Se without the fungal pathogen, Uniform + *F. solani*, and MnO_2 + Se + *F. solani* with the pathogen) showed significant differences compared to the control treatments (plant only and *F. solani* only). Their average dry weights were 4.6 g, 4.33 g, and 4.1 g, respectively. Additionally, all treatments demonstrated significant differences compared to the fungal pathogen control, as shown in Table (5).

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Table 5. Effect of selenium, manganese oxide, and their combination on growth parameters (plant height, fresh weight, and dry weight) of pepper plants under greenhouse conditions (pot experiments)

No.	Treatment	Concentration mg L^{-1}	Plant height cm	Fresh weight gm	Dry weight gm
1	Control (Plant)	0	27.83	8.4	2.67
2	Control (*F. solani*)	0	25.73	5.13	1.67
3	Se + F. s	200	29.2	10.2	3.50
4	Mno_2 + F. s	200	29.86	10.64	3.33
5	Mno_2 + Se + F. s	100+100	31.13	11.26	4.1
6	Se	200	30.53	11.2	3.77
7	Mno_2	200	31.13	11.37	3.93
8	Mno_2 + Se	100+100	32.61	12.32	4.6
9	Uniform + F. s	2.5	30.21	11.03	4.33
	L.S.D $_{0.05}$		0.1666	0.4168	1.424

Each number in the table represents the mean of 3 replicates

The results for infection severity and percentage showed that all treatments had significant differences compared to the fungal pathogen control (*F. solani* only). Treatments without the fungal pathogen performed better due to the absence of the disease-causing agent. Among the treatments with the pathogen, the combined treatment of manganese oxide and selenium with the fungal pathogen (Mno_2 + Se + *F. solani*) achieved the best results, with an average infection severity of 16.7% and an infection percentage of 29.97%. Other treatments followed in performance, as shown in Table (6). The increase in growth parameters in plants can be attributed to the added materials stimulating plant defenses to combat the pathogen, in addition to their inhibitory effect on the pathogenic fungus. These materials also enhanced photosynthesis and improved plant growth parameters (Rashed *et al.*, 2019; El-Ramady *et al.*, 2022; Shahbaz *et al.,* 2023).

Table 6. Effect of Selenium, Manganese Oxide, and their combination on infection severity and percentage in pepper plants under greenhouse conditions (pot experiments)

No.	Treatment	Concentration mg L^{-1}	Infection severity	Infection percent %
1	Control (Plant)	0	0	0
2	Control (*F. solani*)	0	100	100
3	Se + F. s	200	35	56.64
4	MnO_2 + F. s	200	36.7	74
5	MnO_2 + Se + F. s	200	16.7	29.97
6	Se	200	0	0
7	MnO_2	200	0	0
8	MnO_2 + Se	200	0	0
9	Uniform + F. s	2.5	0	0
	L.S.D $_{0.05}$		11.20	5.067

Each number in the table represents the mean of 3 replicates

4-1 Evaluation of the efficiency of the best treatments in field pot experiments:

4-1-1. Effect of induction factors on Peroxidase enzyme activity in pepper plants: The results of peroxidase enzyme activity measurements showed a significant increase in enzyme activity during the second week after treatment with all materials. The three-week average results indicated that the combined treatments with the fungal pathogen and the Uniform fungicide with the pathogen significantly outperformed the control treatments (plant only and *F. solani* only). The combined treatment with the fungal pathogen demonstrated the highest enzyme activity, with a three-week average of 78.4 U/ml, followed by the Uniform fungicide with the pathogen treatment, which had an average of 72.9 U/ml over three weeks. Other treatments did not show significant differences compared to the

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fungal pathogen control, whereas all treatments exhibited significant differences compared to the plant-only control without the fungal pathogen, as shown in Table (7). The enzyme value decreases after a while because the resistance induction does not last for a long time and requires adding materials to the soil again.

Table 7. Effect of selenium, manganese oxide, and their combination on peroxidase enzyme activity in pepper plants in the field

No.	Treatment	Peroxidase Enzyme Activity (U/ml) after 7 Days	Peroxidase Enzyme Activity (U/ml) after 14 Days	Peroxidase Enzyme Activity (U/ml) after 21 Days	Mean
1	Control (Plant)	32.44	33.79	34.33	33.5
2	Control (*F. solani*)	55.50	60.07	51.35	55.6
3	Se + *F. solani*	58.55	64.12	52.18	58.3
4	Mno_2 + *F. solani*	44.23	73.47	64.23	60.6
5	Mno_2 + Se + *F. solani*	75.87	88.36	70.92	78.4
6	Uniform + *F. solani*	71.12	79.28	68.27	72.9
	$L.S.D_{0.05}$	0.686	6.541	1.441	11.35

Each number in the table represents the mean of 3 replicates

4-1-2. Effect of induction factors on Phenylalanine Ammonia-Lyase (PAL) enzyme activity in pepper plants: The results of PAL enzyme activity measurements indicated a significant increase in enzyme activity during the second week after treatment with all materials. The three-week average results showed that the treatments with selenium and the fungal pathogen, as well as the combination of selenium and manganese oxide with the fungal pathogen, had significantly higher enzyme activity compared to the fungal pathogen control. The three-week average enzyme activity for these treatments was 81.41 and 80.76 (U/ml), respectively. Other treatments did not show significant differences compared to the fungal pathogen control, whereas all treatments showed significant differences compared to the plant-only control without the fungal pathogen, as presented in Table (8).

Table 8. Effect of Selenium, Manganese Oxide, and Their Combination on PAL Enzyme Activity in Pepper Plants in the Field

No.	Treatment	PAL Enzyme Activity (U/ml) after 7 Days	PAL Enzyme Activity (U/ml) after 14 Days	PAL Enzyme Activity (U/ml) after 21 Days	Mean
1	Control (Plant)	41.31	44.72	42.48	42.84
2	Control (*F. solani*)	67.64	76.56	53.37	65.86
3	Se + F. s	82.35	91.55	70.32	81.41
4	MnO_2 + F. s	74.46	85.65	62.34	74.15
5	MnO_2 + Se + F. s	84.36	93.46	64.47	80.76
6	Uniform + F. s	66.56	74.55	57.5	66.20
	$L.S.D_{0.05}$	0.3411	1.363	0.4187	8.81

Each number in the table represents the mean of 3 replicates

4-1-3. Effect of induction factors on Catalase enzyme activity in pepper plants: The results of catalase enzyme activity measurements showed an increase in activity during the second week, similar to the previous sections, after treatment with all materials. The three-week average results indicated that the chemical fungicide (Uniform) with the fungal pathogen and the combined treatment of selenium and manganese oxide with the fungal pathogen exhibited significantly higher enzyme activity compared to the untreated control and the fungal pathogen control. The average enzyme activity for these treatments over three weeks was 33.86 and 23.23 U/ml, respectively. All treatments showed significant differences compared to the plant-only control without the fungal pathogen, as shown in Table (9). The increase in enzyme activity can be attributed to the fact that these enzymes are naturally present in plants but are stimulated by external

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factors such as infection by a pathogen, as seen in the fungal pathogen control (Hussein *et al.*, 2019; Khan *et al.*, 2021, Shahbaz *et al.*, 2023). Additionally, the induction materials, including selenium, manganese oxide, and their combination, further stimulated these enzymes. These materials enhanced the plant's defense mechanisms and increased the levels of defensive enzymes such as peroxidase, PAL, and catalase (Schmidt & Husted, 2019).

Table 9. Effect of Selenium, Manganese Oxide, and Their Combination on Catalase Enzyme Activity in Pepper Plants in the Field

No.	Treatment	Catalase Enzyme Activity (U/ml) after 7 Days	Catalase Enzyme Activity (U/ml) after 14 Days	Catalase Enzyme Activity (U/ml) after 21 Days	Mean
1	Control (Plant)	7.46	8.18	8.38	8.01
2	Control (*F. solani*)	13.17	17.2	11.56	13.98
3	Se + F. s	16.27	25.39	11.8	17.82
4	MnO_2 + F. s	14.18	19.21	10.32	14.57
5	MnO_2 + Se + F. s	22.49	27.24	19.96	23.23
6	Uniform + F. s	33.15	37.39	31.04	33.86
	$L.S.D_{0.05}$	0.4941	0.7075	0.6399	4.141

Each number in the table represents the mean of 3 replicates

4-1-4 Calculation of Infection Percentage and Severity: The results of the added treatments on the soil to combat the fungal pathogen *F. solani* showed that the combined treatment of materials with the fungal pathogen and the Uniform fungicide with the fungal pathogen were the most effective in reducing infection severity and percentage. Both treatments achieved infection severity and percentage of (0, 0%), respectively. These were followed by the combined treatment of conventional materials with the fungal pathogen, which resulted in an infection severity and percentage of (10, 36.7%), respectively. Other treatments followed in performance, as shown in Table (10). The reduction in infection severity in the treatments can be attributed to the effects of the added materials and their combinations, as well as the chemical fungicide, on the fungal pathogen and the plant. These factors stimulated the plant to produce enzymes, proteins, and induced resistance, ultimately leading to the death of the pathogen in the Uniform fungicide treatments. Moreover, the other treatments significantly reduced the growth of the pathogen to varying degrees (Eskandari *et al.*, 2020; Troni *et al.*, 2021, Wulandari *et al.*, 2022).

Table 10. Effect of selenium, manganese oxide, and their combination on infection severity and percentage in pepper plants in the field.

No.	Treatment	infection	infection
1	Control (Plant)	0	0
2	Control (*F. solani*)	95	100
3	Se + *F. solani*	16.67	40
4	MnO_2 + *F. solani*	23.33	46.7
5	MnO_2 + Se + *F. solani*	10	36.7
6	Uniform + *F. solani*	0	0
	$L.S.D_{0.05}$	8.79	9.20

Each number in the table represents the mean of 3 replicates

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

AUTHOR/S DECLARATION

We confirm that all Figures and Tables in the manuscript are original to us. Additionally, any Figures and images that do not belong to us have been incorporated with the required permissions for re-publication, which are included with the manuscript.

Author/s signature on Ethical Approval Statement.

Ethical Clearance and Animal welfare

Funds:

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تأثير عنصري السيلينيوم وأوكسيد المنغنيز والخلط بينهما في استحثاث المقاومة في نبات الفلفل المصاب بالفطر الممرض *Fusarium* spp.

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المستخلص

نفذت التجربة في احد البيوت البلاستيكية التابعة لقسم وقاية النبات/ كلية علوم الهندسة الزراعية/ جامعة بغداد- الجادرية في الموسم الزراعي 2023-2024 وذلك لبيان تأثير عنصري السيلينيوم واوكسيد المنغنيز في استحثاث مقاومة نبات الفلفل ضد الفطر الممرض *Fusarium solani* فضلاً عن زيادة بعض معايير النمو في النبات، إذ بينت نتائج التجربة ان إضافة هذه العناصر بخلطها معاً بالتركيز الأفضل 200 ملغم/ لتر أدى الى تثبيط نمو الفطر في المختبر بنسبة 77.71% مقارنة مع معاملة الفطر الممرض فقط والتي بلغت نسبة التثبيط فيها 0%، كما أدت هذه المعاملة الى زيادة بعض معايير النمو (اطوال النبات، الوزن الطري، الوزن الجاف) في تجربة الاصص، كما أدت الى خفض شدة ونسبة الإصابة في تجارب الاصص والتجربة الحقلية، فضلاً عن زيادة الانزيمات (البيروكسديز، PAL، الكاتليز) في نبات الفلفل في الحقل.

الكلمات المفتاحية: **Se، Mno_2، *F. solani*، *Capsicum annuum*.**