https://doi.org/10.48047/AFJBS.6.13.2024.1979-1995

African Journal of Biological Sciences

Effect of some Fungicides on *Fusarium oxysporum* f. sp. *lycoprsici* Colony growth in the laboratory.

Ahmad AL-MOURRH[1], Abdulkreem ALSALMO[2], Salloum MOUSA[1], Khaled AL-TAWEEL[1], and Gökmen KOÇ[2]

1.Faculty of Agricultural Engineering, University of Idlib, Syria.
2. Faculty of Agricultural Engineering, University of Çukurova, Turkey.

Corresponding Author: Ahmed Al-Mourrah

E-mail: ahmad-almourrh@idlib- university.com, *ALSALMO:kremsalmo1@gmail.com, Salloummousa@idlib-university.com, Khalid.Taweel@idlibuniversity.com*

Abstract

Tomatoes (*Solanum lycopersicum* L.) is one of the main crops in Syria. Fusarium wilt disease caused by the fungus *Fusarium oxysporum* f. sp. *lycoprsici* (*Fol*) isolated from local production fields of Syria(Atma), is one of the most important diseases that affect tomato plants. This research aims to isolate the (*Fol*) of infected plants, And test Four fungicides in inhibiting the growth of mycelium of the fungus *Fusarium oxysporum*. (*Fol*) in the laboratory, And det ermine the best fungicide and the best concentration in inhibiting the growth of the fungus colony. The fungicide Bavastin was the best among the fungicides and inhibited the growth of the (*Fol)* fungal colony by 76.71%. with significant differences with the fungicides (Thiophanat, Proficor, and Fosetyl aluminum) whose inhibition rates were (63.29%, 57.53%, and 60.82%) respectively. Without significant differences, it was found that the use of low concentrations of fungicides was less effective in inhibiting the growth of the fungal colony.

Keywords: *Fusarium oxysporum*- Fusarium Wilt of Tomato- Fungicides.

Article History

Volume 6, Issue 13, 2024

Received: 18June 2024

Accepted: 02July 2024

doi:*10.48047/AFJBS.6.13.2024.* 1979-1995

*1.*INTRODUCTION:

Tomatoes (*Solanum lycopersicum* L.) are one of the most consumed and produced vegetables in the world (Al-Maghribi et al.,2016), production of tomatoes reached approximately 189 million tonnes in the world (FAO, 2023). The tomato crop ranks second among the vegetable crops grown in Syria, in addition to the importance of the tomato crop in the areas of fresh consumption and manufacturing.

Tomatoes are affected by several fungal diseases, the most important of which are: *Fusarium oxysporum* f.sp. *lycopersici* (*Fol*) and *Fusarium solani* (Mouhanna et *al*., 2020). (*Fol*) causes tomato crop losses estimated between 10% to50% (Tawil et *al*., 2019), And (Alkbaily et *al*., 2020) reported that infected plants By Fusarium wilt are not able to give production.

This disease is widespread in most tomato-growing areas in the world and causes vascular wilt and root rot (Sidawi et *al*., 2015; Elias and Schneider, 2010). There are three known worldwide strains of the fungus *Fusarium* sp. (Hibar et *al*., 2006; Cai et *al*., 2002; Gupta et *al*., 2010), where the strains differ in their behavior toward the symptoms of Fusarium wilt infection on tomato varieties (Merjan and Aljenabi, 2015). Symptoms on tomato begin with the veins on the outer parts of the leaf becoming transparent, the petioles of the leaves drooping, and then the lower leaves wither, turn yellow, and die (Minshid and Salihy, 2019). The disease may progress and the entire plant dies before it reaches the production stage (Mouhanna et al., 2020). The occurrence of wilting may begin on one side of the plant before it spreads to the entire plant, and when a section is made in the stem of the plant, the discoloration of the xylem vessels is observed in a dark color. This discoloration may extend to a large distance in the stem and is clear in the areas where the leaf petioles connect to the stem (Al-Maghribi et *al*., 2015).

The infection also appears on seedlings, it is causing plants to wilt or die (Srinivas et *al*., 2019). In addition, the fungus can infect the fruits, causing rot and fall, and then contaminate the seeds with the pathogen. This helps to increase the spread of the pathogen (Kazem and Ajnabi, 2013).

During the past decades, systemic chemical fungicides have been used to control the fungus *Fusarium oxysporum* f.sp. *lycopersici* (Song et al., 2004; Patiyal et al., 2020). The disease is considered difficult to control as it is a soil-dwelling disease, but the infection can be reduced by eliminating infected remains and following agricultural rotations (Amir and Alabouvette.1993). In infected lands, sterilization with met hyl bromide gas (Barakat and Al-Masri, 2011), and the cultivation of wilt-resistant tomato variet ies (Ilyaas et *al*., 2020; Okocha et *al*., 2023). is useful in reducing the severity of the infection. And also the use of beneficial bacteria to reduce the incidence of vascular wilt and soil pathogens (Pavlova et *al*., 2020). And the Plants Aquatic Extracts Inhibit Conidial Growth of the Phytopathogenic Fungus (Omer et al.,2023)

For decades, chemical control has succeeded in controlling pests, increasing production, and limiting the spread of pests and their damage to cultivated crops and to pests that infect humans and parasitize them or farm animals. It was and still is the ideal solution to stop the spread of pests and increase production (Tawil et *al*., 2019,

Patiyal et al., 2020). Chemical fungicides remain the best and final solution when all attempts to stop the plant disease fail (Matar, 2012; Petkar et al., 2017).
Many measures can be taken to mitigate its damage in greenhouses and the field, the most important of which is the necessity of combating root-knot nematodes because their presence leads to the entry of the Fusarium fungus into the roots (Khafta, 2019).

(Alkbaily et *al*., 2020) showed that treating the soil with systemic fungicides, like spraying the soil around the plants with these fungicides, such as carbendazim, or watering the plants with them, or with met hyl thiophanate, gave good results in reducing the incidence of disease.

(Amini and Sidovic 2010). treated six fungicides, and the result showed thatthe two fungicides bromuconazole and Prochloraz were Effected the Fusarium wilt.

(Sidawi et *al*., 2015) used a group of compounds extracted from fig leaves, myrtle, and aqueous root extracts of the amaranth plant, which gave promising results for reducing the inoculum density of the *Fol* fungus and reducing the diamet er of the fungal colony in the laboratory experiment.

(Omer et *al*., 2023). found that botanical extracts of *Allium sativum, Ocimum basilicum, Nerium oleander, Melia azedarach,* and *Zingiber officinale* have antifungal properties against *Fusarium oxysporum.* (Matar 2012). found that when irrigating seedling soil with solutions of systemic chemical fungicides: Bavistin (carbendazim 50% WP), Tachigarin 30 L (himexazol 30%), Beltanol SL (chinosol 50%), and the biocide Biocont- Biocont-T WP (*Trichoderma harzianum*) immediately after planting or dipping the seedling roots with fungicide solutions immediately before planting in combating Fusarium wilt disease on tomato plants artificially infected with the pathogenic fungus (*Fusarium oxysporum* f. sp. *lycopersici*). These fungicides have the ability to protect seedlings. Tomatoes are protected from wilt when grown in the greenhouse under natural conditions. The results showed the efficiency of all fungicides used in reducing the incidence of infection, and its severity compared to the control when used by irrigating seedlings or by dipping the roots in fungicide solutions. The fungicide Beltanol outperformed the rest of the tested fungicides, especially when irrigating the soil after planting, as the infection rate reached 26.66%, and its severity reached 22.5%, after 40 days in the 2011 season, followed by the fungicide Buffestin (30%, 26.83%), without significant differences bet ween them, then the biofungicide Biocont-T (36.6%, 27.5%). The fungicide Chagarin was the least effective in protecting tomato seedlings from infection with the disease. No significant differences were observed bet ween the two met hods in the ability of fungicides to reduce The incidence of the disease and its severity.

(Cai et *al*., 2002). noted that both the fungicides chloropicrin and Dichloropropene Telone gave effective results in combating many soil-borne plant diseases, as they can be used as an alternative to met hyl bromide.

(Song et *al*., 2004). noted that tomato wilt disease can be controlled well by low toxicity and systemic fungicides added in the hydroponic system at the appropriate concentration, as seven fungicides were tested: carbendazim, prochloraz, tocloFos-

met hyl, thiram, azoxystrobin, hymexazol, carboxin, in vitro for their inhibitory activities against the pathogen by inhibiting fungal growth with effective concentration values (EC50) of 0.019, 0.235, 26.2, 53.6, 69.9, 144.58, 154.03 micrograms/ml separately. It was found that the fungicides prochloraz and carbendazim They were the most effective fungicides in inhibiting fungal growth. The inhibition rate was 69.6% after adding 0.4 µg/ml of prochloraz to the liquid medium for two weeks, with a therapeutic efficacy of 50.0%. It was also found that the fungicide carbendazim had a preventive effect of 87.0% and a therapeutic effectiveness of 34.4%.

It was also found (Sahar et *al*., 2013). that the fungicide Topsin -M inhibits the growth of (*Fo*l) by 76.66%, followed by difenoconazole 67.50% and Allite 53.50% at 800 ml/L after 9 days of incubation at 25°C. In contrast, the Natavo fungicide is the least effective, with an efficiency rate of 42.40% compared to the untreated control.

Due to the spread of wilt diseases and root rot caused by the fungus *Fusarium* sp. Which caused a loss in yield and production, despite all attempts to reduce the infection of plants by agricultural, mechanical, agricultural quarantine, and even biological met hods, chemical met hods were the last and ideal solution to reduce plant disease infections, and some chemical fungicides were not effective in combating the fungus, so the aim of this research is to test four Fungicides following different chemical groups in the chemical control of the fungus *Fusarium oxysporum*. Det ermine the best fungicide to inhibit the growth of mushroom mycelium in Pet ri dishes in a laboratory experiment, and det ermine the best concentration of the fungicide to inhibit the growth of the fungus colony.

2. MATERIALS AND MET HODS

Table 1. M**aterials used in the research.**

M**aterials**	**Values**
Sterile plastic	9 cm
Cork drill	0.5 cm diameter
Fungicide Bavastin	Carbendazim 50% EC
Thiophanate Methyl	70% WP
Fosetyl Aluminum	80% WP
Fungicide Probamocarb hydrochloride	72% EC
Nutrient culture medium (PDA)	500 mg/liter
Cylinders	250 mm capacity
Microliter pipet	1000 µL

2.1. Method of preparing nutrient medium (PDA) Potato Dextrose Agar

39g of the ready culture PDA was weighed (200 g potato extract, 20 g dextrose, 20 g agar) and according to the manufacturer's recommendations, the nutrient medium was dissolved in 1 liter of sterile, distilled water over low heat. After complete dissolution, it was placed in an autoclave and sterilized at 121 °C for 20 minutes and under pressure 1 bar, after the autoclave had cooled, the antibiotic ampicillin 500 mg per liter was added to the nutrient environment, and the beaker was shaken well to distribute the antibiotic, noting that the temperature of the beaker was approximately

50 degrees Celsius. Then the sterile dishes were poured into the isolation chamber at a rate of 20 ml for each dish with a diameter of 9 cm.

2.2. Collect samples of tomato plants affected by wilt:

Samples of tomato plants apparently infected with wilt were collected from a tomato field in the town (Atma) pointed (36.273447-36.706185), northwest of Aleppo, in the year 2022. The plant samples that showed symptoms of Fusarium wilt were taken to the plant pathology laboratory at the College of Agricultural Engineering at the University of Idlib, and the fungi causing the wilt were isolated. Vascularization of tomato plants from the stem of infected plants.

2.3. **Definite of isolate of the fungus causes wilt:**

The met hod (Kazim and Al-Janabi, 2013; Summerell et *al*., 2003). was adopted in phenotypic and microscopic diagnosis to identify the fungus. This is done by examining the color of the colony, and the speed of the colony's growth, as it was characterized by the cottony growth of the mycelium and the pink color.

The microscopic characteristics of the spores were studied using an optical microscope at several magnification powers (10, 40, and 100), and based on the presence and shape of macroconidia, microconidia, and chlamydospores.

2.4. **Testing the pathogenicity of the fungal isolate.**

2.4.1. **Preparing the fungal inoculum:**

A fungal inoculum was prepared after growing the isolate on PDA nutrient culture medium supplemented with 250 mg/L ampicillin. For 8 days, at 25°C. To prepare the fungal suspension, 20 ml of sterile distilled water was added to a dish covered with *Fol*, and the mycelium and spores were scraped off with a sterile tool to obtain a spore suspension. The conidia were counted and the number was adjusted to 1 x 10^6 spores/ml according to the met hod (Al-Maghrabi et al., 2016).

2.4.2. **Industrial infection procedure:**

Artificial infection was carried out according to the met hod (Murjan and Al-Janabi, 2015). on tomato seedlings (Noorshan variety, which is sensitive to infection).

Tomato seeds were sterilized with a 5% sodium hypochlorite solution for one minute. Then it was washed with sterile distilled water three times, then it was planted in plastic germination trays containing sterile soil and placed in the incubator at a temperature of 25°C until germination, then it was transferred to the greenhouse until it became two weeks old.

When the seedlings at the second true leaf stage, it washed their roots with tap water, then cut the roots with a sterile scalpel, then dipped root in the previously prepared fungal suspension with a concentration of 1 x 10^6 spores/ml to isolate the fungus Fusarium sp. For thirty minutes, as for the control treatment, the roots of the seedlings were cut and immersed in distilled water.

The seedlings were replanted in three-litre plastic pots containing sterilized soil, then the pots were placed in the greenhouse at a temperature of 25°C, with three seedlings per pot and 5 replicates.

2.4.3. **Estimating the incidence rate**

The percentage of infection was calculated using the met hod (Rekah et *al*., 2000). According to the equation:

percentage of Infection = (n× 100) / N

n: the number of infected plants in the treatment.

N: the total number of plants in the treatment.

2.3. Prepare the nutrient culture with fungicides added

2.3. 1. Preparation of Bavastin solution:

The Bavastin solution was prepared by dissolving 250 microliters of the fungicide in 1000 ml of sterile distilled water, resulting in a concentration of 250 microliters per 1000 ml. Subsequently, 25 ml of this solution was added to 225 ml of Potato Dextrose Agar (PDA) to achieve a chemical concentration equivalent to 25 parts per million (ppm) in the nutrient culture. The mixture was then heated until it reached 45°C and left to solidify. Once solidified, a 0.5 cm disk of the *Fol* fungus was placed in the center of the plate, which was then incubated at 22°C for 7 days.

Similarly, Bavastin solutions with concentrations of 500 microliters per 1000 ml and 1000 microliters per 1000 ml were prepared. For each concentration, 25 ml of the solution was added to 225 ml of PDA to achieve chemical concentrations of 50 ppm and 100 ppm, respectively. The plates were then incubated under the same conditions as described above.

2. 3. 2. Preparation of Thiophanat Almet hyl Solution**

The Thiophanat Almet hyl solution was prepared using the same met hod as described for Bavastin. The respective fungicide was dissolved in sterile distilled water to achieve concentrations of 250 mg per 1000 ml, 500 mg per 1000 ml, and 1000 mg per 1000 ml. These solutions were then added to PDA to obtain concentrations equivalent to 25 ppm, 50 ppm, and 100 ppm, respectively. The plates were incubated under the same conditions as described above.

2. 3. 3. Preparation of Proficor-N Solution

Proficor-N solutions were prepared similarly to the Bavastin and Thiophanat Almet hyl solutions. The respective fungicide was dissolved in sterile distilled water to achieve concentrations of 250 microliters per 1000 ml, 500 microliters per 1000 ml, and 1000 microliters per 1000 ml. These solutions were then added to PDA to obtain concentrations equivalent to 25 ppm, 50 ppm, and 100 ppm, respectively. The plates were incubated under the same conditions as described above.

2. 3. 4. Preparation of Fosetyl Aluminum Solution

Fosetyl Aluminum solutions were prepared following the same procedure outlined for the other fungicides. The respective fungicide was dissolved in sterile distilled water to achieve concentrations of 250 mg per 1000 ml, 500 mg per 1000 ml, and 1000 mg per 1000 ml, resulting in chemical concentrations of 25 ppm, 50 ppm, and 100 ppm, respectively. These solutions were added to PDA and incubated as described above.

The same treatment protocol was applied to all fungicides, ensuring uniformity in the experimental procedure.

2. 3.5. Preparation of the control culture solution:

25ml sterile distilled water was added to 225 ml PDA nutrient culture medium and was considered as the control for all treatments.

***2. 4.* Measuring the rate of inhibition of Radial growth of the *Fol* fungal colony in poisoned cultures:**

The diamet er of the growing *(Fol*) fungus colony was measured after 7 days of incubation, where the two perpendicular diamet ers of the colony were measured, and the average colony diamet er of the (*Fol*) fungus was taken.

The percentage of fungal growth inhibition was calculated according to the formula: IG%= (RC-RT) ×100 /RC

IG%: inhibition growth%

RC: Average diameter of the control colony

RT: Average diameter of the treatment

***2. 5.* Experiment design:**

The research was carried out in the plant pathology laboratory at the College of Agriculture at the University of Idlib. The experiment was designed according to a completely randomized design with 5 replicates for each treatment, where 5 Petri dishes were planted for each treatment of fungicides at three different concentrations (250, 500, 1000) microliters.

The results were analyzed with the statistical program Genstat12, and the average diameter of the growing colony of the fungus *(Fol)* was compared with the least significant difference test.

3. RESULTS

3.1. identified the isolate

This isolate was identified as belonging to the fungus *Fusarium oxysporum* f.sp. *lycopersici*. The color of the mycelium was pink, As for the microscopic characteristics, the conidial spores were large, crescent-shaped, and their foot cells resembled a foot (pointed). The spores were divided into three to four transverse septa, in addition to the small conidial spores, which appeared oval-shaped, two-celled, and unicellular, The fungal colonies formed spherical chlamydial spores, single or double, on the tip or middle of the hypha (fig. 1), This is consistent with what was mentioned by (Leslie and Summerell, 2006).

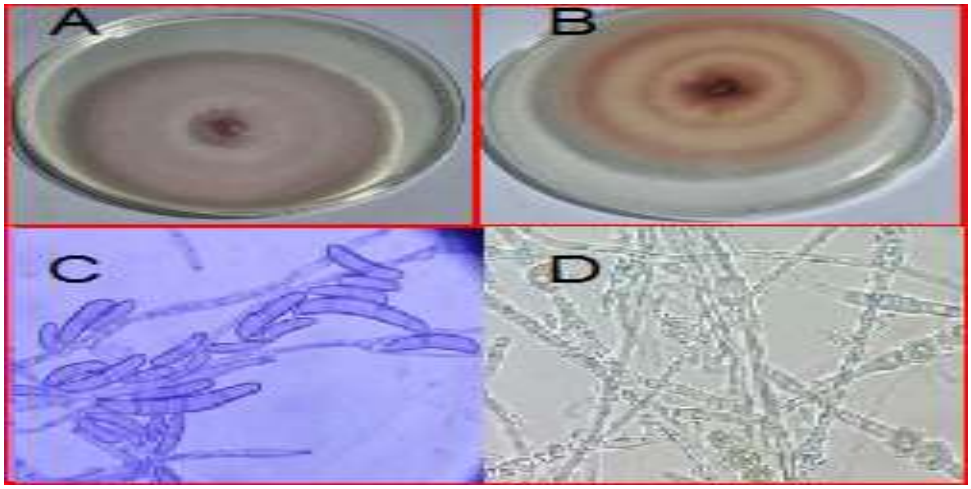

Figure 1. The colony of the fungus. A: upside, B: downside, C: Macroconidia and Microconidia, D: Chlamydospore

This isolation causes vascular wilt of tomato plants, and this is consistent with what was indicated by (Murjan and Al-Janabi, 2015; Srinivas et *al*., 2019). It infects the vessels transporting the shoots and has been isolated from the crown region and the stem of infectious plants, and this is also consistent with (Al-Maghrabi et al., 2016). (Fig. 2)

Figure 2. The crown region and the stem of infectious plants

Symptoms of infection began to appear on the infected seedlings twenty days after the artificial infection and caused the seedlings to die fifty days after the artificial infection. The infection percentage was 78%, And all infected plants died compared to the control. (Fig. 3)

Figure 3. A. control with no infection, B: infected plant with *(Fol)* after 35 days after artificial infection.

In comparison, it was found that these isolates belong to the fungus (*Fol*), a fungus specialized in vascular wilt on tomato plants, and this matches what was found (Al-Maghrabi et al., 2016).

3.2. Percentage of radial growth inhibition of *Fusarium oxysporum* colonies:

3.2.1. Effect of Bavastin after 7 days:

It was found that all treatments of the fungicide Bavastin reduced the diameter growth of the fungal colony *(Fol)*, with high significant differences with the control which the diameter of the colony reached 36.5mm. But without significant differences bet ween them. This is consistent with the manufacturer's recommendations, as Bavastin is used at a rate of 0.5 ml/1 liter of water to combat fungal pests in the field, and the fungicide Bavastin at a concentration of 1 ml inhibited growth. The fungal colony reached 8.8 mm, then a concentration of 0.5 ml reduced growth to 10.3 mm, a minimum concentration of 0.25 ml reduced it to 11.3 mm (Fig. 4)

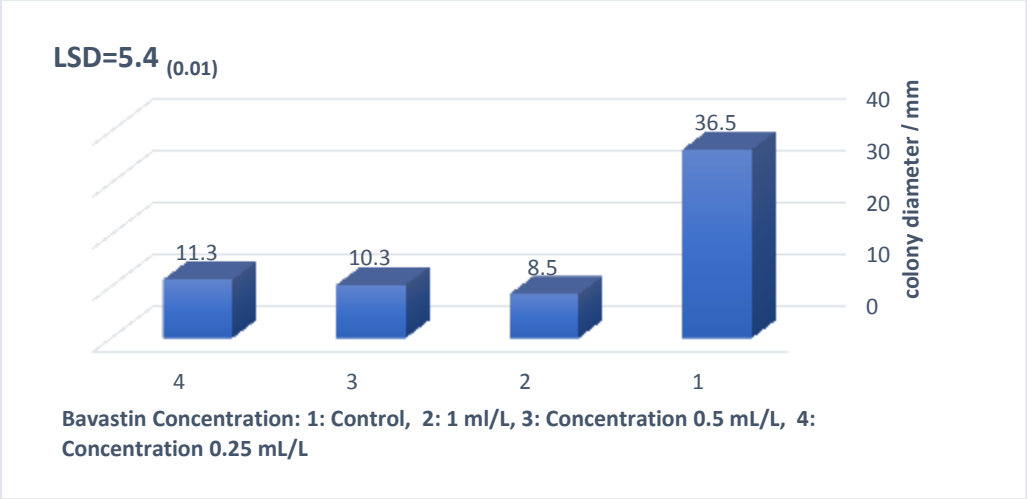

Figure 4. shows the effect of the fungicide Bavastin on the growth of the (*FOl)* colony after 7 days of incubation on the PDA nutrient medium at 22°C.

3.3. Effect of the fungicide Thiophanat Almethyl after 7 days:

It was shown that the fungicide Fosetyl Almethyl has the ability to stop the growth of fungal mycelium and inhibited the growth of the fungal colony by 13.4 for the concentration of 1g/1 liter, with significant differences with the following concentration of 0.5 g/liter, where the average diamet er of the fungal colony (*Fol)* was 19.4 mm, and also with high significant differences compared to the lower concentration. 0.25 g/L, where the average diameter of the fungal colony was 32.8 (Fig. 5)

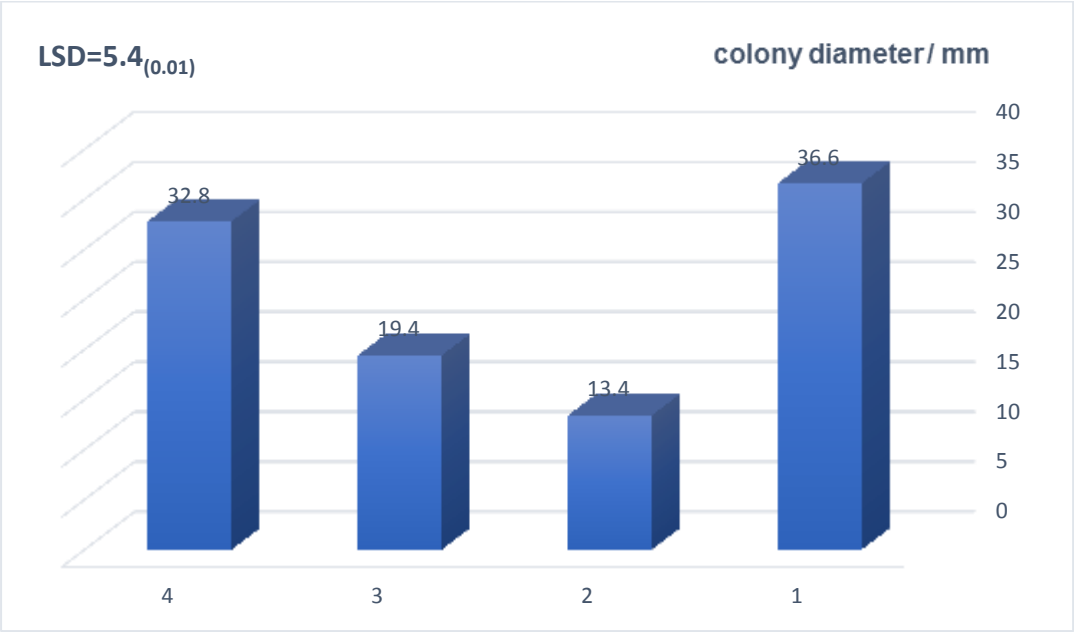

Figure 5. shows the effect of thiophanat met hyl fungicide on the growth of (*Fol*). colony after 7 days of incubation on the PDA nutrient medium at 22°C. 1: Control, 2: Concentration 1 g/L, 3: Concentration 0.5 g/L, 4:Concentration 0.25 g/L.

3.4. Effect of Fosetyl Aluminum fungicide after 7 days:

It was shown that the fungicide Fosetyl Aluminum has the ability to stop the growth of fungal mycelium and inhibited the growth of the fungal colony by 15.5mm at the concentration of 1 ml/1 liter, with significant differences with the following concentration of 0.5 ml/liter, where the average diameter of the fungal colony (*Fol)* was 19.9 mm, and also with highly significant differences compared to the lower concentration. 0.25 ml/liter, as the average diameter of the fungal colony was 29.8mm, which stimulated the growth of the fungal mycelium due to the small concentration in 1 liter, where the control was 36.5 mm, the average diameter of the colony (Fig. 6).

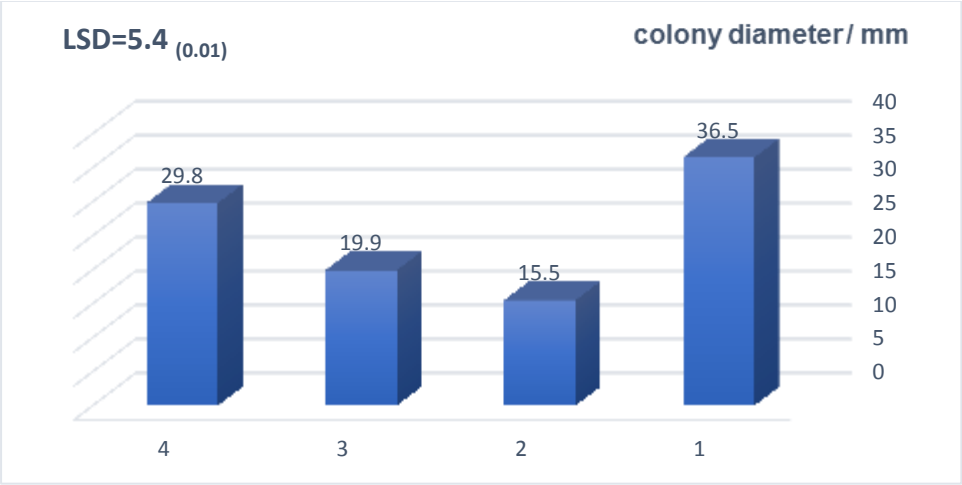

Figure 6. shows the effect of the fungicide Fosetyl Aluminum on the growth of the (*Fol*) fungus colony after 7 days of incubation on the PDA nutrient medium at 22°C. 1: Control, 2: Concentration 1 ml/L, 3: Concentration 0.5 mL/L, 4: Concentration 0.25 mL/L.

3.5. Effect of Proficor N after 7 days

The fungicide Proficor N inhibited the growth of *(Fol)* fungal colonies with significant differences bet ween the control 36.5 mm and the treatments 1 ml/l and 0.5 ml/l, where the average diameters of the two treatments was 14.3 and 18.4 mm, respectively. However, the diameter of the treatment 0.25 ml/L was 33.2mm and there were no significant differences with the control for it. (Fig.7)

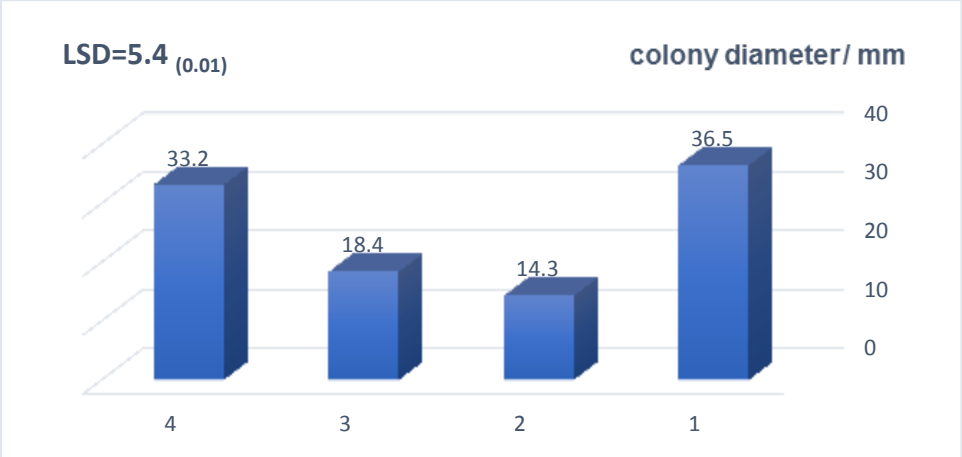

Figure 7. shows the effect of the fungicide Proficor N on the growth of the *Fol* fungal colony after 7 days of incubation on the PDA nutrient medium at 22°C. 1: Control, 2: Concentration 1 ml/L, 3: Concentration 0.5 mL/L, 4: Concentration 0.25 mL/L.

***3.6.* The effect of fungicides on the growth of the mycelium *(Fol)* in the laboratory:**

The average diameters of the colonies for the treatment 100 (mg or ml)/for the fungicides (Fosetyl AL, Proficor, Thiophanat, and Bavastin) compared to the control were as follows (15.5 mm, 14.3 mm, 13.4 mm, 8.5 mm) respectively, and The average diamet ers of the control colonies 36.5 mm, (Fig. 8)

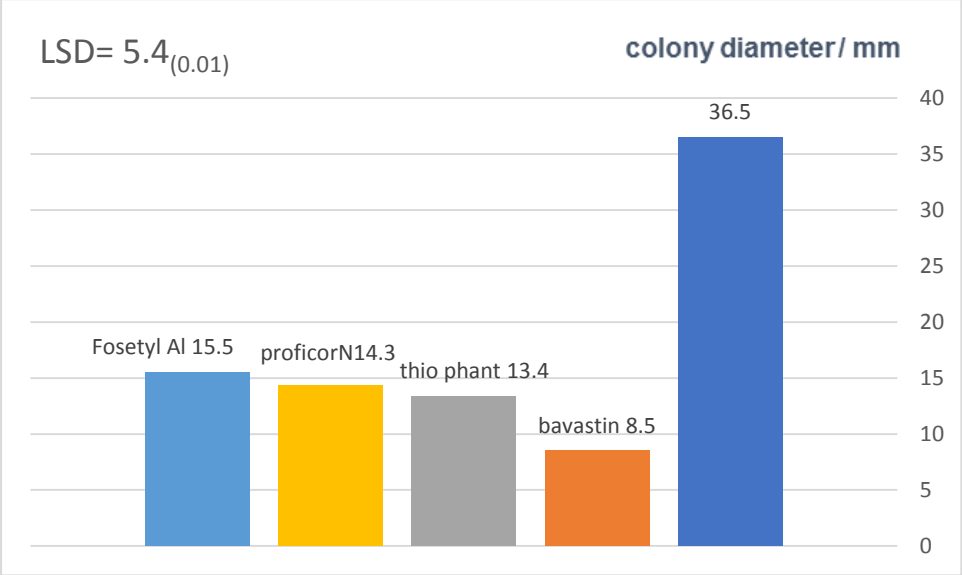

Figure 8. shows the effect of fungicides on the growth of the (*Fol*) fungus colony after 7 days of incubation on the PDA nutrient medium at 22°C.

***3.7.* The effect of fungicides of all concentrations on the growth of the *Fol* fungal mycelium:**

After 7 days of laboratory incubation, the average diameter of the fungal colony grown for control at about 4.6 mm a day, but in treatment still poor growth of about 1-2 mm for concentrations 100 ppm and 50 ppm a day. But the growth of the colony was bet ter in concentration 25ppm and it rashed 3 mm a day except for bavastin which was 1 mm a day, whereas the control growth was 5 mm approximately a day. (Fig. 9)

The average colony diameters for the concentration 50ppm (g or ml)/L treatments were (10.3mm, 18.4mm, 19.4mm, and 19.9mm) respectively for the fungicides (Bavastin, Fosetyl AL, Thiophanat Almethyl, and Proficor N). (Fig. 9)

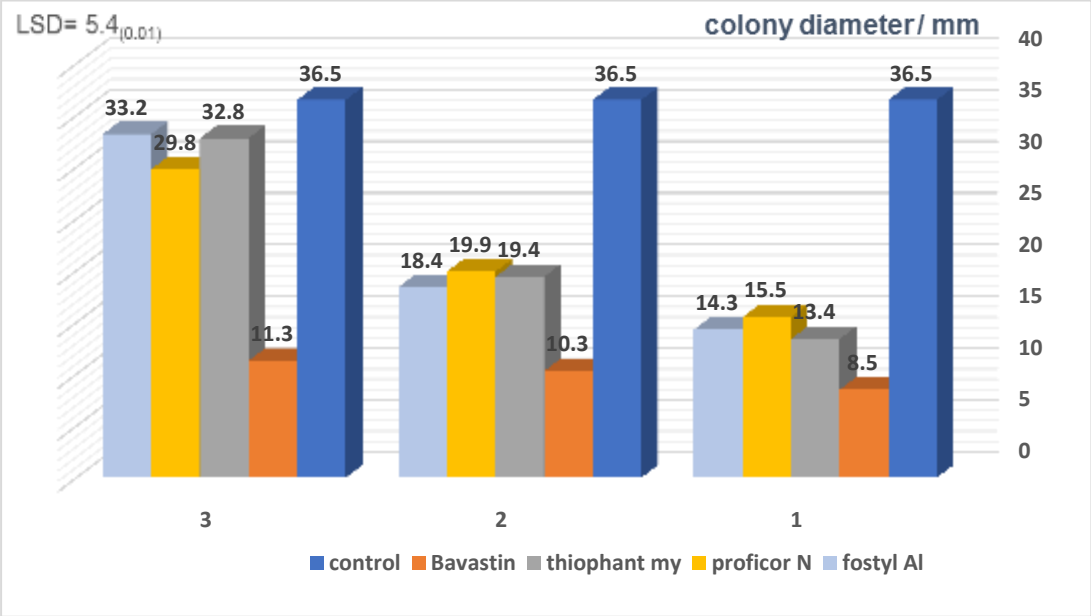

Figure 9. shows the effect of fungicides of all concentrations on the growth of the (*Fol*) fungus colony after 7 days of incubation on the PDA nutrient medium at 22°C.

Whereas The average diameters of the colonies for the concentration 25ppm (g or ml)/L treatments of the fungicides were (11.8mm, 29.8mm, 32.8mm, and 33.2mm) for the treatments (Bavastin, Proficor, Thiophanat, and Fosetyl Al) respectively.

3.8. Percentage of inhibition growth for the four fungicides:

The fungicide Bavastin inhibited (*Fol*) fungal colony growth (76.71% and 71.78%) for concentrating 0.1 ml/L and 0.05 ml/L (similar to Matar, 2012). It was the best among the fungicides, with significant differences from the remaining fungicides and similar to (Song et al., 2004), whose inhibition ranged from 45% to 63% for concentrations 0.5 ml/L and 1ml/L for the fungicides, And this is consistent with (Alkbaily et al., 2020) showed the effectiveness of the fungicide Bavastin and the fungicide thiophanate Almethyl, respectively, Thiophanat, Proficor, and FosetylAL.Without significant differences between them (Table .2)

Table 2. shows the Percentage of inhibition for the four fungicides after 7 days of incubation on the PDA-poisoned nutrient medium.

treatments	concentration	Percentage of inhibition
Control	0	0
Bavastin	100ppm	76.71a*
	50ppm	71.78a
	25ppm	69.04a
Thiophanat almethyl	100ppm	63.29b
	50ppm	46.85c
	25ppm	10.14
Proficor N	100ppm	57.53b
	50ppm	45.48c
	25ppm	18.36d
Fosetyl aluminum	100ppm	60.82b
	50ppm	49.59c
	25ppm	9.04e
		$LSD_{(0.01)}$= 8.7

*: no significant between the same letter.

4. DISCUSSION:

4.1. The fungal isolate

The isolate was identified as belonging to *Fusarium oxysporum* f.sp. *lycopersici*. The mycelium was pink, and the conidial spores were large, crescent-shaped with three to four transverse septa. The small conidial spores appeared oval-shaped and unicellular. The fungal colonies formed spherical chlamydospores, either single or double, at the tip or middle of the hypha. And that goes with (Wang et al., 2020).

This isolate causes vascular wilt in tomato plants. Symptoms of infection appeared 20 days after artificial infection, causing the seedlings to die 50 days later and that goes with (Shanmugam & Kanoujia, 2011).

4.2. Effect of Fungicides on Fungal Colony Growth:

All concentrations of Bavastin significantly reduced the diameter growth of the fungal colony compared to the control. At a concentration of 1 ml/L, the growth was reduced to 8.8 mm, at 0.5 ml/L it was reduced to 10.3 mm, and at 0.25 ml/L it was reduced to 11.3 mm. Goes with (Pant et al., 2020. Sharma & Arun Kumar, 2015).

and the second fungicid was Thiophanat Methyl After 7 Days: effectively inhibited fungal mycelium growth, with the colony diameter at 13.4 mm for 1 g/L, 19.4 mm for 0.5 g/L, and 32.8 mm for 0.25 g/L. Goes with (Petkar et al., 2017)

And the thread fungicide was Effect of Fosetyl Aluminum After 7 Days:

effectively inhibited fungal mycelium growth, with the colony diameter at 15.5 mm for 1 ml/L, 19.9 mm for 0.5 ml/L, and 29.8 mm for 0.25 ml/L, compared to the control at 36.5 mm. Goes with (Aslam et al., 2019).

And the last fungicide was Proficor N After 7 Days:

Proficor N significantly reduced the fungal colony growth. At 1 ml/L, the diameter was 14.3 mm, and at 0.5 ml/L, it was 18.4 mm. There was no significant difference at 0.25 ml/L, with a diameter of 33.2 mm compared to the control.

4.3. Comparison of Fungicide Effects:

Bavastin showed the highest inhibition rate of fungal growth at 76.71% for a concentration of 100 ppm, followed by Thiophanat Methyl at 63.29%, Fosetyl Aluminium at 60.82%, and Proficor N at 57.53%. Lower concentrations showed decreased inhibition rates, with 50 ppm concentrations inhibiting growth between 45% and 71.78%, and 25 ppm concentrations showing significantly lower inhibition.

Based on the results, Bavastin was the most effective in inhibiting the growth of *Fusarium oxysporum* f.sp. *lycopersici* colonies, followed by Thiophanat Methyl, Fosetyl Aluminium, and Proficor N.

4.4. Growth Inhibition Percentages After 15 Days:

After 15 days, the inhibition percentages increased for all fungicides, reflecting their sustained effectiveness over time. These results would provide a comprehensive view of each fungicide's long-term effectiveness in inhibiting fungal growth.

5. CONCLUSIONS

It was found that the best fungicide that inhibited the growth of the fungal colony was the fungicide Bavastin at a concentration of 0.1 ml/liter.

It turns out that high concentrations of the tested fungicides have a clear effect on the growth of the *Fo* fungal mycellium, and low concentrations are never recommended because they become a stimulant for fungal growth, as in the Fostyl Aluminum fungicide.

*6.*ACKNOWLEDGMENT

We extend our thanks to the administration of the College of Agricultural Engineering, to the two Engineers, Fatima Al-Buwaidani and Nour Al-Khatib, and to everyone who contributed to the success of this work.

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