

EFFICACY OF DIFFERENT COMMERCIAL PRODUCTS ON CONTROLLING DATE PALM ROOT ROT UNDER GREENHOUSE CONDITIONS.

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ABSTRACT: Disease incidence and disease severity of date palm root rot were evaluated on cvs. Barhey, Majdol and Zaghloul during 2021 and 2022 growing seasons in different locations. The highest percentages of disease incidence and disease severity were recorded in nursery located at Beheira governorate, where the lowest were recorded from new orchards in Giza and Qaloubiya governorates during 2021. Isolation trials of the naturally infected date palm root rot yielded four fungal species identified as *Fusarium solani*, *F. moniliforme*, *F. semitectum* and *Lasiodiplodia theobromae*. Pathogenicity test showed that all isolated fungi were able to induce root rot on date palm seedlings. The highest average disease severity was obtained from the infection with *F. solani*, followed by *F. moniliforme*. While, little symptoms showed on the roots inoculated by *F. semitectum*. Zaghloul cultivar was more susceptible than Barhey and Majdol under artificial inoculation carried out during the two years of the investigation. Efficacy of Biocontrol T34 12% WP (*Trichoderma asperellum* strain T34), Serenade ASO 1.34% SC, Uniform 39 % SE, Hexaten and Tshgarin 30%SL was evaluated *in vitro* and under greenhouse conditions for controlling root rot of date palm seedlings. Complete reduction in colony growth of the most frequent fungi was observed due to using Uniform 39 % SE, followed by Hexaten and Tshgarin 30%SL. T34 and Serenade ASO 1.34% SC recorded the lowest efficacy. However, under greenhouse conditions Uniform, Tshgarin and Hexaten gave the highest efficacy for controlling date palm root rot on the two cultivars, Barhey and Zaghloul during the two seasons, while the lowest efficacy was recorded after treatment with T34 and Serenade ASO, respectively. The highest values of total phenol in the three tested date palm cultivars were observed in Barhey cv., while the lowest production were recorded in cv. Zaghloul. The highest values of total phenols was observed after using Uniform and Tshgarin, while the lowest levels of total phenols were recorded by using Serenade ASO. The highest values of polyphenoloxidase activity (PPO) were recorded in cv. Barhey. While the lowest were recorded in cv. Zaghloul. The highest values of PPO were observed after treatment with Tshgarin, while the lowest levels were obtained by using Serenade ASO.

Key words: Root rot, *Trichoderma asperellum* T34, Serenade, Tshgarin, Uniform, Hexaten.

INTRODUCTION

Date palm (*Phoenix dactylifera* L.) offshoots and adult trees are liable to attack by a lot of soil-borne pathogenic fungi which causing considerable losses in mass production (Baraka *et al.*, 2011). Rashed, (1991) found that *Lasiodiplodia theobromae* the causal pathogen of deterioration of date palm offshoots in Egypt. Kamhawy *et al.*, (2005) inoculated fifteen isolates of *L. theobromae* on date palm (cv. Zaghloul) offshoot. Fourteen days after inoculation, the fungal hyphae completely colonized the metaxylem. Ziedan *et al.*, (2013) found that several

fungi including *Fusarium oxysporum*, *F. moniliforme*, and *F. semitectum* caused root rot diseases on date palm offshoots in different countries. Ahmed, (2018) found that *Fusarium* species were isolated from date palm seedlings and offshoots. The species were identified as *F. oxysporum*, *F. solani* as well as *Macrophomina phaseolina* and *Rhizoctonia solani*, under greenhouse the pathogenicity test were confirmed on date palm seedlings. In general, disease symptoms appear on the affected seedlings as reduction in vegetative growth. The first symptoms appear as drying of outer leaves. The youngest leaves appeared shorter than the normal

one and sometime malformed. On root system of affected date palm seedlings, the infected root showed dark, necrotic regions and some roots were dead (Rashed *et al.*, 2006). Arafat *et al.*, (2012) evaluated five date palm cultivars against soil borne pathogenic fungi that cause many losses in the offshoots, showed that disease symptoms were observed in all examined cultivars, the most susceptible was cv. Barhey while, Sakkoty was the less susceptible one and the rest cultivars were in between. Okigbo and Osuinde (2003) found that *Bacillus subtilis* isolated from soil can inhibit *L. theobromae* on agar media. Hassan, (2015) evaluated the efficacy of nine different fungicides against *L. theobromae* and *F. moniliforme*. Both Occidor and Antracol gave greater inhibition of mycelium growth. As well as the bio-agents *Trichoderma* spp. and *Bacillus subtilis* were able to antagonize and retard the radial growth of *L. theobromae* and *F. moniliforme* growth on PDA under all methods. To get over this problem, biological and chemical control methods were used to reduce lose seedlings and new offshoots in orchard such as Tachigaren and Topsin M -70 (Abdulsalam *et al.*, 1993); Topsin M- 70, Aliette, Coprus, Euparin and Saprol (Rashed and Abd El-Hafeez 2001); Plant-Guard (*Trichoderma harzianum*), Rhizo-N (*Bacillus subtilis*) and Topsin M 70 (Baraka *et al.*, 2011); Bio-zeid (*Trichoderma album*) and Plant Guard (*T. harzianum*) (Ahmed, 2018).

This research was planned to survey and tested the efficacy of some commercial products as single treatments on controlling pathogenic fungi causing root rot of date palm and their effects on the activity of defense-related total phenolic content and polyphenoloxidase activity.

MATERIALS AND METHODS

1. Survey of date palm root rot

A survey was conducted at 4 districts of 4 Egypt governorates Qaloubiya, Giza, Monofia and Beheira in spring, 2021 and 2022 growing seasons to determine the root rot incidence and severity percentage on three date palm cultivars Barhey, Majdol and Zaghloul at various orchards and commercial nurseries. The survey was conducted by calculating the percentage of the

disease incidence (disease infection) through counting the number of diseased and non-diseased seedlings or offshoots in a number of seedlings or offshoots of each orchard or nursery. A visual assessment technique was used to evaluate the disease severity (% D S) according to (Ahmed, 2018).

$$D S (\%) = \frac{\sum n \times v}{5N} \times 100$$

Where:

n = Number of infected offshoots or seedlings of each grade.

N = Total number of the inspected offshoots or seedlings

5 = Maximum disease severity grade.

v = Numerical value of each grade as follows:

0 = healthy offshoot or seedling (no root discoloration or leaf yellowing).

1 = above 1% - below 25% of root discoloration or one yellow leaf.

2 = above 25% - below 50% of root discoloration or more than one yellow leaf.

3 = above 50% - below 75% of root discoloration plus one wilted leaf.

4 = up to 75% root discoloration or more than one wilted leaf.

5 = dead offshoots and/or seedlings.

2. Isolation and identification of the associated fungi

Isolations were made routinely from symptomatic material of diseased date palm offshoots and/or seedlings. The infected tissues surface-sterilized in 70% ethanol for 20 sec, 1% NaOCl for 1 min, then planted onto PDA. Hyphae growing out from the tissue pieces were sub-cultured onto a new PDA plates, incubated at 26°C for 7 days. All isolates were preliminary identified (according to cultural characteristics and microscopic examination) according to Sutton (1980) and Barnett and Hunter (2006). Fungal isolates were grown onto PDA plates and maintained at 4°C for further studies. Frequency of the fungal isolates was calculated according to Hassan *et al.*, (2021).

Frequency (%) =

$$\frac{\text{Number of colonies of each fungal species}}{\text{Total number of all fungi}} \times 100$$

3. Pathogenicity test

Pathogenicity tests were carried out in Plant Pathology Greenhouse at El-Qanater El-Khayria Horticultural Research Station, to confirm the pathogenicity of the 4 fungal isolates from infected date palm offshoots and seedlings during 2021 and 2022 growing seasons. Two-year old tissue culture date palm seedlings Barhey, Majdol and Zaghoul cvs. transplanted in sterilized soil were inoculated separately with the fungal pathogens. One hundred gram barely grains and 100 ml of distilled water were put in each 250 ml conical flask and were autoclaved, subsequently inoculated with the fungal isolates using about 6~7 of (1 cm) fungal discs, then incubated at 24°C for 15 days with shake every 5 days. Soil of date palm seedlings were individually infested with the inocula of the tested fungi at the rate of 0.5% (5g fungal inoculum / 1 kg soil) Abdel-Monaim *et al.* (2014). Six pots were used for each fungal isolate as three replicates, each consisted of two pots. Non-infested soil six pots were used as a control. D S % were estimated after 90 days using a disease rating scale as mentioned before.

4. In vitro experiment

Commercial biocontrol agent Biocontrol T34 12% WP (*T. asperellum* strain T34) (T34), Serenade ASO 1.34% SC as well as commercial fungicides, Uniform 39% SE, Hexaten and Tshgarin 30% SL Table (1) were evaluated for their inhibiting effect against the most frequent pathogenic fungi *F. solani*, *F. moniliforme* and *L. theobromae* under *in vitro* conditions. Filter paper disks (Ø5 mm Whatman No.1) were dipped in each treatment suspension 1 minute, then allowed to dry. Disks were placed in the center PDA. Then, inoculated with fungal disk Ø5 mm. Plates incubated at 25±2°C to allow the mycelial

development. Filter paper disks dipped in sterilized distilled water were used as control. Six plates were used for each treatment as 3 replicates. Reduction (RE) in mycelial growth was calculated compared the control according to Hassan *et al.*, (2021).

5. Greenhouse experiment

During of 2021 and 2022 tissue culture date palm seedlings cv. Barhey (less susceptible) and cv. Zaghoul (the highly susceptible) 2-years-old apparently healthy were transplanted in pots (20 cm) containing sterilized soil. Soils were infested by the desired fungus each alone of the three pathogens, *F. solani*, *F. moniliforme* and *L. theobromae* separately as mentioned before. After 4 weeks of artificial infestation, soils of date palm seedlings (6 seedlings as 3 replicate) were drenched 3 times at 15-days intervals with the tested commercial products as shown in Table (1). Control soils was drenched with water. % D S was calculated for each treatment after 90 days from the last application treatment as mentioned before.

6. Effect of the tested commercial products on total phenolic content (TPC) and polyphenoloxidase (PPO) activity

To determine the effect of the tested commercial products with the concentrations showed in Table (1) on the defense enzyme activities and total phenolic content in three date palm seedlings Barhey, Majdol and Zaghoul cvs. two years old, samples of leaves were taken 24 hours after soil drench of the tested compounds to determine total phenolic content (TPC) and polyphenoloxidase (PPO) activity (Monir *et al.*, 2021).

Table (1): Characterizations of tested compounds.

Commercial name	Active ingredient	Dose@
Biocontrol T34 12% WP (biocide)	<i>Trichoderma asperellum</i> strain T34	2g/litre
Serenade ASO 1.34% SC (biocide)	<i>Bacillus subtilis</i> (QST713)	1 ml / litre
Uniform 39 % SE	Azoxystrobin 28.2 % + Metalaxyl_ M 10.8%	1ml/ litre
Hexaten	Hymexazol 30% - Isoxazole 30% H	1ml / litre
Tshgarin 30 % SL	Hymexazole	1ml/ litre

Leaves extraction

To determine enzyme activity and total phenolic contents, 5g fresh leaves of date palm seedlings and 0.1sodium phosphate buffer PH=7 at 100mg/1ml using china homogenizer. The homogenates centrifuged for 50 mn. at 5°C and stored at 4°C for uses.

Total phenolic content (TPC)

Total phenolic content (TPC) was evaluated according to Meighani *et al.*, (2014). TPC was tested as mg gallic acid equivalent in 100 ml of treated or untreated leaves (mg gallic acid /100 ml date palm leaves juice).

Polyphenoloxidase activity (PPO)

Using Spectrophotometer polyphenoloxidase activity was measured according to Matta and Dimond (1963) 1ml solution of phosphate buffer (pH=7), 1ml catechol, 1ml crude enzyme, 1ml crude extracts and the tube was completed with distilled water to 5ml to prepare the reaction mixture. Enzymes activity was expressed as the change in the absorbance of the mixtures every 0.5 min. for 5 minutes at 495 nm.

7. Statistical analysis

All obtained data during both seasons were subjected to analysis of variance method according to Snedecor and Cochran (1990). Duncan's Multiple Range tested (Duncan, 1955) was used to compare differences among means.

RESULTS

1. Survey of date palm root rot

Date palm root rot symptoms were observed on Barhey, Majdol and Zaghloul cvs. in new orchards as well as the commercial nurseries in the four investigated governorates (Fig.1, 2 and 3). Data in Table (2) indicate that disease incidence (D I %) of date palm root rot ranged between 15 and 26% on the surveyed 3 cultivars over the four surveyed governorates with disease severity (D S %) ranged between 10 and 17.33%. However, both disease parameters were significantly higher in nurseries than the new orchards. The highest D I % and D S %, (26 and 17.33 %), respectively were recorded in nursery at Beheira governorate during 2021. Over, the lowest percentages of disease incidence (D I %) and disease severity (D S %), being 15 and 10%, respectively were recorded in the new orchards at Giza and Qaloubiya governorates during 2021.

Table (2): Disease incidence (D I %) and disease severity (D S %) of date palm root rot at the new orchards and the nurseries in the four surveyed governorates during 2021 and 2022 seasons.

Governorate	Locations	2021		2022	
		D I %	D S %	D I %	D S %
Qaloubiya	Orchards	17.00e	10.00f	16.00e	11.26d
	Nurseries	25.00b	14.66c	25.00a	14.26b
Giza	Orchards	15.00g	12.33e	18.00d	15.53a
	Nurseries	24.00c	13.25d	24.00b	15.46a
Monofia	Orchards	16.00f	12.73e	20.00c	14.66b
	Nurseries	21.00d	16.26b	20.00c	12.73c
Beheira	Orchards	16.00f	13.73d	25.00a	14.13b
	Nurseries	26.00a	17.33a	25.00a	12.46c

Within each column, the same letter/s indicates no significant difference among treatments at ($p < 0.05$).

D I % = % disease incidence & D S % = % disease severity.



Fig. (1): Date palm seedlings in nursery expressed root rot symptoms on cv. Barhey (A) and cv. Zaghloul (B).



Fig. (2): Date palm root rot symptoms were observed on cv. Barhey (A), cv. Majdol (B) and cv. Zaghloul (C) in commercial nursery.



Fig. (3): Root rot symptoms produced on date palm offshoots under naturally infection in new orchards on cv. Barhey (B), cv. Majdol (A) and cv. Zaghloul (C).

2. Fungi associated with date palm root rot:

The obtained data in Table (3) found that 4 fungal species *i.e.*, *Fusarium solani*, *F. moniliforme*, *F. semitectum* and *Lasiodiplodia theobromae* were isolated from naturally infected date palm root rots and collected from natural infected in commercial nursery and new orchards. The most frequently isolated fungus of the four governorates during the two seasons was *F. solani*, being (37.03% - 48.14%) over the two years of the present studies. This was followed by *F. moniliforme* (22.22% - 33.33%) while the lowest frequencies (7.40% - 14.82%) were recorded for *F. semitectum* and *L. theobromae* respectively.

3. Pathogenicity test

The pathogenicity test showed that all isolated fungal species were able to induce root rot disease on date palm seedlings with different degree of response (Fig.4, 5 and 6). Data in Table (4) show that the highest average of root rot D S %, on Barhey, Majdol and Zaghloul cvs., date palm seedlings during 2021 and 2022 seasons was occurred due to infection with *F. solani* where the corresponding mean values were 52.66 and

55.33% disease severity with 2021 and 2022, respectively, followed by *F. moniliforme* 44.00 and 45.33%, while *L. theobromae* recorded 12.66 and 14.33%, respectively. On contrary, little symptoms were appeared on the seedlings inoculated by *F. semitectum* 7.00 and 9.00%, respectively. Additionally, cv. Zaghloul was more susceptible cultivar with root rot disease than Barhey and Majdol cvs., during tests of the two seasons of the present investigation.

4. In vitro experiment

The inhibitory effect of five commercial tested compounds against the growth of the most frequent isolated pathogenic fungi, *F. solani*, *F. moniliforme* and *L. theobromae* was tested *in vitro*. Data in Table (5) revealed that the treatments differed in their ability to inhibit the mycelial growth of the three pathogens. Complete inhibition in liner growth of the three fungi was showed at the commercial fungicide Uniform 39 % SE followed by Hexaten and Tshgarin 30% SL. While the biocide Biocontrol T34 12% WP (*Trichoderma asperellum* strain T34) (T34) and Serenade ASO 1.34%, SC recorded the lowest efficacy in this respect, being 84.43 and 87.03% on the average, respectively.

Table (3): Frequency (%) of fungal species isolated from naturally infected date palm root rot collected from the new orchards and commercial nurseries located in four governorates during 2021 and 2022 seasons.

Isolated fungi	Isolation frequency %							
	2021				2022			
	Qaloubiya	Giza	Monofia	Beheira	Qaloubiya	Giza	Monofia	Beheira
<i>F. solani</i>	37.03a	44.44a	37.03a	44.44a	40.74a	48.14a	37.03a	48.14a
<i>F. moniliforme</i>	33.33b	29.62b	25.93b	22.22c	25.93b	29.62b	25.93b	25.93b
<i>F. semitectum</i>	14.82c	11.11d	18.52c	11.11d	14.81d	7.40d	18.52c	11.11d
<i>L. theobromae</i>	14.82c	14.82c	18.52c	22.22b	18.52c	14.82c	18.52c	14.82c
Total	100	100	100	100	100	100	100	100

Within each column, the same letter/s indicates no significant difference among treatments at ($p < 0.05$).

Table (4): Pathogenicity test expressed as root rot disease severity%, using fungal species recovered during 2021 and 2022 from Barhey, Majdol and Zaghloul cvs. date palm.

Tested fungus	Disease severity % on date palm cvs.							
	2021				2022			
	Barhey	Majdol	Zaghloul	Mean	Barhey	Majdol	Zaghloul	Mean
<i>F. solani</i>	50.00a	52.00a	56.00a	52.66a	52.00a	56.00a	58.00a	55.33a
<i>F. moniliforme</i>	40.00b	44.00b	48.00b	44.00b	40.00b	46.00b	50.00b	45.33b
<i>F. semitectum</i>	5.00d	8.00d	8.00d	7.00d	8.00d	8.00d	11.00d	9.00d
<i>L. theobromae</i>	10.00c	12.00c	16.00c	12.66c	12.00c	15.00c	16.00c	14.33c
Control	00.0e	00.0e	00.0e	00.0e	00.0e	00.0e	00.0e	00.0e

Within each column, the same letter/s indicates no significant difference among treatments at ($p < 0.05$).



Fig. (4): Root rot symptoms on date palm seedlings cv. Barhey after 90 days of artificial inoculation with *F. solani* (A), *F. moniliforme* (B) and *L. theobromae* (C).



Fig. (5): Root rot symptoms on date palm seedlings cv. Majdol after 90 days of artificial inoculation with *F. solani* (A), *F. moniliforme* (B), *L. theobromae* (C) and control (D).



Fig. (6): Root rot symptoms on date palm seedlings cv. Zaghloul after 90 days of artificial inoculation with *F. solani* (A), *F. moniliforme* (B), *L. theobromae* (C) and control (D).

Table (5): Efficacy of five tested compounds on growth (g) and reduction (% RE.) of the isolated date palm root rot fungi *in vitro*.

Treatment	Concen. /L	<i>F. solani</i>		<i>F. moniliforme</i>		<i>L. theobromae</i>		Mean	
		g (mm)	RE. %	g (mm)	RE. %	g (mm)	RE. %	g (mm)	RE. %
Biocontrol T34 12% WP (biocide)	2g	10.00b	88.88	12.00b	86.66	20.00b	77.77	10.00 ^c	84.43
Serenade ASO 1.34% SC (biocide)	1ml	10.00b	88.88	10.00c	88.88	15.00c	83.33	11.66b	87.03
Uniform 39 % SE	1ml	00.00d	100	00.00e	100	00.00e	100	00.00e	100
Hexaten	1ml	5.00c	94.44	5.00d	94.44	10.00d	88.88	6.66d	92.58
Tshgarin 30%SL	1ml	5.00c	94.44	5.00d	94.44	10.00d	88.88	6.66d	92.58
Control	-	90.00a	-	90.00a	-	90.00a	-	90.00a	-

Within each column, the same letter/s indicates no significant difference among treatments at ($p < 0.05$).

5. Greenhouse experiment

After four weeks of artificial infestation of soil with each of the three pathogenic fungi, date palm Barhey and Zaghoul cvs., were drenched three times at 15-days intervals with the commercial products. The results in Table (6) show that all treatments decreased D S% compared with the control. Mostly, complete protection from root rot emerged on date palm seedlings exposed to infection with each of the three fungi and treated with each of Uniform 39 % SE, Tshgarin 30 % SL and Hexaten. Uniform 39 % SE, Tshgarin 30 % SL and Hexaten gave the highest efficacy for controlling date palm root rot on the two tested cultivars during the two seasons, while the lowest efficacy was recorded when date palm seedlings were treated with the biocide Biocontrol T34 12% WP (*Trichoderma asperellum* strain T34) (T34) and the biocide Serenade ASO 1.34% SC (*Bacillus subtilis* QST713), respectively.

6. Determination of total phenolic content (TPC) and polyphenoloxidase activity (PPO) as pathogenesis related compounds

Total phenolic content (TPC)

Total phenols were determined in three cultivars of date palm seedlings Barhey, Majdol and Zaghoul cvs. after 24 hours of treating the tested commercial compounds. Data in Table (7), show that, total phenols were the highest level in

Barhey than each of Majdol and Zaghoul cvs.. Treating the tested commercial compounds as elicitors affected the activities of total phenols in the three tested date palm cultivars compared with control. Generally, Barhey showed the highest total phenols compared with Zaghoul and Majdol cvs.. Also, data indicate that, the highest total phenols activities in the three tested cultivars was recorded after 24h from treating with the tested compounds in Barhey cv. While the lowest production of total phenols was recorded in Zaghoul cv. The highest values of total phenols in the three tested date palm cultivars were observed after treating with Uniform 39 % SE and Tshgarin 30%SL, followed by Hexaten, While the lowest levels of total phenols were recorded with Serenade ASO 1.34% SC.

Polyphenoloxidase activity (PPO)

Polyphenoloxidase activity (PPO) in date palm seedlings was higher in Barhey than Majdol and Zaghoul, cvs., Data in Table (8) indicate that, the highest PPO values in the three tested cultivars were recorded after 24h from treating with tested compounds in cv. Barhey, while the lowest were recorded in cv. Zaghoul. The highest values of PPO in the three tested date palm cultivars were observed after treating with Tshgarin 30%SL, followed by Uniform 39 % SE, while the lowest levels of PPO were recorded due to using the biocides.

Table (6): Efficacy (Eff.) % of tested commercial products against the causal pathogens of date palm root rot disease severity (D S%) on Barhey and Zaghoul cvs., growing in soil infested with the tested fungi during 2021 and 2022 seasons under greenhouse conditions.

Cultivars	Treatments	Conc./ L	2021						2022					
			<i>F. solani</i>		<i>F. moniliforme</i>		<i>L. theobromae</i>		<i>F. solani</i>		<i>F. moniliforme</i>		<i>L. theobromae</i>	
			D S %	Eff.	D S%	Eff.	D S%	Eff.	D S%	Eff.	D S%	Eff.	D S %	Eff.
Barhey	Biocontrol T34 12% WP (biocide)	2g	10.0b	80	10.0b	75	00.0b	100	10.0b	83.33	10.0b	75	00.0b	100
	Serenade ASO 1.34% SC (biocide)	1ml	10.0b	80	10.0b	75	00.0b	100	10.0b	83.33	10.0b	75	00.0b	100
	Uniform 39 % SE	1ml	00.0c	100	00.0c	100	00.0b	100	00.0c	100	00.0c	100	00.0b	100
	Hexaten	1ml	00.0c	100	00.0c	100	00.0b	100	00.0c	100	00.0c	100	00.0b	100
	Tshgarin 30 % SL	1ml	00.0c	100	00.0c	100	00.0b	100	00.0c	100	00.0c	100	00.0b	100
	Control	water	50.0a	--	40.0a	--	10.0a	--	60.0a	--	40.0a	--	10.0a	--
Zaghoul	Biocontrol T34 12% WP (biocide)	2g	10.0c	83.33	10.0c	80	10.0b	50	20.0b	66.66	20.0b	60	10.0b	66.66
	Serenade ASO 1.34% SC	1ml	20.0b	66.66	20.0b	60	10.0b	50	20.0b	66.66	20.0b	60	10.0b	66.66
	Uniform 39 % SE	1ml	00.0d	100	00.0d	100	00.0c	100	00.0c	100	00.0c	100	00.0c	100
	Hexaten	1ml	10.0c	83.33	10.0c	80	00.0c	100	00.0c	100	00.0c	100	00.0c	100
	Tshgarin 30 % SL	1ml	00.0d	100	00.0d	100	00.0b	100	00.0c	100	00.0c	100	00.0c	100
	Control	water	60.0a	--	50.0a	--	20.0a	--	60.0a	--	50.0a	--	30.0a	--

Within each column, the same letter/s indicates no significant difference among treatments at (p < 0.05).

Table (7): Total phenol contents mg/g fresh weight at 24h after treating with some commercial products as elicitors.

Date palm cultivars	Control	% Phenol contents (mg/g f w) at 24h after treatment with:				
		Biocontrol T34 12% WP (biocide)	Serenade ASO 1.34% SC (biocide)	Uniform 39 % SE	Hexaten	Tshgarin 30%SL
Barhey	0.79a	0.88a	0.85a	1.31a	0.99a	1.11a
Majdol	0.68b	0.88b	0.80b	0.99b	0.89b	0.99b
Zaghoul	0.66c	0.75c	0.73c	0.94c	0.78c	0.88c

Within each column, the same letter/s indicates no significant difference among treatments at (p < 0.05).

Table (8): Polyphenoloxidase activity at 24h after treating with some commercial products as elicitors.

Date palm cultivars	Control	Polyphenoloxidase activity (PPO) at 24h after treatment with:				
		Biocontrol T34 12% WP (biocide)	Serenade ASO 1.34% SC (biocide)	Uniform 39 % SE	Hexaten	Tshgarin 30%SL
Barhey	0.08a	0.12a	0.12a	0.17a	0.11a	0.19a
Majdol	0.05b	0.09b	0.09b	0.11b	0.11a	0.13b
Zaghloul	0.04c	0.09b	0.09b	0.09c	0.09b	0.11c

Within each column, the same letter/s indicates no significant difference among treatments at ($p < 0.05$).

DISCUSSION

Date palm is one of the most valuable domesticated fruit trees because of its significance in human societies, health benefits, and the range of subsistence products from its fruits and other parts of the large palm (Johnson *et al.*, 2015). Egypt leads the world date palm production with about 1.1 million metric tons annual production and generated about \$41.8 million from export of fresh date palm fruits (Pariona, 2017). Date palm trees and offshoots attacked by several soil borne pathogenic fungi causing severe losses and worldwide deterioration of these trees (Arafat *et al.*, 2012). According to Ziedan *et al.*, (2013), *M. phaseolina*, *Phoma* sp., *F. oxysporum*, *F. solani*, *F. moniliforme*, *F. equiseti*, *F. semitectum*, *R. solani* and *Thielaviopsis paradoxa* have been reported in different countries to cause root rot diseases in young and adult date palm trees. In the present study, results indicated that the highest percentages of disease incidence and disease severity were recorded in nurseries (Beheira governorate). The lowest were recorded in new orchards in Giza and Qaloubiya governorates during 2021. Also, in this study four fungal species *i.e.*, *Fusarium solani*, *F. moniliforme*, *F. semitectum* and *Lasioidiplodia theobromae* were associated with the naturally infected date palm with root rot. Meanwhile, the pathogenicity test showed that all isolated fungi were able to induce root rot on date palm. The highest average disease severity % was recorded on cvs. Barhey, Majdol and Zaghloul date palm was obtained due to infection by *F. solani* followed by *F. moniliforme*. Inoculated date palm seedlings with *F. semitectum* showed little symptoms of root rot. Data indicated that Zaghloul was more

susceptible than Barhey and Majdol cvs., under artificial inoculation in pathogenicity tests carried out during this investigation. Also this study suggests that *F. solani*, *F. moniliforme* and *L. theobromae* might be the main pathogens associated with date palm root rot in Egypt where artificial infection with these fungi induced typical root rot symptoms. Ahmed, (2018) in Egypt, who reported that several, soil borne fungi were isolated from root rots of date palm *i.e.* *F. solani*, *F. oxysporum*, *Rhizoctonia solani* and *Macrophomina phaseolina*, and their pathogenicity was confirmed on date palm seedlings in the greenhouse.

In addition, our results are in harmony with those reported by El-Morsi *et al.* (2021) who isolated *F. solani*, *F. oxysporum*, *F. equiseti*, *F. moniliforme* and *F. Semitectum* from date palm offshoots showing root rot symptoms and their pathogenicity was confirmed on cv. Saïdy.

Our results showed that the efficacy of different products namely Biocontrol T34 12% WP (*T. asperellum* strain T34) (T34), Serenade ASO 1.34% SC, Uniform 39 % SE, Hexaten and Tshgarin 30% SL was evaluated *in vitro* and under greenhouse conditions. Complete reduction in colony growth of the three fungi was observed due to Uniform 39 % SE followed by Hexaten and Tshgarin 30% SL. While T34 and Serenade ASO 1.34% SC recorded the lowest efficacy in reducing the growth of the three tested pathogens. However, under greenhouse conditions Uniform 39 % SE, Tshgarin 30 % SL and Hexaten gave the highest efficacy for controlling date palm root rot on the two cultivars during the two seasons, while the lowest efficacy was recorded when seedlings

were treated with T34 and Serenade ASO 1.34% SC, respectively. El-Morsi *et al.*, (2021) Studies the antagonistic effects of some Bacillus and Trichoderma species as bio control agents against root rot of date palm offshoots in El-Dakhla and El-Kharga under natural infection in nursery. The results show significant reduced severity compared with control. The highest reduction against root rot of date palm offshoots with *B. megaterium* and *T. viride* while *B. cereus* and *T. harzianum* gave the lowest ones respectively.

The highest values of total phenol in the three tested date palm cultivars were observed in Barhey cv.. While the lowest production of total phenols was recorded in Zaghrou cv. The highest values of total phenols in the three tested date palm cultivars were observed after treatment with the tested commercial compounds, Uniform 39 % SE and Tshgarin 30%SL, followed by Hexaten, While the lowest levels of total phenols were recorded in those treated with Serenade ASO 1.34% SC.

The results of total phenol data are in harmony with those recorded by Hussein, Nour El-Hoda (1976) who mentioned that, the total phenol contents (TPC) increased in mango tissues infected with *L. theobromae*. Radwan (1985) mentioned that, free, conjugated and total phenols were higher in infected berries of grapevine inoculated with *L. theobromae*. El-Habaa (1995) found considerable decrease in the total sugar and phenols in all wounded mango fruits. Taimour and Pyri cvs. inoculated with *L. theobromae* isolates as a result to infection at the different growth stages while no clear reduction of these compounds was remarked in un-wounded inoculated fruits. Phenols in wounded and un-wounded mango fruits increased as a result to infection with *F. moniliforme* isolate. Additionally, phenols enhance resistance against *C. gloeosporioides* the main causal agent of anthracnose on avocado fruit (Malick *et al.*, 2014). The grade of TPC in pear leaves is highly dependent on many factors, such as cultivar and infection diseases and or pests (Androetti *et al.*, 2006).

Venkatesan and Tamilmani (2010) noted that phenols compounds decreased during ripening,

both in the control and treated fruits. Also, the activity of peroxidase (PO) and polyphenoloxidase (PPO) of mango. While, the PPO activity of the fruits showed a decrease during post-harvest ripening (Othman, 2012). Salicylic acid (SA) treatment increased the activities of PPO and TPC in mango fruit against postharvest anthracnose, caused by *C. gloeosporioides* during storage period after inoculation (Junyu *et al.* 2017). Abd El-Hafeez, (1991) found that phenolic compounds were found at high level in resistant mango cultivars compared with susceptible ones. Treated bean plants with Jasmonic acid (JA) induced systemic resistance against *Rhizoctonia solani* through induction a lot of defense enzymes (Hathout *et al.*, 2010). There are positive relationships between peroxidase and polyphenoloxidase enzymes and resistance developed in Fuerte and Hass cvs., after dipping the scion in the treatments in comparison to control. The highest values of production of peroxidase and polyphenoloxidase activities in the two tested avocado cultivars Hass and Fuerte were observed after dipping the scions in Amistar Top and Bellis, followed by Kocide (2000) and Serenade ASO (*B. subtilis* QST713). While the lowest values of peroxidase and polyphenoloxidase activities were recorded after dipping the scions in Star copper and Bio Zeid (*Trichoderma album*) (Monir *et al.*, 2021).

CONCLUSION

The present investigation on root rot of date palm indicates to the identification of fungi isolated from infected date palm offshoots and seedlings collected from natural infection of four governorates showed *Fusarium solani*, *F. moniliforme*, *F. semitectum* and *Lasiodiplodia theobromae*. Pathogenicity test with each fungus separately on three tested cultivars showed positive response and the highest percentage of root rot obtained by *F. solani* followed by *F. moniliforme*. On the other hand Zaghroul cultivar was the highly susceptible one. Laboratory evaluation of some commercial products showed that Uniform 39 % SE was the most promising fungicide. Additionally, in greenhouse Uniform 39 % SE was the best fungicide in controlling root rot of date palm followed by Tshgarin 30 % SL.

This result maybe help the grower in new orchards as well as improve date palm seedlings in the nursery.

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كفاءة بعض المنتجات التجارية المختلفة في مكافحة عفن جذور النخيل تحت ظروف الصوبة

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أجريت هذه الدراسة خلال موسمي النمو ٢٠٢١ و ٢٠٢٢ وتم خلالها تقييم نسبة وشدة الإصابة بمرض عفن الجذور على ثلاثة اصناف من النخيل هي البرحي والمجدول والزغول وذلك في مشاتل وحقول حديثة الزراعة في اربعة محافظات هي القليوبية والجيزة والمنوفية والبحيرة ، ولقد اثبتت النتائج ان اعلى نسبة وشدة اصابة بالمرض سجلت في محافظة البحيرة واقل نسبة وشدة اصابة سجلت في محافظة الجيزة والقليوبية خلال موسم النمو ٢٠٢١. تحت ظروف الإصابة الطبيعية تم عزل اربعة فطريات كانت لها جميعا القدرة الامراضية على شتلات النخيل ناتج زراعة الانسجة للاصناف تحت الدراسة وكان اعلى شدة اصابة على الشتلات ناتج زراعة الانسجة للاصناف الثلاثة عند العدوى بالفطر *Fusarium solani* بلية الفطر *F. moniliforme* بينما اظهرت شتلات النخيل اعراض قليلة بالمرض عند العدوى الصناعية بالفطر *F. semitectum* كما اظهرت النتائج قابلية الصنف زغول للإصابة بصورة اعلى من الصنف البرحي والمجدول. تم دراسة كفاءة بعض المنتجات التجارية تحت ظروف المعمل والصوبة للتغلب على هذه المشكلة فكان المركب يونيفورم SE 39 % اعلى المركبات المستخدمة كفاءة تحت ظروف المعمل في حين ان المركب تشجارين Tshgarin 30%SL اعلى المركبات المستخدمة كفاءة عند المعاملة تحت ظروف الصوبة. اجري تقديرات للفينولات الكلية وكذلك لانزيم البولي فينول اوكسيداز للوقوف على الفروق في المحتوى بين الاصناف الثلاثة تحت الدراسة فكان الصنف البرحي اعلى الاصناف وكان الصنف زغول الاقل في محتوى الفينولات الكلية والبولي فينول اوكسيداز كما كان المركب يونيفورم SE 39 % اعلى المركبات المستخدمة استحداثا لمحتوى الفينولات الكلية وكذلك المركب تشجارين Tshgarin 30%SL اعلى المركبات المستخدمة استحداثا للبولي فينول اوكسيداز بينما كان الاقل هو المركب سيريناد ايسو (Serenade ASO 1.34% SC).