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THE ABILITY OF GRAFTED WATERMELON ON SQUASH ROOTSTOCKS IN RESISTANCE AGAINST THE INFECTION WITH *FUSARIUM OXYSPORUM* F. SP. NIVEUM AND *FUSARIUM SOLANI* IN IRAQ

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ABSTRACT

A vascular wilt disease caused by the fungus *Fusarium oxysporum* and the root and crown rot caused by the fungus *Fusarium solani* is one of the most important diseases that attack the watermelon plant and cause economic losses worldwide. This study aimed to provide a method for controlling the pathogenic of watermelon wilt disease caused by *Fusarium oxysporum* f.sp. *niveum* (FOX), root and crown rot caused by *Fusarium solani* (FS) by grafted watermelon on squash rootstocks to reduce losses. The results of isolation and identification showed that 18 fungal isolates were isolated from the stems, crown, and roots of watermelon plants, they were identified morphologically and divided into 14 isolates belonged to *F.oxysporum* and 4 isolates belonged to *F. solani*. Furthermore, the results of the pathogenicity test of these isolates on local radish seeds showed that the disease severity index ranged between 1.9-4.9 and on the watermelon seedlings cultivar Sugar Baby showed a variation in the percentage of infection with the fungus. Similarly, the isolate B belonged to the fungus *F. solani* showed the highest infection percentage had reached 100% with significant differences from the rest of the tested fungus isolates, which ranged between 66.8-77.7%. They were followed by the isolate N belonged to *F.oxysporum*, which caused an infection percentage of 88.8% with significant differences from the rest of the tested fungus isolates, which ranged between 55.23 - 76.8%. The two isolates B (FS) and N (FOX) were identified molecularly, and deposited in the GenBank under the accession numbers B (FS) (MT509567) and N(FOX) (MT509568). The results of the grafted watermelon plant effectiveness in reducing the infection percentage of the two pathogenic fungi *F.oxysporum* and *F.solani* in the pot experiment after 45 days of inoculum, showed the superiority of the grafted watermelon plant with significant differences in both the fungus FOX treatment, the fungus FS treatment, and the treatment of fungi FOX and FS. Further, the infection percentage reached 12.26, 25, and 12.36%, respectively, compared with nongrafted watermelon plants in each of the nongrafted FOX treatment, FS treatment, FOX and FS treatment, and FOX and FS with fungicide(thiophante methyl as the infection percentage reached 48, 62, 55 and 25% respectively. The grafted watermelon plant treatment was also superior with significant differences in both of the FOX treatment, FS treatment, FOX, and FS treatment in the length of branches and average number of branches. The results also showed the effectiveness of grafted watermelon plants in reducing the infection percentage of the two pathogenic *F. oxysporum* and *F. solani* in the field, where the grafted watermelon plant treatment was significantly superior within the drip irrigation experiment under greenhouse conditions in each of FOX treatment, FS treatment, FOX and FS treatment. Generally, the infection percentage was 19.66%, 26.53%, 6.53%, respectively, compared with the nongrafted watermelon treatment in both of the FOX treatment, FS treatment, FOX and FS treatment, and the fungicide treatment, where the infection percentage amounted to 39.66%, 60%, 40.33%, and 33.10% respectively. The grafted watermelon plant treatment was also significantly superior in vegetative growth parameters, which included length of branches, number of branches, number of leaves, sexual expression, and number of fruits in both of the FOX treatment, FS treatment, FOX and FS treatment. Moreover, the grafted watermelon plants treatment was significantly superior within the experiment of surface irrigation (tradition irrigation) in both of the FOX treatment, FS treatment, FOX and FS treatment in reducing the infection percentage with *F.oxysporum* and *F.solani*. As the infection percentage reached 13.40, 19.66, 6.53 respectively, compared with the nongrafted watermelon treatment in each of the FOX treatment, FS treatment, FOX and FS treatment, and the fungicide treatment, in which the infection percentage reached 33.43, 40.33, 32.76, and 19.33, respectively. Still, the grafted watermelon plants treatment was significantly superior to the improving the vegetative growth parameters, which included length of branches, number of branches, number of leaves, sexual expression and number of fruits.
Keywords: Fusarium wilt disease, root and crown rot, watermelon diseases, grafting.

Introduction

The watermelon crop that belongs to the Cucurbitaceae family is an important economic and food summer vegetable crop. The watermelon plants are affected by many pathogens that reduce the productivity and quality of the fruits, where the most important of which are the pathogens that infected the watermelon plant in the soil (Ramírezet-Huitrón *et al*., 2009). A vascular wilt disease caused by *F. oxysporum* and the root and crown rot caused by the fungus *F. solani* are among the most important diseases that infected watermelon plants and cause an economic loss worldwide (Wu *et al*., 2009; Hao *et al*., 2010 and Turoczi *et al*., 2011). Several methods of controlling *Fusarium* spp. including agricultural rotation, fungicides, resistant cultivars, solar pasteurization, and biological control have been used to reduce the risk of vascular wilt disease, root and crown rot diseases (Luo *et al*., 2010; Zhao *et al*., 2011; Roberti *et al*., 2012). The grafting was first used commercially on watermelon in Japan and Korea and in the past 20 years, which its use has increased in many watermelon-production regions of the world (Davis *et al*., 2008; King *et al*., 2008). Grafting technology is used all over the world to control pests transferred by soil or to increase plant tolerance to various environmental stress conditions such as salinity, drought and temperature, and enhance nutrient absorption. As well as, improve water use efficiency and reduce the negative effects of some minerals toxicity. However, the grafting of the watermelon plant on the squash plant is characterized by its ability to withstand the pathogens in the soil, such as *Fusarium* spp., *Veriticillium* spp., *Phytophthora* spp., and root-knot nematodes, which are among the main pathogens that infect the watermelon plant (Davis *et al*., 2008). A significant decrease in *Fusarium* wilt disease incidence was observed on watermelon grafted on hybrid squash (Cucurbita maxima × Cucurbita moschata) It was resistant to race 0, 1, and 2 in Turkey (Yetisir *et al*., 2003,). Besides, A decrease in Fusarium wilt disease was observed on watermelon grafted on the hybrid squash (Cucurbita maxima × Cucurbita moschata) and watermelon grafted on the (*Lagenaria siceraria*) bottle gourd reached less than 6%, while the wilt percentage reached more than 52% in the nongrafted watermelon plants in the southeastern United States (Keinath and Hassell, 2014). Therefore, the study aimed to provide a method for controlling the pathogen of watermelon wilt disease caused by *F. oxysporum* f.sp. *niveum*, root and crown rot caused by *F.solani*, by grafting the watermelon on squash rootstocks to reduce their losses.

Materials and Methods

Isolation and identification and pathogenicity test of the pathogen:

The pathogenic fungus from the watermelon plants was isolated from that included all of the Al-Hai, Jableh region, Diyala governorate, which included Al-Muqdadiya and Al-Uzim regions. In addition to a field in the Faculty of Agricultural Engineering Sciences in Al-Jadriya–Baghdad. The plant samples were washed with running water for 30 minutes. Further, they were cut into small pieces of 0.5 cm length and surface sterilized using sodium hypochlorite solution of 1% free chlorine for two minutes, washed with sterile distilled water, and dried on sterile filter paper. The pieces were transferred to a petri dish that contains the Potato Dextrose Agar (PDA) medium (4 vegetable pieces/dish) and incubated at 25 °C and left for 3 days. Then, the fungus was identified depending on the morphological characteristics (Booth, 1971). Also, the isolates were molecularly identified using a primer ITS1 / ITS4 to amplifyication them with a polymerase chain reaction according to Najem and Kareem (2018). As the nucleotide sequences of the internal transcribed spacer (ITS) region of the isolates were determined and compared with the global isolates in the NCBI Gen-Bank (https:// www.nebi.nlm.nih.gov). Finally, the pathogenicity of the pathogenic *Fusarium* spp. isolates on radish seeds were tested in the laboratory and on the watermelon seedlings (sugar baby) in the pots under greenhouse conditions. These experiments were carried out according to Freeman and Rodriguez (1993), Sneh *et al.* (2004) and Kareem and Hassan (2015).

- **Grafting of watermelon plants:**

The grafting process was carried out after the formation of the first true leaf of both watermelon seedlings (graft) and squash (rootstock) using the side grafting method as mentioned by Kent Cushman (2006).

The ability test of grafted watermelon to protect the watermelon plants from infection with the pathogen Fusarium spp. in the pots under greenhouse conditions.

An experiment was carried out in pots in the greenhouse of the Plant Protection Department of the College of Agricultural Engineering Sciences / University of Baghdad. The grafted watermelon seedlings and nongrafted watermelon seedlings were transferred to plastic pots of 2 kg capacity contained a mixture of loamy soil and peat moss in a ratio of 1: 2 and sterilized by the autoclave at a temperature of 120 °C and a pressure of 1.5 bar for two consecutive times separated by one day. The soil was inoculum by the two pathogenic fungus isolates according to the treatments after three days of planting by adding 10 ml of the fungal spores suspension at a concentration of 1 x 10^6 spores per pot by four replicates for each treatment and two watermelon seedlings for each pot. In addition to leaving, four replicates as a comparison treatment without fungus, where the pots were irrigated regularly and as needed with the addition of the recommended fertilizer. The treatments used are as follows.

1. Grafted watermelon plants + *Fusarium oxysporum* f. sp.*niveum* (FOX).
2. nongrafted watermelon plants + fungus FOX.
3. Grafted watermelon plants + *Fusarium solani* f.sp. *cucurbitae* (FS).
4. non grafted watermelon plants + fungus FS.
5. nongrafted watermelon plants as a comparison without fungus.
6. Grafted watermelon plants + FOX + FS.
7. nongrafted watermelon plants + FOX + FS
8. nongrafted watermelon plants + FOX + FS + fungicide Thiophanate-methyl at a concentration of 100 g / 100 L. of water, as 50 ml of the fungicide was added to each pot after three days of inoculum. The infection percentage, the number of branches, and the branches' length were calculated after 45 days of soil inoculum.

The ability test of grafted watermelon to protect watermelon plants from infection with the *Fusarium* spp. In the field

An experiment was carried out at two sites, the first experiment within the greenhouse with dripirrigation system of the Plant Protection Department (Station B) - Faculty of Agricultural Engineering Sciences - University of Baghdad, and the second experiment in the Abu-Ghraib district of the Sheha village- Baghdad within surface irrigation system. The experiment land was prepared by blowing in an orthogonal manner, leveling and dividing according to the experimental treatments and the adopted experimental design. The seedlings were transferred to the field, and after three days of planting, the soil was inoculum with the two *Fusarium* isolates, by adding 10 ml of suspension with a concentration of 1 x 10^6 spores, the field was irrigated regularly twice a week. The field was also fertilized once a week and according to the recommendation, the percentage of infection and some growth parameters were calculated such as (branch length, number of branches, number of leaves, sexual expression, the number of fruits).

- **Phenolic compounds estimation:**

The number of phenols in the water and alcoholic extracts of plants was determined using the Folin-Ciocalteu method, according to (Slinkard and Singleton, 1977).

Results and Discussion

Sampling, isolating, and identifying the fungi that accompanying to the stems, crown, and root of watermelon:

The results of sampling from the watermelon cultivation areas the Wasit Governorate of Al-Kut and Jableh, in addition to Diyala Governorate from Al-Muqdadiya and Al-Azim region, the College of Science and Agricultural Engineering field showed symptoms of yellowing of the lower leaves, shoot pale, wilt, and vascular necrosis and colored with brown color. However, the results of isolation and identification showed that 18 fungal isolates were isolated from the area of the stems, crown, and root of watermelon plants, as these isolates showed a clear variance in the growth speed, the mycelium density, and the colony color. Therefore, the fungal isolates were divided into 14 isolates belonged to the fungus *Fusarium oxyspourm* and four isolates belonged to the fungus *Fusarium solani*.

Pathogenicity test of Fusarium spp. isolates on radish seeds:

The results of the pathogenicity test of *Fusarium* spp. isolates showed a variation in their pathogenicity on radish seeds (Table 1). Further, the disease severity index for all *Fusarium* spp. isolates were ranged between 1.9-4.9, and the b and B isolates of *F.solani* showed the highest disease severity index on radish seeds was 4.9 and 4.5 respectively, which is considered highly pathogenic according to this test. Besides, the remaining *F.solani* isolates, which are C and D, were pathogenic, as their disease severity index reached 3.8 and 3.7, respectively. Whereas the *F. oxysporum* isolates were distributed between Virulent, moderately virulent and low virulent, where the highest disease severity index reached 3.7 in the F and N isolates, while the other isolates of the fungus ranged between 1.9-3.6.

Table 1 : Disease severity index of *Fusarium* spp. isolates on radish seeds

Seq.	Isolation Code *	Disease severity index(DSI) **	Pathogenicity***
1	b (FS)	Virulent Strongly	4.9
2	B (FS)	Virulent Strongly	4.5
3	C (FS)	Virulent	3.8
4	D (FS)	Virulent	3.7
5	F (FOX)	Virulent	3.7
6	N (FOX)	Virulent	3.7
7	E(FOX)	Virulent	3.6
8	J (FOX)	Virulent	3.1
9	d (FOX)	Virulent Moderately	2.9
10	A (FOX)	Virulent Moderately	2.9
11	e (FOX)	Virulent Moderately	2.5
12	a (FOX)	Virulent Moderately	2.5
13	G (FOX)	Virulent Moderately	2.5
14	K (FOX)	Virulent Moderately	2.3
15	c (FOX)	Virulent Moderately	2
16	H	Virulent Low	1.9
17	I	Virulent Low	1.9
18	M	Virulent Low	1.9

* (FOX) = *Fusarium oxysporum* and (FS)= *Fusarium solani*

** Each number in the table represents the average of three replicates for each replicate 8 radish seeds

*** As 1<1 mm (the length of rot), 2 = 1⁻< 3 mm, 3 = 3⁻ < 5 mm, 4 = 5⁻ < 7 mm, 5 ≥ 7 mm or the seedling death

Pathogenicity test of *Fusarium* spp. isolates on the watermelon seedlings Sugar Baby

The results of the pathogenicity test of eight isolates for *Fusarium* spp. that has the highest disease severity index in the pathogenicity test on radish seeds on the watermelon seedlings Sugar Baby recorded a variation in the fungus infection percentage (Table 2). Moreover, the isolates differed significantly among themselves in causing an infection on the watermelon seedlings Sugar Baby. The isolate B belonged to *F.solani* showed the highest infection percentage reached 100% with significant differences from the rest of the tested fungus isolates, with an infection percentage ranged between 66.8 - 77.7%. Followed by the N isolate that belonged to *F.oxysporum*, which caused an infection percentage of 88.8% with significant differences from the rest of the tested fungus isolates, where the infection percentage ranged between 55.23 - 76.8%.

Table 2 : Test of isolates of the pathogen Fusarium spp. On watermelon, Seedlings class Sugar Baby

Seq.	Isolation Code *	Infection percentage%
1	B(FS)	100.00
2	b(FS)	77.70
3	C (FS)	77.70
4	D (FS)	66.83
5	E (FOX)	76.83
6	F (FOX)	66.10
7	J (FOX)	55.23
8	N (FOX)	88.80
9	Control	0.00
LSD 5%		1.553

Molecular identification of *Fusarium* spp:

The results of electrophoresis of DNA extracted from isolates of *Fusarium* spp. after its replication by a polymerase chain reaction device using a universal primer (internal transcribed spacer) ITS1 / ITS4 showed the formation of fragments with a molecular weight of approximately 550 base pairs. The nucleotide sequences of the ITS for the tested isolates were determined, and they were compared with global isolates in the NCBI GenBank (http://www.nebi.nlm.nih.gov), it was found that it belonged to *Fusarium solani*, which was submitted in the GenBank under the accession number (MT509567), and the fungus *Fusarium oxysporum*, which were submitted in the GenBank under accession number (MT509568).

The ability test of grafted watermelon to protect the watermelon plants from infection with *F. oxysporum* and *F. solani* in pots

The test results showed the ability of grafted watermelon to protect the watermelon plants from infection with the *F. oxysporum* and *F.solani* in pots as shown in Table 1. These results showed the superiority of the grafted watermelon plant treatment in both the treatment of the FOX treatment, FS treatment, FOX, and FS treatment, where the infection percentage reached 12.26, 25, and 12.36, respectively. Whereas, the infection percentage in normal watermelon plants in each of the FOX treatment, FS treatment, FOX and FS treatment reached 48, 62, and 55, respectively. Also, the grafted watermelon plants treatment was superior with significant differences in both the treatment of the FOX treatment, FS treatment, FOX and FS treatment. The infection percentage reached 12.26 and 12.36, respectively, compared with the fungicide treatment that its infection percentage reached 25. Besides, there was no significant difference between the grafted watermelon plants treatment in the FS treatment and the fungicide treatment, which its infection percentage amounted to 25 for both treatments. The ability of grafted watermelon plants was also reflected in some growth parameters, such as the length of branches and number of branches, where the grafted watermelon plants exceeded with significant differences in the average length of branches. As the length of branches in each of the FOX treatment, FS treatment, FOX and FS treatment and the fungicide treatment reached 50, 45, 39.66, respectively, compared with nongrafted watermelon plants in both the FOX treatment, FS treatment, FOX and FS treatment and the fungicide treatment, as the length of branches reached 39.80, 33.83, 34.33 and 34.43 cm, respectively. There was no significant difference between the grafted watermelon plants treatment + FOX and FS and nongrafted watermelon treatment + FS, as the average branch length reached 39.66 and 39.80 cm, respectively. The grafted watermelon plants treatment was also exceeded with a significant differences in both the treatment of the FOX treatment, FS treatment, FOX and FS treatment in the average number of branches. These treatments reached 3, 2.7, 2.5 branch / plant, respectively, compared with the normal watermelon plant in both the treatment of the FOX treatment, FS treatment, FOX and FS treatment and the fungicide treatment, where the average number of branches was 1.30, 1.50, 1.86, 2.06 branch / plant, respectively.

Table 1 : The ability test of the grafted watermelon to protect the watermelon plants from infection with the *Fusarium oxysporum* and *Fusarium solani* in pots

Seq.	Treatments	After 45 days of inoculum		
		Infection percentage%	Growth parameters of watermelon	
			Average length of branches (cm)	Average number of branches
1	Grafted plant + FOX	12.267	50.000	3.000
2	nongrafted plant + FOX	48.000	39.800	1.300
3	Grafted plant + FS	25.000	45.000	2.700
4	nongrafted plant + FS	62.000	33.833	1.500
5	nongrafted plant without fungus as comparison	0.000	49.200	2.867
6	Grafted plant + FOX + FS	12.367	39.667	2.500
7	nongrafted plant + FOX + FS	55.360	34.333	1.867
8	nongrafted plant + FOX + FS + fungicide	25.000	34.433	2.067
LSD 5%		1.633	2.793	0.267

* Each value in the table in the mean of 3 replication

The ability test of grafted watermelon to protect the watermelon plants from infection with *F. oxysporum* and *F. solani* in the field.

1. The test using drip irrigation within the greenhouse

The results of the grafted watermelon ability test to protect the watermelon plants from infection with the *F.oxysporum* and *F.solani* in the field within station B using the drip irrigation method implemented on 5/3/2020 (Table 2). These results showed that the grafted watermelon plants treatment was superior with significant differences in both the FOX treatment, FS treatment, FOX, and FS treatment. Furthermore, the infection rate was 19.66, 26.53, 6.53, respectively, as the infection percentage reached 19.66, 26.53, and 6.53, respectively, compared with nongrafted watermelon plants in each of the FOX treatment, FS treatment, FOX and FS treatment, and fungicide treatment, where the infection percentage was 39.66, 60, 40.33 and 33.10 respectively. Moreover, grafted watermelon plants exceeded in the growth parameters (length of branches, number of branches, number of leaves, a ratio of sexual expression, number of fruits), as it was observed that average length of branches of grafted watermelon plant in the FOX treatment amounted to 207.30 cm, with significant differences over the nongrafted watermelon plants, which amounted to 190.80 cm. Also, the grafted watermelon plants were superior in both of the FS treatment, FOX, and FS treatment in the average length of branches, which reached 192.10 and 181, respectively. Further, significant differences over the nongrafted watermelon treatment in the FS treatment, FOX, and FS treatment, where the average length of branches reached 160 and 144.60 respectively. Similarly, it was observed that all treatments exceeded in the average length of branches with significant differences over the fungicide treatment (methyl thiophenate), which reached 108 cm. In addition, the grafted watermelon plants exceeded in the average number of branches in both the FOX treatment, FS treatment, FOX and FS treatment reached 7, 6.76, and 6.93, respectively, with significant differences over the nongrafted watermelon plants in the FOX treatment, FS treatment, FOX and FS treatment and the fungicide treatment reached 6.26, 5, 5.5 and 5.56, respectively. Furthermore, there was a significant difference in the average number of leaves between the grafted watermelon plants in the FOX treatment reached 237.66 leaf/plant, compared with the nongrafted watermelon plants, which reached 186 leaf/plant. Also, a significant difference was observed in the average number of leaves between the grafted watermelon plants in both of the FS treatment, FOX and FS treatment reached 182 and 210.33 leaf/plant, respectively, compared with the nongrafted watermelon plants in the FS treatment, FOX and FS treatment and the fungicide treatment reached 130.33, 162 and 132.33, respectively. Moreover, the average ratio of sexual expression was higher in the grafted watermelon plants in both the FOX treatment, FS treatment, FOX, and FS treatment, which was 0.77, 0.47, and 0.45, respectively. Also, a significant differences compared with the nongrafted watermelon plants in each of the FOX treatment, FS treatment, FOX, and FS treatment and the fungicide treatment reached 0.29, 0.22, 0.39, and 0.41, respectively. Significant differences were also observed between the average number of fruits in grafted watermelon plants in each of the FOX treatment, FS treatment, FOX, and FS treatment, which amounted to 1.74, 1.49, 1.23 fruit/plant, respectively, compared with nongrafted watermelon plants in both the FOX treatment. Finally, FS treatment, FOX, and FS treatment and the fungicide treatment amounted to 0.52, 0.26, 1.05, 1.06 fruit/plant respectively.

Table 2 : The grafted watermelon ability to protect the watermelon plants from infection with the *Fusarium oxysporum* and *Fusarium solani* using drip irrigation method within the greenhouse

Seq.	Treatments	After 60 days of inoculum					
		Infection percentage %	Average length of branches (cm)	Average number of branches	Average number of leaves	Average sex expression	Average number of fruits
1	Grafted plant + FOX	19.66	207.30	7.00	237.66	0.77	1.74
2	Nongrafted plant + FOX	39.66	190.80	6.26	186.00	0.29	0.52
3	Grafted plant + FS	26.53	192.10	6.76	182.00	0.47	1.49
4	Nongrafted plant + FS	60.00	160.00	5.00	130.33	0.22	0.26
5	Nongrafted plant without fungus as comparison	6.23	173.33	6.00	168.00	0.51	1.51
6	Grafted plant + FOX + FS	6.53	181.00	6.93	210.33	0.45	1.23
7	Nongrafted plant + FOX + FS	40.33	144.60	5.50	162.00	0.39	1.05
8	Nongrafted plant + FOX + FS + fungicide	33.10	108.00	5.56	132.33	0.41	1. 06
LSD 5%		1.540	3.116	0.112	1.002	0.016	0.099

* Each value in the table in the mean of 3 replication

2. The test using surface irrigation method in the Abu Ghraib area

The results of the grafted watermelon ability test to protect the watermelon plants from infection with the *F.oxysporum* and *F.solani* in the field using the surface irrigation method (Table 3). These results showed that the grafted watermelon plants treatment was significantly superior in both the FOX treatment, FS treatment, FOX, and FS treatment. The infection percentage reached 13.40, 19.66, 6.53, respectively, compared with the nongrafted watermelon treatment in each of the FOX treatment, FS treatment, FOX, and FS treatment and fungicide treatment, as the infection percentage amounted to 33.43, 40.33, 32.76, 19.33, respectively. Furthermore, the grafted watermelon plants treatment was also significantly superior in improving vegetative growth parameters, which included length of branches (cm), number of branches, number of leaves, sex expression, and number of fruits. However, it was observed that the average length of branches of the grafted watermelon plants exceeded in both the FOX treatment, FS treatment, FOX, and FS treatment reached 113.33, 106, and 125 cm, respectively. In addition to significant differences from the rest of the nongrafted watermelon treatments in each of the FOX treatment, FS treatment, FOX and FS treatment, and the fungicide treatment, as the average length of branches was 75, 68.33, 83, and 74.33, respectively. Also, the grafted watermelon plants treatment exceeded in the average number of branches in both the FOX treatment and FS treatment, which reached 6.73 and 6.60 respectively, with significant differences over the normal watermelon plants in both of the FOX and FS treatments reached 4.70 and 4.23 respectively. Whereas, there was no significant difference in the grafted watermelon plants treatment + FOX and FS and the nongrafted watermelon treatment + FOX and FS, in which the average number of branches was 6.70 and 6.43, respectively. The average number of branches in grafted watermelon plants was superior in each of the FOX treatment, FS treatment, and FOX and FS treatment, which reached 6.73, 6.60 and 6.70, respectively, with significant differences, compared to nongrafted watermelon plants in the fungicide treatment which reached 5.20. There was a significant difference in the average number of leaves in the grafted watermelon plants in both the FOX and the FS treatments, in which the average number of leaves reached 150.33 and 140.66 leaf/plant, respectively, compared to the number of leaves in the normal watermelon plants in both treatments. Wherever, the average number of leaves reaches 70 and 90 leaf/plant, respectively, The treatment of grafted watermelon plants + FOX and FS was also superior in the average number of leaves, as it reached 155 leaf/plant with significant differences over the nongrafted watermelon treatment in both the treatment of the FOX and the FS treatments. As well as, the fungicide treatment, in which the average number of branches was 146.66 and 111.66 respectively, where the grafted watermelon plants treatment was superior in the average number of leaves in both the FOX and FS treatments, FOX and FS treatment. As the average number of leaves was 150.33, 140.66 and 155 leaf/ plant respectively, with significant differences compared to the fungicide treatment, which its average number leaves reached 111.66 leaf/plant. Moreover, a significant difference was observed in the average sex expression between the grafted watermelon plants in both the FOX treatment, FS treatment, FOX and FS treatment, in which the sex expression ratio was 0.24, 0.23, and 0.24 compared with the normal watermelon plants in both the FOX treatment, FS treatment, FOX and FS treatment and the fungicide treatment. The ratio of sex expression was 0.16, 0.17, 0.18 and 0.160, respectively. Furthermore, a significant difference was observed in the average number of fruits in grafted watermelon plants in each of the FOX treatment, FS treatment, FOX, and FS treatment reached 0.54, 0.42, and 0.56 fruit/plant, respectively. These results were compared with the number of fruits in normal watermelon plants in each of the FOX treatment, FS treatment, FOX, and FS treatment and the fungicide treatment reached 0.26, 0.31, 0.32, and 0.33 respectively.

Table 3 : The effect of *F. oxysporum* and *F. solani* isolates on the infection percentage of grafted and normal watermelon plant using a surface irrigation method

Seq.	Treatments	After 60 days of inoculum					
		Infection percentage %	Average length of branches (cm)	Average number of branches	Average number of leaves	Average sex expression	Average number of fruits
1	Grafted plant + FOX	13.40	113.33	6.73	150.33	0.24	0.54
2	nongrafted plant + FOX	33.43	75.00	4.70	70.00	0.16	0.26
3	Grafted plant + FS	19.66	106.00	6.60	140.66	0.23	0.42
4	Nongrafted plant + FS	40.33	68.33	4.23	90.00	0.17	0.31
5	Nongrafted plant without fungus as comparison	0.00	101.66	6.33	129.00	0.24	0.55
6	Grafted plant + FOX + FS	6.53	125.00	6.70	155.00	0.24	0.56
7	nongrafted plant + FOX + FS	32.76	83.00	6.43	146.66	0.18	0.32
8	nongrafted plant + FOX + FS + fungicide	19.33	74.33	5.20	111.66	0.16	0.33
LSD 5%		1.196	2.610	0.3095	5.107	0.016	0.008

* Each value in the table in the mean of 3 replication

- **Phenolic compounds estimation**

Table 4 showed the results of phenolic compounds estimation of both grafted and nongrafted plants in the drip irrigation test. These results showed an increase in the concentration of phenolic compounds in grafted watermelon plants compared with nongrafted watermelon plants. As there was an increase in the concentration of phenolic compounds with significant differences in the grafted watermelon plants treatment in both the FOX treatment, FS treatment, FOX, and FS treatment, as it reached 1.54, 1.42, and 1.41 respectively. These results were compared with the nongrafted watermelon plant treatment in both of the FOX treatment, the FS treatment, the FOX and FS treatment, and the fungicide treatment, which reached 1.15, 1.20, 1.22, and 1.34, respectively. Also, the grafted watermelon plants treatment exceeded in estimation the phenols concentration with significant differences over the normal watermelon plants in the surface irrigation test, as the estimation of phenols concentration in the grafted watermelon treatment was 2.05, 1.42, and 1.43, respectively. These treatments compared with the normal watermelon treatment in both of the FOX treatment, FS treatment, FOX and FS treatment, and the fungicide treatment, which reached 1.26, 1.15, 1.06, and 1.33 respectively.

Table 4 : The effect of Fusarium spp. isolates on the concentration of phenolic compounds in both of the grafted and normal watermelon plants

Seq.	Treatments	Station B within greenhouse	Abu-Ghraib field
1	Grafted plant + FOX	1.543	2.052
2	nongrafted plant + FOX	1.154	1.269
3	Grafted plant + FS	1.428	1.428
4	nongrafted plant + FS	1.204	1.152
5	nongrafted plant without fungus as comparison	1.136	1.271
6	Grafted plant + FOX + FS	1.411	1.438
7	nongrafted plant + FOX + FS	1.224	1.064
8	nongrafted plant + FOX + FS + fungicide	1.344	1.336
LSD 5%		0.0032	0.0014

Evrenosoglu *et al*. (2010) pointed out that the grafting of the watermelon plant cultivar (Crispy) on hybrids of squash, which is the rootstock Tz-148 and RS841 has led to an increase in the concentration of the phenolic compound such as Kaempferol in the grafted watermelon plants leaves compared to the normal watermelon plants. It was concluded that the ability of the rootstocks to resist pathogens is due to the high levels of phenolic compounds. Lvarez *et al*. (2015) also pointed out that the grafted watermelon plants (Robusta) (*Citrullus lanatus*) on the squash hybrid (Super Shintoza) (*Cucurbita maxima* × *Cucurbita moschata*) showed resistance to vascular wilt disease and withstand the root-knot nematodes. The grafted watermelon plant has become resistant to vascular wilt disease caused by *Fusarium oxysporum*, in addition to its effect on plant growth in terms of increasing root length, main stem length, number of side branches, number of leaves, number and weight of fruits, and the roots dry weightfound within specific agricultural applications evaluating and combining them with particular biological control factors including the use of sun protection covers, black polyethylene covers and the grafting of watermelon plant on the squash rootstocks plant observed that the grafted watermelon plants exceeded in all the studied traits. Finally, the infection percentage and severity reached 0%, and also exceeded in other growth parameters, which included length of branches, number of branches, biological weight, wet and dry weight of the root, and the percentage of plants that reached the production stage (Al-Shayal *et al*., 2020).

We are found the efficiency of grafted watermelon plants in controlling infection by the pathogenic fungi *F.oxysporum* and *F.solani* with significant differences compared with the nongrafted watermelon plants. The efficiency of watermelon plants sugar baby in identifying pathogenic isolates of the fungi *F. oxysporum* and *F. solani.* The efficiency of grafted watermelon plants in improving vegetative growth parameters compared with nongrafted watermelon plants. The concentration of phenols in the grafted watermelon plants increases compared with the nongrafted watermelon plants, which plays an important role in resisting infection with the two pathogenic fungi.

References

Álvarez-Hernández; Javier Zaragoza Castellanos-Ramos; César Leobardo Aguirre-Mancilla; María Victoria Huitrón-Ramírez; Francisco Camacho-Ferre (2015). Influence of Rootstocks on Fusarium Wilt, Nematode Infestation, Yield and Fruit Quality in Watermelon Production Ciênc. Agrotec. Lavras. 39(4).

Booth, C. (1971). Fusarium: laboratory guide to the identification of the major species. Kew, Surrey: Commonwealth Mycological Institute.

Davis, A.R.; Perkins-Veazie, P.; Sakata, Y.; Lopez-Galarza, S.; Maroto, J.V.; Lee, S.G. Huh, Y.C.; Sun, Z.; Miguel, A.; King, S.R.; Cohen, R.; Lee, J.M. (2008). Cucurbit grafting. Crit. Rev. Plant Sci. 27.

Evrenosoglu, Y.; Ozlem, A. and Nilay, O.L. (2010). phenolic content of some squash rootstocks used on watermelon (*Citrullus lanatus* (thumb.) Matsum and Nakai) growing and phenolic accumulation on grafted cultivar, African Journal of Agricultural Research Vol. 5(8).

Freeman, S. and Rodriguez, R.J. (1993). Arapid inoculation technique for assessing pathogenicity Fusarium oxysporum I. sp. niveum and I. o. melonis on cucurbits. Plant Dis. 77: 1198 of 1201.

Hao, W-y.; Ren, L-x.; Ran, W. and Shen, Q-r. (2010). Allelopathic effects of root exudates from watermelon and rice plants on Fusarium oxysporum f.sp. niveum. Plant Soil 336: 485–497.

Huitrón-Ramírezet, M.V.; Ricardez-Salinas, M. and Camacho-Ferre, F. (2009). Influence of grafted watermelon plant density on yield and quality in soil infested with melon necrotic spot virus . Hort Science. 44: 1838-1841.

Kareem, T.A. and Hassan, M.S. (2015). Comparison of Rhizoctonia solani Isolated from Soil in Baghdad – Iraq Genetically with world Isolates. Donnish Journal of Agricultural Research, 2: 29-35.

Keinath, A.P. and Hassell, R.L. (2014). Suppression of Fusarium wilt caused by Fusarium oxysporum f. sp. niveum race 2 on grafted triploid watermelon. Plant Dis. 98.

Kent, C. (2006). Assistant Professor, Department of Horticultural Science s, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Southwest Florida Research and Education Center, Immokalee, 34142.

King, S.R.; Davis, A.R.; Liu, W.; Levi, A. (2008). Grafting for disease resistance. HortScience 43.

Luo, J.; Ran, W.; Hu, J.; Yang, X. and Xu, Y. (2010). Application of bio-organic fertilizer significantly affected fungal diversity of soils. Soil Sci Soc Am J., 74: 2039–2048.

Najem, H.W. and Kareem, T.A. (2018). Morphological and molecular identification of *Monosporascus cannonballus* causal agent of melon root rot and plant decline in Iraq. J. Bio. Env. Sci. 13(6): 83-88.

Roberti, R.; Veronesi, A. and Flamigni, F. (2012). Evaluation of microbial products for the control of zucchini foot and root rot caused by *Fusarium solani* f. sp. cucurbitae race 1.Phytopathologia Mediterranea. 51: 317-331.

Slinkard, K. and Singleton, V.A. (1977). Total phenol analysis: automation and comparison with manual methods. American Journal of Enology and Viticulture, 28: 49-55.

Sneh, B.; Yamoah, E.; and Stewart, A. (2004). Hypovirulent Rhizoctonia spp. Isolates from New Zealand soils protect Radish seedlings against Damping-off caused by R. solani. New Zealand Plant Protection 57: 54-58.

Turoczi, G.; Posta, K.; Badenszky, L. and Ban, R. (2011). *Fusarium* wilt of watermelon caused by Fusarium solani in Hungary. Plant Breeding and Seed Science. 63: 23-28.

Wu, H.-S.; Liu, D.-Y.; Ling, N.; Bao, W.; Ying, R.-R. and Shen, Q.-R. (2009). Influence of root exudates of watermelon on Fusarium oxysporum f. sp. niveum. Soil Sci. Soc. Am. J. 73:1150–1156.

Yetisir, H.; Sari, S. and Yucel, S. (2003). Rootstock resistance to Fusarium wilt and effect on watermelon fruit yield and quality. Phytoparasitica, 31: 163-169.

Zhao, Q.Y.; Dong, C.X.; Yang, X.M.; Mei, X.L.; Ran, W.; Shen, Q.R. and Xu, Y.C. (2011). Biocontrol of Fusarium wilt disease for Cucumismelo melon using bio-organic fertilizer. Appl. Soil Ecol. 47: 67−75.

Al-Shayal; Hassan, Z.K.; Ismail, S.M. and Saeed, K.F. (2020). Efficiency of some agricultural methods and biological formulations in the management of the watermelon wilt disease caused by the fungus *Fusarium oxysporum* f.sp. melonis. College of Agriculture - University of Tikrit - Ministry of Higher Education and Scientific Research.