J. Agric. Sci. Mansoura Univ., 32 (8): 6787 - 6798, 2007

SUSCEPTIBILITY OF SOME CITRUS ROOTSTOCKS TO INFECTION WITH PHYTOPHTHORA ROOT ROT DISEASE AND ITS CONTROL IN EGYPT.

Mahrous, H.A.H.[1] and O. Y. Shalaby[2]

1 - Plant Pathology Research Institute, Agricultural Research Center, Giza, Egypt.

2- Agric. Botany Department, Faculty of Agriculture, Fayoum Univ., Fayoum, Egypt.

ABSTRACT

Evaluation of some citrus rootstocks against the causal fungus of citrus root rot, *i.e*., *Phytophthora parasitica* revealed that Sour orange was the most susceptible rootstock to infection with the tested fungus, while Volkamer lemon (*Citrus volkameriana*) was less susceptible to Phytophthora root rot, whereas Rangpour lemon and Troyer citrange were intermediate. Metalaxyl (Ridomil), Fosetyl-Al (Aliette), Agri-Fos 400 (Phosphorous Acid) and Chito care (Chitosan) gave good effect against Phytophthora root rot.

The greatest reduction in incidence and severity was obtained when the combined treatment of fungicides *i.e*., pre-planting +soil drench was applied.

Keywords: Citrus root rot, citrus rootstocks, fungicides, chito care (Chitosan), *biofertilizer, citrus volkameriana, Phytophthora parasitica*

INTRODUCTION

Citrus (*Citrus spp*.) are the most important among the fruit crops in the world particularly in the tropical and sub-tropical regions. In Egypt, citrus occupies the first rank among fruit crops. However, the cultivated area of citrus fruits reached 364798 feddans and the average of citrus production reached to 3030244 tons (Anonymous, 2005).

Under the Egyptian environmental conditions citrus is attacked by several diseases, among them Phytophthora gummosis and root rot which are considered the most serious fungal diseases of citrus causing considerable yield losses.

Klotz (1978) mentioned that Phytophthora gummosis and root rot are caused by *Phytophthora citrophthora* and *P. parasitica* in the United States. Both fungi are cited as major citrus pathogens in nurseries and groves in Arizona (Matheron *et al.*, 1997) and California (Fawcett, 1936 and Klotz *et al*., 1958), whereas *P. parasitica* alone is the primary pathogen in Florida (Timmer *et al*., 1993) and in Texas (Timmer, 1972 and 1973).

In citrus nurseries and orchards, diseases due to *Phytophthora spp* can be prevented or minimized by avoiding over irrigation, facilitating soil drainage (Anonymous, 1991). Moreover, using the systemic fungicides fosetyl-Al (Aliette) or metalaxyl (Ridomil) and choosing a rootstock with resistance to *Phytophthora spp*. (Davis, 1982),

The use of resistant rootstocks plays a critical role in the integrated disease management approaches. Due to the international importance of Phytophthora gummosis and root rot, several researchers have evaluated

several citrus rootstocks for resistance or tolerance to *Phytophthora spp* (Carpenter and Furr, 1962; Graham, 1990; Klotz *et al*; 1968 and Tuzeu *et al*.; 1984).

Rootstocks vary in their tolerance to *Phytophthora spp*. Previously, they were rated according to their root rot tolerance or resistance until the extent and importance of fibrous root loss caused by root rot had been established (Graham 1990). The same author added that Sour orange, Ridge Pineapple Sweet Orange, Cleopatra mandarin and Carrizo citrange were highly susceptible to *Phytophthora spp*., whereas trifoliate orange and Swingle citrumelo were tolerant rootstocks, while Volkamer lemon was intermediate between that two groups.

Fibrous root losses have been assumed to be minimal, except perhaps on highly susceptible rootstocks such as sweet orange. In general, sweet orange and some sources of rough lemon are considered highly susceptible to infection, whereas trifoliate orange, Swingle citrumelo and alenow are resistant (Carpenter and Furr, 1962 and Grimm and Hutchinson, 1973). Troyer and Carrizo citranges, Cleopatra mandarin and Sour orange are intermediate between the two extremes (Whiteside, 1974).

Losses attributable to Phytophthora gummosis and root rot have been reduced through the use of the systemic fungicides fosetyl-Al (Aliette) and metalaxyl (Ridomil) (Davis, 1982; Farih *et al.*, 1981; Sandler *et al.*, 1989 and Timmer and Castle, 1985). A single application of either fungicide can provide maximum protection from colonization by *P. citrophthora* and *P. parasitica* for at least 3 months.

The efficacy of the systemic fungicides, fosetyl-Al (Aliette) and metalaxyl (Ridomil) for control of Phytophthora root and crown rot of citrus has been demonstrated (Farih *et al.*, 1981; Laville and Chalandon, 1981; Davis, 1982; Timmer and Castle, 1985 and Ohr *et al.,* 1986). Wicks *et al.* (1990) found that the phosphonate as Foli-R. FOS was used to control Phytophthora root rot. Also, Boer *et al.* (1990) indicated that foliar sprays of phosphite controlled Phytophthora root rot (*Phytophthora parasitica*) by reducing severity of root rot. Ann (2001) indicated that application of high concentration (>1000ppm) of neutralized phosphorous acid could directly protect plants by inhibition and interference of mycelial growth and sporangial production of *Phytophythora* spp. and other member of Oomycetes

Another potential role for reducing the development of Phytophthora root rot is the use of bio-fertilizer (chitosan) such as chito care. Chitosan is a hydrophilic polysaccharide, which is soluble in dilute aqueous organic acid solutions and insoluble in pure water. Chitosan has been used as a seed treatment and a pesticide (Webster *et al.*, 2007).Also, they added that seed treatment with chitosan inhibited the fungus *Pythium aphanidermatum* and was useful for preventing the occurrence of the seedling blight disease of corn.

Sams *et al.* (2005) found that the area of decay on the surface of apples caused by *Botrytis cinerea, Penicillium expansum* and *Penicillium solitum* was reduced by all of chitosan treatments. They added that chitosan from all the three pathogens were effective at eliciting resistance to decay as was chitosan from commercial sources.

Therefore, the objectives of this study were to determine the relative susceptibility of some citrus rootstocks to infection with phytophthora root rot disease, to identify rootstocks that are resistant to Phytophthora root rot and to compare the effect of some fungicides and the bio-fertilizer (chitosan) on the development of Phytophthora root rot on Sour orange rootstock (highly susceptible).

MATERIALS AND METHODS

This experiment was carried out to study the relative susceptibility of some citrus rootstocks to infection with Phytophthora root rot disease.

The four citrus rootstocks namely, Sour orange, Volkamer lemon (*Citrus volkameriana*), Rangpour lemon and Troyer Citrange were evaluated against Phytophthora root rot disease. Rootstocks were arranged in a randomized complete block design with three replications of each rootstock .The tested fungus (*Phytophthora parasitica*) was isolated from infected citrus rootstocks roots and identified at the Mycological Department, Plant Pathology Research Institute, Agric. Res. Center, Giza, Egypt.

. Healthy rootstocks seedlings (one year old) were transplanted in heavy soil artificially infested with *Phytophthora parasitica* at the rate of 5% (w/w) (Mahrous, 1994). One seedling was transplanted in each pot. A set of 6 replicate pots was used for each treatment. The same number of seedlings for each rootstock was transplanted in disinfested soil amended with equal amounts of the uninoculated substrate to serve as control.

Data were recorded by counting the survived seedlings and subtracting from the total number of planted seedlings to obtain the number of dead seedlings at 60 days after planting.

Another experiment was carried out under natural field conditions. The seedlings were transplanted in the naturally infested soil (clay soil), *i.e.* plots naturally infested with *Phytophthora parasitica* the causal of root - rot disease.

Disease assessment:

In most cases disease assessment was determined as follows:

Number of dead plants due to Phytophthora root - rot was recorded 60 days after planting and the percentage of dead plants was calculated according to the original number of the used seedlings of citrus rootstocks. Moreover, the survived plants were also examined periodically.

Disease severity:

Severity of root - rot disease was estimated according to the disease index of grapevine root- rot proposed by Mahrous, (1994) as follows:

0- Roots with no visible disease symptoms.
1- Slight to moderate root discoloration from (1 to 25%)
2- Severe rot with extensive decay from (25.1 - 50%)
3- Very severe rot involving the crown area and most of the root system as well as the lower part of the stem with the absence of most lateral and feeder roots (more than 50.1 %)

Chemical control:

Formulation of four systemic and non-systemic combinations were tested for their efficiency in controlling Phytophthora root rot of citrus (*Phytophthora parasitica*) under greenhouse and field conditions.

1- Greenhouse experiments:

A-Pre-planting foliar spraying treatment:

Three different fungicides *i.e*., metalaxyl (Ridomil), fosetyl-Al (Aliette), Agri-Fos 400 (Phosphorous acid) and Bio-fertilizer Chito care (Chitosan) were used as suspensions at the rate of 5 grams, or 5 cm^3 for each fungicide or 5o $cm^3$for bio-fertilizer Chito care (Chitosan) separately per liter of water. Triton B or Agral as sticker was added to each fungicide or bio-fertilizer suspension at the rate of 0.5 ml/liter. Rootstock seedlings (Sour orange) were sprayed with the desired fungicidal suspension immediately before transplanting.

Treated Sour orange seedlings were transplanted in soil infested with *Phytophthora parasitica*. Three replicate pots with 6 seedlings "1/pot" were used for each treatment. Rootstock seedlings treated with water were used as control. Percentage of infection was estimated at 60 days after transplanting.

B- Soil drench treatment:

The three mentioned fungicides and bio-fertilizer Chito care (Chitosan) were used as suspensions at the rate of 5 grams or 5 cm^3 of each fungicide or 5o cm^3 for bio-fertilizer Chito care (Chitosan) separately per liter of water. Pots filled with soil infested with *Phytophthora parasitica* were drenched using one liter of the desired fungicidal suspension after transplanting directly. Three replicate pots with 6 citrus rootstock seedlings (Sour orange) were used for each treatment. Pots treated with water were used as control. Percentage of infection was estimated at 60 days after transplanting.

C- Combined treatment:

Sour orange seedlings were sprayed with the desired fungicidal suspension then transplanted in pots containing soil infested with each of the tested fungus. After transplanting directly, the soil in each pot was also drenched with the desired fungicidal suspension as mentioned before. Percentage of infection was estimated at 60 days after soil drenching.

2- Field Experiments:

A-Pre-planting foliar spraying treatment:**:**

Three different fungicides and bio-fertilizer (chitosan) were used as suspensions at the rate of 5 grams or 5 cm^3 for each fungicide per liter of water, adding to this suspension Triton B at 0.5 ml/liter. Sour orange seedlings were sprayed with the fungicidal suspension immediately before transplanting. Sour orange seedlings were examined at 60 days after transplanting to estimate the number of diseased seedlings. Sour orange seedlings were sprayed with water to serve as control.

B. Soil drench treatment:

The three mentioned fungicides and bio-fertilizer (chitosan) were used as mentioned before. Soil prepared for transplanting was drenched with one liter of the fungicidal or bio-fertilizer suspension after transplanting

directly above the roots then watered. Soil treated with water by the same manner served as control. Diseased plants were counted 2 months after transplanting.

C- Combined treatment:

Sour orange seedlings were sprayed with the desired fungicidal or bio-fertilizer suspension as described before. After planting directly, the soil was also drenched with the desired fungicidal suspension as mentioned before. Diseased Sour orange seedlings were counted in both treated and untreated soils 2 months after soil drenching treatment.

The sprayed substances efficiency:

The efficiency of the sprayed substances in controlling the disease was determined according to the following equation (Ghoneim, 1991):

$$\% \text{ Efficiency} = \frac{\% \text{ infection in control} - \% \text{ infection in the treatment}}{\% \text{ infection in control}} \times 100$$

Statistical analysis of the obtained results was carried out according to Snedecor and Cochran (1972).

RESULTS

This experiment was carried out to determine the relative susceptibility of some citrus rootstocks, *i.e*. Sour orange, Volkamer lemon (*Citrus volkameriana*), Rangpour lemon and Troyer citrange to infection with phytophthora root rot disease.

Data presented in Table (1) clearly show that percentage of dead plants was significantly varied according to soil infestation with the tested fungus. Meanwhile, all the control plants were remained healthy.

The tested citrus rootstocks exerted significant difference in the percentage of dead plants. Sour orange, exhibited the highest percentage of dead plants, being 100% while rootstocks *i.e.*, Rangpour and Troyer showed intermediate infection, being 66.67and 66.67% on the average, respectively. Meanwhile, Volkameriana rootstocks showed the lowest infection, being 33.33 % dead plants on the average, respectively.

Table (1): Reaction of different citrus rootstocks to Phytophthora root rot .

Citrus Rootstocks	% infection in soil infested artificially with *Phytophthora parasitica*				Citrus rootstocks grown in naturally infested soil	
	Disease incidence		Disease severity			
	Dead plants, %	Survivals, %	Length of discolored area inside root (cm)	Length of discolored area on the root (cm)	Infection, %	Survival, % **
Sour orange	100.00	00.00	11.73	08.52	60.83	39.17
Volkamer lemon	33.33	66.67	04.20	01.87	10.67	89.33
Rangpour lemon	66.67	33.33	07.18	04.22	35.50	64.50
Troyer citrange	66.67	33.33	08.40	05.74	28.70	71.30
LSD at 0.5%	3.4	-	0,73	0.85	1.76	-

***All the control plants were healthy**.

The response of any tested citrus rootstock to infection with *Phytophthora parasitica* exerted significant differences.

Data (Table,1) show that under natural field conditions, where Sour orange seedlings were transplanted in the naturally infested soil *i.e*., pots naturally infested with Phytophthora root-rot showed lower values in the percentage of dead plants in comparison with those obtained from the artificially inoculated pots. Varietal susceptibility results collected from the field showed the same trend of that obtained from the greenhouse experiment (Table, 1).

Generally, Sour orange was the most vulnerable rootstock, while Volkamer Lemon was far the least affected. Meanwhile, Rangpour lemon and Troyer Citrange were relatively intermediate.

Concerning disease severity *i.e*., length of discolored tissues on and inside the root, data (Table, 1) show the same trend. The length of discolored zone on and inside the roots was increased in the case of Sour orange rootstock. Meanwhile, Rangpour and Troyer were relatively intermediate, while the length of discolored zone on and inside the roots was decreased in the case of Volkamer lemon (*Citrus volkameriana*).

With regard to varietal susceptibility, different ranges of disease severity were manifested by the tested rootstocks indicating different levels of susceptibility. Data indicate that among the four citrus rootstocks tested during this study against Phytophthora root-rot disease, the response of any tested rootstock to infection with the disease exerted significant differences. Sour orange was the most susceptible to infection with the tested fungus. Rangpour lemon and Troyer citrange were moderately susceptible, while Volkamer lemon was the least susceptible to the Phytophthora root-rot.

Chemical control

1- Greenhouse experiments

A. Pre-planting foliar spraying treatment.

Pot experiments were conducted to study the effect of some fungicides on Phytophthora root-rot disease incidence by treating roots of the seedlings before transplanting.

Data in Table (2) show that the different fungicides were differed in their effect on disease incidence caused by the tested fungus under greenhouse. The disease incidence values at 60 days after transplanting reached 13.44, 20.33, 29.12, 37.83 and 70.33% for Ridomil, Aliette, Agri-Fos 400, Chito care and the control treatments, respectively. This indicated that Ridomil and Aliette significantly decreased the disease incidence in comparison with the other tested fungicides.

B. Soil drench treatment.

Results in Table (2) indicate that the fungicides showed significant differences due to their effect on the incidence of Phytophthora root-rot disease, the disease incidence after 60 days recorded 18.47, 20.32, 25.87, 35.27 and 70.33% for Ridomil, Aliette, Agri-Fos 400, Chito care and the control treatments, respectively.

Data in Table (2) show that the different fungicides were differed in their effect on disease incidence caused by the tested fungus under greenhouse conditions. The disease incidence at 60 days after transplanting was 13.44,

20.33, 29.12, 37.83 and 70.33% for Ridomil, Aliette, Agri-Fos 400, Chito Care and the control treatments, respectively.

Table (2): Effect of some fungicides on the incidence of Phytophthora root rot of Sour orange rootstock under green house conditions after 60 days from transplanting.

Fungicides	Rate of use	Dead plants,%	Survivals, %	Efficiency,%
Pre-planting treatment				
Control (Untreated)	00.00	70.33	29.67	00.00
Ridomil	5g/1L.w	13.44	86.56	80.89
Aliette	5g/1L.w	20.33	79.67	71.09
Agri-Fos 400	5 cm^3/1L.w	29.12	70.88	58.59
Chito care	50cm^3/1L.w	37.83	62.17	46.21
L.S.D at 5%	-	3.42	-	-
Soil drench *treatment*				
Control (Untreated)	-	70.33	29.67	-
Ridomil	5g/1L.w	18.47	81.53	73.74
Aliette	5g/1L.w	20.32	79.68	71.11
Agri-Fos 400	5 cm^3/1L.w	25.87	74.13	63.22
Chito care	50cm^3/1L.w	35.27	64.73	49.85
L.S.D at 5%	-	2.38	-	-
Combined treatment				
Control (Untreated)	00.00	70.33	29.67	-
Ridomil	5g/1L.w	00.00	100.00	100.00
Aliette	5g/1L.w	00.00	100.00	100.00
Agri-Fos 400	5 cm^3/1L.w	10.00	90.00	8578
Chito care	50cm^3/1L.w	22.00	78.00	68.72
L.S.D. at 5%	-	2.59	-	-

Data indicate that Ridomil and Aliette significantly decreased the disease incidence in comparison with the other tested fungicides.

C. Combined treatment:

Data (Table 2) show that the tested fungicides clearly decreased the disease incidence percentage of citrus root-rot. The disease incidence after 60 days from transplanting was 00.00, 00.00, 10.00, 22.00 and 70.33% for Ridomil, Aliette, Agri-Fos 400, Chito Care and the control treatments, respectively indicating that Ridomil and Aliette were the best treatments for decreasing the disease incidence.

2. Field experiments:

Experiments were conducted under natural field conditions to study the effect of different fungicides on Phytophthora root-rot disease incidence.

A. Pre-planting foliar spraying treatment:

Data presented in Table (3) show that the four fungicides used to spray Sour orange seedlings with their suspensions separately before transplanting significantly decreased root-rot disease. After 60 days from transplanting, disease incidence recorded values were 15.24, 20.67, 27.42, 32.83 and 69.33% for Ridomil, Arietta, Agri-Fos 400, Chito care and the control treatments, respectively.

Table (3): Effect of some fungicides on the incidence of Phytophthora root rot of Sour orange rootstock under field conditions after 60 days from transplanting.

Fungicides	Rate of use	Dead plants %	Survivals %	Efficiency %
Pre-planting treatment				
Control (Untreated)	-	69.33	30.67	-
Ridomil	5g/1L.w	15.24	84.76	78.02
Aliette	5g/1L.w	20.67	79.33	70.19
Agri-Fos 400	5cm^3/1L.w	27.42	72.58	60.45
Chito care	50cm^3/1L.w	32.83	67.17	52.65
L.S.D at 5%	-	3.62	-	-
Soil drench				
Control (Untreated)	-	69.33	30.67	-
Ridomil	5g/1L.w	19.47	80.53	71.92
Aliette	5g/1L.w	22.32	77.68	67.81
Agri-Fos 400	5 cm^3/1L.w	29.87	70.13	56.92
Chito care	50cm^3/1L.w	39.27	60.73	43.36
L.S.D at 5%	-	2.81	-	-
Combined treatments				
Control (Untreated)	-	69.33	30.67	-
Ridomil	5g/1L.w	00.00	100.00	100.00
Aliette	5g/1L.w	00.00	100.00	100.00
Agri-Fos 400	5 cm^3/1L.w	07.00	93.00	89.90
Chito care	50cm^3/1L.w	17.00	83.00	75.47
L.S.D. at 5%	-	2.67	-	-

B. Soil drench treatment:

Data presented in Table (3) show that the used fungicides added as soil drench had significant effect on Phytophthora root-rot disease incidence. The fungicides were clearly differed in their effect and any of them was not able to cause a complete control for this disease. The infection percentages after 60 days were 19.47, 22.32, 29.87, 39.27 and 69.33% for Ridomil, Aliette, Agri-Fos 400, Chito Care and the control treatments, respectively.

C. Combined treatment:

Data (Table, 3) indicate significantly that this treatment was the best during this study. All the used fungicides were more effective when compared to the untreated control. Ridomil and Aliette gave a complete disease control and no visible disease symptoms were noticed for a period of two months. When Agri-Fos 400 and Chito care were used, disease incidence percentage reached 7.00 and 17.00 %, respectively, while the disease incidence percentage of control was 69.33% after 60 days.

DISCUSSION

The present study was carried out to determine the relative susceptibility of some citrus rootstocks to infection with Phytophthora root rot, to identify rootstocks that are resistant to Phytophthora root rot.

With regard to varietal susceptibility, different ranges of disease severity values were manifested by the tested rootstocks indicating different levels of susceptibility. Data indicate that among the four citrus rootstocks tested during this study against Phytophthora root-rot disease, the response

of any tested rootstock to infection with the disease exerted significant differences. Sour orange was the most susceptible to infection with the tested fungus. Rangpour lemon and Troyer citrange were moderately susceptible, while Volkamer lemon was the least susceptible to the Phytophthora root rot. This result confirms the previous findings concerning on the relative susceptibility of some citrus rootstocks to infection with Phytophthora root rot (Carpenter and Furr, 1962; Grimm and Hutchinson, 1973 and Graham, 1990). The work was expanded to compare the effect of some fungicides and a bio-fertilizer (chitosan) on the development of Phytophthora root rot on Sour orange rootstock (highly susceptible).

Under greenhouse conditions using the different fungicides as suspensions for controlling Phytophthora root-rot by foliar spraying before transplanting in soil infested with *Phytophthora parasitica*, caused different effects on disease incidence. Ridomil and Aliette significantly reduced the disease incidence than other fungicides used when the soil was infested with *Phytophthora parasitica*.

Date also show that the effect of spraying Sour orange seedlings with suspensions of different fungicides before transplanting in soil infested with Phytophthora root rot was differed significantly according to the action of fungicides. Matheron and Matejka (1991) came to the same conclusion.

Using the different fungicides as soil drenches under the greenhouse conditions when the soil in the pots was infested with *Phytophthora parasitica* showed that the Phytophthora root rot incidence was much affected by Ridomil and Aliette than using other fungicidal treatments and the control.

The results of the present investigation indicated that the best fungicides used were Ridomil and Aliette for controlling Phytophthora root-rot after transplanting by drenching soil. Meanwhile, the least effective formulations were Agri-Fos 400(fungicide) and Chito Care (bio–fertilizer). Combining all methods of control in one time, the used fungicides decreased very much the disease incidence of citrus root rot.

Under natural conditions pre-planting foliar spray with the suspensions of different fungicides gave good effect in controlling Phytophthora root-rot incidence. However, Ridomil and Aliette were the best. Drenching different fungicides to soil proved that Ridomil, Aliette, Agri-Fos 400 and Chito care decreased the disease incidence percentage in the field than the control.

Combining all methods of control in the field showed significantly that Ridomil and Aliette gave a complete effect and no visible disease symptoms were noticed. Similar results were obtained by Matheron and Matejka (1991).

Accordingly, Ridomil and Aliette can be recommended for controlling Phytophthora root-rot disease of citrus by using the combined treatments method under natural conditions in the field.

Phosphoric acid (H_3PO_3) and its salts (phosphite or phosphonate) are reduced phosphorus compounds, which could be used as a fertilizer. Many researchers were interested in the functions and the mechanisms of this kind of compounds on disease control since it was very effective in controlling Phytophthora diseases in 1980s. Several reports, in early years, indicated that application of high concentration (>1000 ppm) of neutralized

phosphorous acid could directly protect plants by inhibition and interference of the mycelial growth and sporangial production of *Phytophthora* spp. and other members of Oomycetes. However, it was subsequently found that the indirect effect of inducing host resistance against the pathogens is a more important action contributing to disease control. Disease reduction was associated with increase in production and accumulation of phytoalexins, phenolic compounds or other antifungal substances. Currently, most researchers believe that phosphorous acid has both direct (plant protection) and indirect (host defense) modes of actions, but plant defense induced by the chemical is more important in breaking down pathogen attack. Commercialized products of phosphorous acid include fungicides such as Foli-R-Fos 400 (20% H_3PO_3) and fertilizers such as Nutri-Phite P Foliar (4-30-8) and Guard PK (7-21-21) for disease control. These products are commonly used for control of citrus foot and root rot caused by *Phytophthora* spp. (Ann, 2001).

REFERENCES

Ann, P.J. (2001). Control of plant diseases with non-pesticide compound-phosphorous acid. Plant Pathology Bulletin. 10 (4): 147-154.

Anonymous (1991). Integrated Pest Management for Citrus. 2nd ed. Division of Agriculture and Natural Resources, Publ. 3303. Oakland, CA.

Anonymous (2005). Annual Report of Agric. Statistical Dept. Egyptian Min. of Agric. A.R.E. (In Arabic).

Boer, R.F. de; F.C. Greenhalgh; K.G. Pegg; P.E. Mayers; T.M. Lim and S. Flett (1990). Phosphorous acid treatments control phytophthora diseases in Australia. Bulletin- OEPP. 20(1): 193-197.

Carpenter, J. B. and J. R. Furr (1962). Evaluation of tolerance to root rot caused by *Phytophthora parasitica* in seedlings of citrus and related genera. Phytopathology 52:1277-1285.

Davis, R.M. (1982). Control of Phytophthora root and foot rot of citrus with systemic fungicides metalaxyl and phosethyl aluminum. Plant Dis. 66:218- 220.

Farih, A.; J.A. Menge; P.H. Tsao and H.D. Ohr (1981). Metalaxyl and efosite aluminum for control of Phytophthora gummosis and root rot on citrus. Plant Dis. 65: 654-657.

Fawcett, H.S. (1936). Citrus Diseases and Their Control. McGraw-Hill, New York.

Graham, J.H. (1990). Evaluation of tolerance of citrus rootstocks to Phytophthora root rot in chlamydospore infested soil. Plant Dis.74:743-746.

Ghoneim, S.S. (1991). Studies on Mango Rot in Egypt. Ph.D. Thesis, Faculty of Agric. Ain Shams Univ.

Grimm,G.R., and Hutchison, D.J. (1973). A procedure for evaluating resistance of citrus seedlings to *Phytophthora parasitica*. Plant Dis. Rep. 57: 669-672.

Klotz, L.J. (1978). Fungal, bacterial, and non-parasitic diseases and injuries originating in the seedbed and nursery orchard. Pages 1-66 in: the Citrus Industry. Vol. 4, Crop Protection. W. Reuther, E. C. Calavan and G. F. Carman, eds. University of California Agricultural Sciences Publications, Richmond.

Klotz, L. J.; T. A. De Wolfe and P. P. Wong (1958). Influence of two varieties of *Citrus* scions on the pathogenicity of three isolates of *Phytophthora parasitica* to sweet orange rootstocks. Phytopathology 48: 520-521.

Klotz, L.J.; W.P. Bitters; T.A. De Wolfe and M.J. Garber (1968). Some factors in resistance of citrus to *Phytophthora* spp. Plant. Dis. Rep., 52: 952-955.

Laville, E.Y. and A.J. Chalandon (1981). Control of Phytophthora gummosis in citrus with foliar sprays of fosetyl-Al, a new systemic fungicide. Proc. Int. Soc. Citric. 1: 346-349.

Mahrous, H.A.H. (1994). Studies on root-rot disease of grapevine. Ph.D. Thesis, Fac. Agric., Fayoum Cairo Univ.

Matheron, M.E. and J.C. Matejka (1991). Effect of Sodium Tetrathiocarbonate, Metalaxyl, and Fosetyl-Al on development and control of Phytophthora root rot of citrus. Plant Dis. 75:264-268.

Matheron, M.E.; M. Porchas and J.C. Matejka (1997). Distribution and seasonal population dynamics of *Phytophthora citrophthora* and *P. parasitica* in Arizona citrus orchards and effect of fungicides on tree health. Plant Dis. 81:1384-1390.

Ohr, H.D.; M.K. Murphy and G. Bender (1986). Control of Phytophthora root rot in container-grown citruc. Calif. Agric. 40:18-19.

Sams, C.E.; S. Zivanovic; C.S. Charron; T. Wu; A.B. Blodgett and W.S. Conway (2005). Fungal chitosan extracts are as effective in reducting decay caused by *Botrytis cinerea*, *Penicillium expansum* and *Penicillium solitum* as commercial seashell chitosan extracts. Phytopathology. 95 (SUPPL.): Abstract. P. 591.

Sandler, H.A.; L.W. Timmer; J.H. Graham and S.E. Zatko (1989). Effect of fungicide applications on populations of *Phytophthora parasitica* on feeder root densities and fruit yields on citrus trees. Plant Dis., 73: 902-906.

Snedcor, G.W. and Cochran, W.G. (1972). Statistical Methods. 6th ed. Ames, Iowa, the Iowa State Univ. Press

Timmer, L.W. (1972). Management of soil-borne diseases of citrus in the Lower Rio Grande Valley. J. Rio Grande Valley Hortic. Soc. 26:44-58.

Timmer, L.W. (1973). Characteristics of *Phytophthora* isolates from Texas citrus orchards. J. Rio Grande Valley Hortic. Soc. 27:44-

Timmer, L.W. and W.S. Castle (1985). Effectiveness of metalaxyl (Ridomil) and fosetyl- Al against *Phytophthora Parasitica* on sweet orange. Plant Dis., 96:741-743.

Timmer, L.W.; J.A. Menge; S.E. Zitko; E. Pond; S.A. Miller and E.L. Johnson (1993). Comparison of ELISA techniques and standard isolation methods for *Phytophthora* detection in citrus orchards in Florida and California. Plant Dis. 77:791-796.

Tuzcu, O.; A. Cinar; M.O. Goksedef; M. Ozsan and M. Bicici (1984). Resistance of citrus rootstocks to *Phytophthora citrophthora* during winter dormancy. Plant Dis., 68: 502-505.

Webster, C.; O.U. Onokpise; J.J. Muchovej; M. Abazinge and E. Johnson (2007). The Extraction of Chitosan from *Callinectes sapidus* (Blue Crab) on the Germination of Sweet Corn Seeds Inoculated with *Pythium aphanidermatum*.(http.//www.fshs org / Meetings/2007/All – Abstracts – FSHS-2007-For WebSite-April 27htm)

Whiteside, J.O. (1974). Zoospore inoculation techniques for determining the relative susceptibility of citrus rootstocks to foot rot. Plant Dis. Rep., 58: 713-717.

Wicks, T.J.; P.A. Magarey; R.F.de. Boer and K.G. Pegg (1990). Evaluation of phosphonic acid as a fungicide in Australia. Brighton – Crop Protection Conference, Pests and Diseases, 1: 97-102.

قابلية بعض أصول الموالح الجذرية للإصابة بمرض عفن الجذر الفيتوفثورى ومقاومته في مصر.

حسين عبد القوي حسين محروس[١] و أسامة يوسف شلبى[٢]

١- معهد بحوث أمراض النباتات ، مركز البحوث الزراعية – جيزة – مصر.

٢- كلية الزراعة ، جامعة الفيوم – الفيوم – مصر.

من خلال التجارب التي أجريت على أصول الموالح المختلفة ، أظهرت نتائج دراسات قابلية بعض أصول الموالح للإصابة بعفن الجذر المتسبب عن *Phytophthora parasitica* أن الأصل الجذري النارنج كان أكثر الأصول المختبرة حساسية للإصابة ، بينما كان الأصل الجذري Volkamer lemon (*Citrus volkameriana*) أقل الأصول حساسية للإصابة.

وفيما يتعلق بتجارب المقاومة أظهرت النتائج أيضاً أن الريدوميل ، الأليت ، الأجريفوث٤٠٠ (Agri-Fos 400) ، والشيتوكير (Chito care) كان لها تأثيراً جيداً في مقاومة مرض عفن الجذور على شتلات أصول الموالح المدروسة تحت ظروف الصوبة والحقل. ويعتبر الريدوميل و الأليت أ فضل المبيدات المختبرة في مقاومة المرض وكانت معاملة رش الشتلات قبل زراعتها مع غمر التربة حول الشتلات بآي من المبيدات المستخدمة أفضل في مقاومة المرض.