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Effect of Salinity on Root Rot of *Cucumis melo* L. Caused by *Phytophthora melonis*

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ABSTRACT

Cultivars of *Cucumis melo* L. are important economic crops planted in both saline and non-saline soils in Iran. Root rot on *C. melo* caused by *Phytophthora melonis* is one of the most devastating soil-borne diseases causing great loss. *C. melo* crops cultivated in saline soil adjacent to Maharloo Lake (salt lake) in Fars Province have been associated with diseases caused by *Phytophthora* species for many years. In this study, effect of salinity on Phytophthora root rot on *C. melo* under hydroponic system was investigated: Four-week-old plants of three cultivars, namely, Shahde-Shiraz, Dastanbo-Khorasan, and Kharbozeh-Mashhad grown in Nukaya solution were subjected to salinity stress for one week. A week later, all plants were inoculated with zoospore suspension of *P. melonios.* After 48 hours, inoculated solution was replaced by fresh nutrient solution and post-inoculation salt-stressed treatment was applied to some plants. Based on shoot dry weight and concentration of Na^+, K^+, and Cl^-, cultivars Shahde-Shiraz and Dastanbo-Khorasan were sensitive and resistant to salinity and also with the highest and lowest colonization of roots by *P. melonis*, respectively. Interaction of salinity and infection by *P. melonis* reduced shoot dry weight in the salt-tolerant cultivar more than salt-sensitive plants. Salinity increased root colonization by *P. melonis* compared to non-saline condition. The increase in root colonization due to salinity was not significantly different in Shahde-Shiraz and Kharbozeh-Mashhad cultivars. In Dastanbo-Khorasan, due to its higher resistance to *P. melonis*, salinity resulted in significant increase in root colonization, indicating reduction of root resistance due to salinity stress.

Keywords: Dastanbo-Khorasan, Root colonization, Salt stress, Shahde-Shiraz.

INTRODUCTION

Cucumis melo L. is one of the major crops in arid and semiarid regions worldwide, many of which have an indigenous salinity problems (Meiri *et al*., 1981). In these regions, accumulation of salt at root zone is one of the major environmental threats to plant growth (Weicht and MacDonald, 1992) and several root diseases are aggravated under saline soil conditions (Blaker and MacDonald, 1986; Rasmussen and Stanghellini, 1988). Annual production of cantaloupe and other melons in Iran has been estimated around 1,615,642 tons cultivated in more than 82,000 ha (FAOSTAT, 2016). Climatic conditions of Iran are mostly typical of arid and semi-arid regions. Salinity of soil and water resources is a serious threat in many parts of the country. In these area, poor water management and irrigation system, inadequate soil drainage, geological conditions, climatic factors (evaporation, rain fall, and wind), and salt transport by water often result in the accumulation of salt (Siadat *et al*., 1997). Depending on severity and duration, salinity stress can change various physiological and metabolic processes, and ultimately inhibit crop production (Rozema and Flowers, 2008; James *et al*., 2011). Initially, soil salinity represses plant growth as a result of osmotic

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stress and ion toxicity (Rahnama *et al*., 2010; James *et al*., 2011). The growth and fruit yield of "Verna" lemon trees was decreased by increasing salinity in the root zone (Cerda *et al*., 1990). Osmotic stress in the initial stage of salinity stress causes various physiological changes, such as interruption of membranes, nutrient imbalance, and decreased photosynthetic activity (Munns and Tester, 2008; Rahnama *et al*., 2010). Accumulation of Na^+ and Cl^- ions in tissues of plants exposed to soils with high NaCl concentrations is the other effect of salinity stress. NaCl salinity raised the concentration of Na^+ and Cl^- in young and old leaves of cucumber and suppressed the K^+ concentration (Trajkova and Papadantonakis, 2006). Entry of both Na^+ and Cl^- into the cells causes severe ion imbalance and excess uptake might cause significant physiological disorders. High Na^+ concentration inhibits uptake of K^+ ions, which is an essential element for growth and development, resulting in lower productivity and even probable death (James *et al*., 2011).

In Iran, melons are infected by several soil-borne and air-borne oomycetes and fungi such as *Pythium aphanidermatum*, *Podosphaera fusca*, *Fusarium oxysporum* f. sp. *melonis*, *Monosporascus cannonballus*, *Macrophomina phaseolina* (Banihashemi, 1968; Rahimian and Banihashemi, 1979; Banihashemi, 1982; Banihashemi and Zakeri, 1989; Sarpeleh and Banihashemi, 2000; Sarpeleh, 2008; Roustaee *et al*., 2011; Mirtalebi *et al.*, 2013). Among soil-borne diseases, root and crown rot caused by *P. melonis* Katsura is considered as an important disease of melons (Ershad, 1971; Banihashemi and Fatehi, 1989; Khosrowfar and Banihashemi, 2003). The status of *P. melonis* as a species is problematic because it is morphologically similar to *P. drechsleri* which is suggested to be conspecific (Ho, 1986). However, based on isozyme and mitochondrial DNA analysis, *P. melonis* was maintained as a distinct species (Mills *et al*., 1991). Phylogenetic reconstruction of the Internal Transcribed Spacer (ITS) region of rDNA revealed that *P. melonis* isolates from cucurbit and non-cucurbit plants were highly uniform, thus *P. melonis* was placed in distinct clade comprised of *P. sinensis* (Mostofizadeh- Ghalamfarsa, 2005). Mostofizadeh-Ghalamfarsa (2005) considered *P. melonis* and *P. sinensis* to be conspecific but not in the same clade with *P. drechsleri*. The species is hereby re-described to facilitate accurate identification of *P. melonis* (Ho *et al.*, 2007). Recent studies by Mostofizadeh-Ghalamfarsa (2015), on a worldwide collection of *Phytophthora* species isolated from cucurbit and non-cucurbit hosts, found that all of the cucurbit isolates previously identified in Iran as *P. drechsleri* (Ershad, 1971) were distinct, which was regarded as *P. melonis* and placed it in a different clade from *P. drechsleri*.

Salinity stress has been shown to increase the susceptibility of several crops such as citrus, chrysanthemum, chilli pepper, and tomato to Phytophthora root rots (MacDonald, 1984, Blaker and MacDonald, 1986; Swiecki and MacDonald, 1988; Swiecki and MacDonald, 1991; Sanogo, 2004). In addition, extensive use of fertilizer salts increased damping-off disease of tomato seedlings caused by *Rhizoctonia solani* or *Fusarium oxysporum* f. sp. *lycopersici* (Beach, 1949). In pistachio, salt stress significantly increased shoot and root colonization by *Verticillium dahliae* (Mohammadi *et al*., 2007; Saadatmand *et al*., 2008), whereas salt stress had only a minor effect on root rot caused by *P. citrophthora* in salt-sensitive pistachio rootstock and had no effect on salt-tolerant root stock (Banihashemi and Tabatabaee, 2004).

Most melons in Iran are grown in areas where salinity of soil is a problem, such as soils adjacent to Maharloo Lake in Fars Province (Matinfar and Zandieh, 2016). However, limited information is available on salinity effect on Phytophthora root rot of melons, therefore, the present study was conducted to assess the effects of NaCl levels on susceptibility of salt-stressed and non-stressed melons roots to colonization by *P. melonis*.

MATERIALS AND METHODS

Preliminary Experiment on Salinity Effect on Some Iranian *C. melo* Cultivars

Seeds of local long melon (Kharbozeh-Mashhad) and cantaloupe (Shahde-Shiraz, Majidi-Abarkoh, Dastanbo-Khorasan and Semsori-Maharloo) were surfaced-disinfested with 1% sodium hypochlorite for 5 min, rinsed twice using sterile distilled water, sown in pots containing 2,000 g oven dry weight virgin sandy loam soil (pH= 7.9, Organic matter= 2.2%, and Electrical conductivity= 0.83 dS m^{-1}) and irrigated with distilled water to field capacity. Pots were kept in greenhouse (25-30°C, 14 hours photoperiod). Four levels of salinity (0, 750, 2,250, and 3,000 mg NaCl kg^{-1} soil) were used six weeks after planting. The experiment was arranged in a completely randomized design having four replicates.

Effect of Salinity Stress on Development of *P. melonis* Root Rot in *C. melo* Cultivars.

Growing Seedlings

Seeds of selected *C. melo* cultivars (Shahde-Shiraz, Kharbozeh-Mashhad and Dastanbo-Khorasan) were surface-disinfested as described above and planted in plastic trays filled with autoclaved vermiculite. Seedlings were grown in vermiculite at room temperature (25-30°C).

Plants Grown in Nutrient Solution

Ten days after germination, seedlings were removed and their roots were washed with tap water to remove excess vermiculite and grown hydroponically in the greenhouse. Ten-day-old seedlings were transplanted into black plastic pots containing Nukaya solution (Nukaya *et al.*, 1983). Sponge stoppers at the lower stem were used to support the plants in a hole in the pot lids. Using air pump and air tubing, nutrient solutions were aerated by constant bubbling of air into each plastic pot, and solutions were then replaced with fresh solutions weekly. Experiments were conducted under greenhouse conditions (25-30°C, 14 hours photoperiod).

Preparation of Zoospore Suspensions

A muskmelon isolate of *P. melonis* obtained from Darab area (Fars Province, Iran), was used in this study. The isolate was identified based on sequencing of ITS region (GenBank accssion number: AY659664) (Mostofizadeh-Ghalamfarsa, 2005), and deposited in culture collection of Plant Protection Department (Shiraz University, Shiraz, Iran). To induce zoospore formation, hyphal tip culture of *P. melonis* was grown on Difco Lima Bean Agar (LBA). After three days, mycelial blocks from the actively growing colony margins were transferred into petri dishes containing distilled water and incubated for 24 hours under fluorescent illumination at 25°C (1,200 lux). After sporangia had formed, petri dishes were chilled for 1 hour at 5°C and returned to room temperature for 1 hour in order to stimulate zoospore release (Banihashemi and Tabatabaee, 2004). Mobile zoospores were encysted by shaking on a vortex mixer and then counted using haemocytometer.

Salt-Stress and Inoculation Treatments

The plants were maintained in Nukaya solution in the greenhouse for 4 weeks. Then, they were assigned at random to one of four treatments: control (non-stressed, non-inoculated), salt-stressed only, inoculated only, or salt-stressed and inoculated (preinoculation salt-stressed or post-inoculation salt-stressed) (Banihashemi and Tabatabaee, 2004). Four levels of salinity (0, 1,300, 2,600, and 4,000 mg NaCl L^{-1}) was used. For each salinity level, concentrated NaCl solution (100 mg mL^{-1}) was added to each pot during one week before and after inoculation to reach the desired concentration of NaCl. Plants were allowed to adjust to salt stress for one week before inoculation by *P. melonis*. Afterwards, in pre-inoculation salt-stressed treatments, solution was replaced by fresh nutrient solution. Plants from the stressed and non-stressed treatments were inoculated with zoospore suspension of *P. melonis* (5,000 zoospore 800 mL^{-1} solution). After 48 hours, inoculated solutions were replaced by fresh nutrient solution and post-inoculation salt-stressed treatments were treated with NaCl levels as previously described. Solution of all pots was replaced by fresh Nukaya solution and all plants were harvested after 24 hours.

Data Collection

At harvest, shoots of plants were cut and dried at 70 °C for 48 h, weighted and ground. Shoots were dry-washed and sodium (Na^+) and potassium (K^+) concentrations were determined by flame photometry (Rich, 1965). The chloride (Cl^-) concentration in plant shoots was determined following the method of Chapman and Pratt (1961). The interactions among salinity and infection by *P. melonis* were evaluated by assessing the percentage of root segments colonized. Inoculated roots were washed under tap water and blotted dry using filter paper. Roots were cut into 2-3 mm segments, thirty sections were randomly chosen from plants in each pot and plated on cornmeal agar amended with 10 μg mL^{-1} pimarcin, 200 μg mL^{-1} ampicillin, 10 μg mL^{-1}, rifampin, 25 μg mL^{-1} PentaChloroNitroBenzene (PCNB) (Jeffers and Martin, 1986). The growing colonies from all segments were identified by boiled hempseed method reported earlier (Banihashemi, 1983).

Statistical Analysis

The experiment was a factorial combination arranged in a completely randomized design with four replications. Analysis of variance for the effects of salinity levels, disease infection, and their interactions for the three cultivars was done using SAS v 9.1.3 software. Duncan's test was used to compare treatment means with the control.

RESULTS

Reaction of Melon Cultivars to NaCl in Soil System.

The preliminary experiment on the influence of salinity on some local cultivars of *C. melo* showed that, based on foliar symptoms, cultivars Shahde-Shiraz and Dastanbo-Khorasan were, respectively, sensitive and moderately resistant to relatively high salinity, and Kharbozeh-Mashhad cultivar was intermediate between the other two cultivars. Salt-injury symptoms, such as chlorosis, scorch and necrosis (Figure 1) were noticed in

Figure 1. Salt-injury symptoms, such as chlorosis, scorch, and necrosis in salt-stressed treatment (3,000 mg NaCl kg^{-1} soil) of Shahde-Shiraz.

Shahde-Shiraz at 2,250 and 3,000 mg NaCl kg^{-1} soil but no symptoms appeared in Dastanbo-Khorasan at any salinity levels. Mild chlorosis and burning of leaf margin developed in Kharbozeh-Mashhad in 3,000 mg NaCl kg^{-1} soil. Analysis of variance for the main effects of cultivars, salinity, and pathogen presence and their interactions on growth (shoot dry weight), ion concentrations, and root colonization(%) of melon cultivars are shown in Table 1.

Reaction of *C. melo* Cultivars to *P. melonis* in Hydroponic System

In solution culture experiments, *P. melonis* caused significantly (P= 0.01) greater percentage of root colonization (Table 2) in both Shahde-Shiraz and Kharbozeh-Mashhad than Dastanbo Khorasan.

Effect of Soil Salinity on *C. melo* Cultivars Growth and Ions Concentration

Shoot dry weight (g) of three cultivars showed a non-significant slight increment (only significant at salinity level 4,000 mg L^{-1} in Shahde-Shiraz as compared with the control) when salinity rose from 0 to 4,000 mg L^{-1}, but more and less reduction of shoot dry weights were observed in Shahde-Shiraz and Dastanbo-Khorasan, respectively (Table 2). As compared with the controls, salt treatments significantly increased Na^+ and Cl^- concentrations in the shoot in three cultivars. However, at all treatments, Na^+ concentrations of Shahde-Shiraz and Kharbozeh-Mashhad increased more than that of Dastanbo-Khorasan. K^+ concentrations of each cultivar slightly (non-significant) diminished (Table 3).

Interactive Effects of Soil Salinity and *P. melonis*

Although statistically insignificant in some treatments, interaction of salinity and infection by *P. melonis* reduced shoot dry weight more compared to *Phytophthora*- or salt-treated treatments (Table 2). At any salinity level, the greatest and smallest shoot dry weights were observed in salt-stressed and pre-inoculation salt-stressed treatments, respectively, and post-inoculation salt-stressed was intermediate. In salinity-*Phytophthora* treatments, shoot dry weights of Dastanbo-Khorasan were suppressed more than Shahde-Shiraz and Kharbozeh-Mashhad (Table 2). Salt-stressed and post-inoculation-treated accumulated greatest and smallest of Na^+ and Cl^- ions and pre-inoculation salt-stressed treatments were intermediate (Table 3).

Although statistically insignificant in some treatments, the percentage of root segments colonized by *P. melonis* was higher in pre-inoculation salt-stressed-treated compared to post-inoculation salt-stressed treatments at each salinity level and for each cultivar (Table 2). The increase in root colonization due to salinity was not significantly (P= 0.01) different in Shahde-Shiraz and Kharbozeh-Mashhad, but significant (P= 0.01) increment in Dastanboo-Khorasan root colonization was noted as NaCl increased in each pre-inoculation salt stressed and salinity of 4,200 mg NaCl L^{-1} in post-inoculation salt-stressed compared to non-stressed inoculated treatments (Table 2).

DISCUSSION

Visual symptoms, e.g. chlorosis and leaf scorch, are among the methods that have been used to screen plants for salt tolerance (Jones *et al*., 1989, Mohammadi *et al*., 2007). Munns *et al*. (1982) reported increased ion toxicity and nutritional imbalances leading to leaf chlorosis and necrosis in plants exposed to high salinity. Based on foliar symptoms of melon in the preliminary experiment in soil system, cultivars Shahde-Shiraz and Dastanbo-Khorasan were, respectively, sensitive and moderately resistant to high salinity.

Table 1. Analysis of variance for growth responses, ion concentration, and colonization by *Phytophthora melonis* of three *Cucumis melo* cultivars under three inoculation treatments and three salinity levels.

Source	*df*	Mean square				
		Shoot dry weight	Na^+	K^+	Cl^-	Colonization
Cultivar (C)	2	0.959**	0.603ns	2.533*	3.449**	2440.442**
Inoculation (I)	2	1.208**	12.525**	13.112**	42.025**	72889.06**
Salinity (S)	2	0.852**	20.104**	6.222**	22.251**	917.97*
C×I	4	0.032ns	1.392*	0.279ns	0.635ns	1084.47*
C×S	4	0.028ns	0.092ns	0.252ns	0.325ns	191.08ns
I×S	4	0.042ns	1.091ns	0.292ns	2.663*	315.35ns
C×I×S	8	0.028ns	0.248ns	0.359ns	0.168ns	105.95ns
Error	54	0.133	0.654	0.868	0.893	230.4

* Significant at P= 0.05; ** Significant at P= 0.01, ns: Not significant at P= 0.05.

Table 2. Effect of salinity and its interaction with *Phytophthora melonis* on shoot dry weight and root colonization of *Cucumis melo* cultivars, Shahde-Shiraz, Kharbozeh-Mashhad, and Dastanbo-Khorasan.[a]

Treatment	NaCl level (mg L^{-1})	Shahde-Shiraz		Kharbozeh-Mashhad		Dastanbo-Khorasan	
		Shoot dry weight (g)	Colonization (%)	Shoot dry weight (g)	Colonization (%)	Shoot dry weight (g)	Colonization (%)
Salt-stressed only	0	1.44 a	0 e	1.32 ab	0 e	1.06 abc	0 e
	1300	1.46 ab	0 e	1.34 ab	0 e	1.10 abc	0 e
	2600	1.23 abc	0 e	1.13 abc	0 e	0.93 abc	0 e
	4000	0.85 bcd	0 e	1.02 abc	0 e	0.91 abc	0 e
Inoculated only	0	1.2 abc	88 ab	1.15 abc	86 ab	0.99 abc	45 cd
Pre-inoculation salt-stressed	1300	1.1 abc	92 ab	0.9 abc	90 ab	0.75 cde	84 ab
	2600	1 abc	94 ab	0.86 bcd	92 ab	0.7 de	92 ab
	4000	0.81 bcd	100 a	0.79 cde	95 ab	0.5 e	100 a
Post-inoculation salt-stressed	1300	1.15 abc	89 ab	1.17 abc	89 ab	0.95 abc	48 cd
	2600	1.13 abc	92 ab	1.01 abc	90 ab	0.83 bcd	64 bcd
	4000	0.9 abc	94 ab	0.9 abc	93 ab	0.7 de	83 ab

[a] Means in the same column followed by the same letter are not significantly different (Duncan, P= 0.01).

In hydroponic culture, increasing salinity levels reduced dry shoot weight in all tested cultivars, although statistically insignificant in some treatments. The reduction of plant growth in saline conditions is due to high osmotic pressure caused by the presence of ions, which eventually lead to a reduction in water use for the plants. This effect can be explained by the high sensitivity of the growing tissue to the moisture deficit resulting from salinity stress (Greenway and Munns, 1980). Reductions in vegetative growth of *C. melo* seedlings with increased salinity were similar to those reported by Franco *et al*. (1993) and Shannon and Francois (1978). As compared with the control, by increasing salinity, Na^+ and Cl^- in *C. melo* crops rose markedly and K^+ fell slightly. However, increasing ions concentrations was more noticed in Shahde-Shiraz and Kharbozeh-Mashhad than Dastanboo-Khorasan. Elemental analysis of the shoot tissue of some cucurbits cultivars revealed that increases in salinity resulted in increased tissue concentrations of Na^+ and reduced concentration of K^+ to enable osmotic adjustment (Jones *et al.,* 1989; Franco, *et al*., 1993). Sensitivity of some

Table 3. Effect of salinity and its interaction with *Phytophthora melonis* on Na^+, Cl^- and K^+ concentration (%) of *Cucumis melo* cultivars, Shahde-Shiraz, Kharbozeh-Mashhad and Dastanbo-Khorasan.[a]

Treatment	NaCl level ($mg L^{-1}$)	Shahde-Shiraz			Kharbozeh-Mashhad			Dastanbo-Khorasan		
		Na^+	K^+	Cl^-	Na^+	K^+	Cl^-	Na^+	K^+	Cl^-
Salt-stressed only	0	1.42 fgh	4.89 ab	0.33 l	1.39 h	4.58 abc		1.29 gh	4.54 abc	0.5 jkl
	1300	2.96 cde	4.74 abc	3.11 bcd	2.72 def	4.08 abc	2.62 cde	2.51 def	3.86 abc	2.47 def
	2600	4.99 ab	3.91 abc	5.71 a	4.62 abc	3.96 abc	4.6 abc	3.47 abc	3.76 abc	4.3 abc
	4000	5.12 a	2.95 bc	5.89 a	4.95 ab	2.72 c	4.91 ab	3.8 abc	3.56 abc	4.4 bcd
Inoculated only	0	1.5 fgh	5.08 ab	0.75 hij	1.22 gh	4.94 ab	0.52 jkl	1.62 efg	4.69 abc	0.59 ijk
preinoculation salt-stressed	1300	2.34 cde	5.23 a	2.18 efg	2.18 def	4.44 abc	1.65 fgh	2.29 def	5.55a	1.4 fgh
	2600	3.25 bcd	5.16 a	3.13 bcd	2.58 def	4.31 abc	2.32 def	3.24 bcd	4.86 ab	2.33 def
	4000	3.52 abc	4.76 abc	3.25 bcd	3.35 abc	3.83 abc	2.79 cde	3.58 abc	4.53 abc	2.69 cde
Post- inoculation salt-stressed	1300	2.02 def	5.64 a	1.18 fgh	1.61 efg	5.08 ab	1 ghi	2.03 def	5.66 a	1.3 fgh
	2600	2.3 def	5.46 a	2.15 efg	2.23 def	4.9 ab	1.18 fgh	2.7 def	5.16 a	1.5 fgh
	4000	3.1 cde	5.31 a	2.56 cde	3.04 cde	4.21 ab	1.48 fgh	3.43 abc	5 a	2.49 def

[a] Means in the same column followed by the same letter are not significantly different (Duncan, P= 0.01).

plants such as citrus and pistachio varieties is associated with the accumulation of excessive concentration of Cl^- and sometimes Na^+ in leaves (Sepaskhah and Maftoun, 1988; Mohammadi *et al*., 2007). The tendency of Shahde-Shiraz to accumulate Cl^- more than Dastanbo-Khorasan might partly explain the greater salt sensitivity of the former cultivar. According to the above considerations on the foliar symptoms, concentration of mineral elements, and shoot dry weight, Shahde-Shiraz is moderately sensitive to salinity, Dastanbo-Khorasan moderately tolerant, and Kharbozeh-Mashhad falls midway between Shahde-Shiraz and Dastanbo-Khorasan in salt tolerance.

Interaction of salinity and infection by *P. melonis* reduced shoot dry weight more compared to *Phytophthora*- or salt-treated treatments. This reduction was more pronounced in Dastanbo-Khorasan cultivar. Reduction in growth may be caused by the alteration of physiological processes in plants (Bernstein, 1975). Although statistically insignificant in some treatments, salt-stressed treatments showed higher concentration of Na^+ and K^+ compared to pre and post-inoculation salt-stressed. This difference may be attributed to the longer period that salt-stressed plants were exposed to NaCl. In the present experiment, Dastanbo-Khorasan showed lower colonization of the roots by *P. melonis* than Shahde-Shiraz and Kharbozeh-Mashhad in pathogen-treated. Furthermore, the results demonstrate that salinity increased root colonization by *P. melonis* compared to non-saline condition. The increase in root colonization due to salinity was not significantly different in Shahde-Shiraz and Kharbozeh-Mashhad, but a significant increase in colonization of root with increasing salinity was observed in Dastanbo-Khorasan as compared with non-stressed inoculated plants. This study confirmed previous works (MacDonald, 1982, 1984), showing that salinity stress can predispose chrysanthemum roots to infection by *P. cryptogea*. Severity of plant disease could be induced by high salinity in several ways. Salt stress of plant roots delayed the cytological defense responses and enhanced colonization by pathogen. The reduced resistance might have been associated with a reduction in phytoalexin production which might reduce plant resistance to pathogens (Murch and Paxton, 1980; Sulistyowati and Keane, 1992).

In the present study, in plants treated with NaCl before inculcation, the fungi was not exposed to NaCl and the effect of increased salinity levels on disease development was apparently on the host. In agreement with our results, Bouchibi *et al*. (1990) observed an increase in Phytophthora root rot of tomato when salt stress was applied to tomato seedling before inoculation with *P. parasitica*. Excess Na^+ can impair selective permeability of plant membranes (Cramer *et al*., 1985; Lynch *et al*., 1987), thereby increasing leakage of ions and organic carbon compounds from salt-stressed roots. This physiological effect probably was responsible for the increased attachment of encysted zoospores of pathogen (MacDonold, 1982) and may have been responsible for the increased root rot by *P. melonis* in pre-inoculation salt-stressed treatment in our study.

Salinity levels used in the study have been shown to increase mycelial growth but inhibit zoospore production of *P. melonis* (Mirtalebi and Banihashemi, 2004). Our results with *P. melonis* were consistent with the known salinity resistance and sensitivity of mycelium and zoospore, respectively, in other oomycetes (Blaker and MacDonald, 1985; Rasmussen and Stanghellini, 1988). In post-inoculation salt-stressed treatments, pathogen was exposed to NaCl and, consequently, the disease progressed by means of vegetative growth of the pathogen or growth reduction in the host. However, the effects of salinity on the percentage colonization in roots was more noticed in pre-inoculation than post-inoculation salt stressed due to longer period that host was exposed to NaCl.

In conclusion, salinity increased root colonization by *P. melonis* compared to non-saline condition. As a result, using salt-tolerant melons can be one of the most important strategies to manage the Phytophthora root rot in region with salinity problem such as soils adjacent to Maharloo Lake, which is one of the salty lakes located on the southeast of Fars Province, Iran. Presence of salt domes has a significant role in the lake's salinity. Sodium chloride, magnesium-sodium chloride, and sodium sulfate are the dominant salts of the lake. Due to the drying of the lake, widespread lands in the surrounding area are exposed to salinity (Matinfar and Zandieh, 2016).

The increase in colonization of root with increasing salinity was significant in the cultivar more resistant to *P. melonis* (Dastanbo-Khorasan), indicating reduction of root resistance due to salinity stress. This suggests studying the cultivars colonized by the pathogen for longer periods to examine in detail the response of salt stressed and non-stressed cultivar to invasion by pathogen, As a result, the time required to study the role of salinity on plant disease development is provided.

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اثر تنش‌های شوری بر میزان پوسیدگی ریشه ***Cucumis melo* L.** ناشی از ***Phytophthota melonis***

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چکیده

در ایران ارقام مختلف خربزه و طالبی در مناطق مختلف اعم از اراضی شور و غیرشور کشت می شوند و بیماری بوته‌میری گیاهان جالیزی ناشی از گونه‌های *Phytophthora* از مهم‌ترین بیماری‌های خاکزاد

این گیاهان است که خسارت زیادی را ایجاد می‌کند. برخی از مناطق جالیزکاری کشور مانند مهارلو در استان فارس در مناطق نسبتاً شور واقع شده‌اند و بیماری بوته‌میری در آنجا شایع است. در این مطالعه بر-همکنش شوری و فیتوفتورا در آلودگی ریشه‌های این گیاهان در سیستم آب‌کشتی مورد مطالعه قرار گرفت و گیاهچه‌های چهار هفته‌ای سه رقم طالبی شهدشیراز، خربزه‌مشهدی و دست‌انبو خراسان در سیستم آبکشتی محتوی محلول Nukayaدر معرض تیمارهای شوری (۰، ۱۳۰۰، ۲۶۰۰ و ۴۰۰۰ میلی‌گرم کلریدسدیم در لیتر) به مدت یک هفته قرار کرفت. یک هفته بعد همه‌ی گیاهان بـا زئوسپورهـای *P. melonis* (۵۰۰۰ زئوسپـور در ۸۰۰ میلـی‌لیتر مـایع آب‌کشت) مایه‌زنی شدند. بعد از ۴۸ ساعت محلول حاوی زئوسپورها با محلول تازه Nukaya جایگزین شد و تیمارهای شوری پس از مایه‌زنی برای بعضی از گیاهان اعمال شد. با توجه به وزن خشک انـدام هـوایی و غلظت یون‌های سدیم، پتاسیم و کلر و همچنین درصد آلودگی ریشه ، طالبی شهدشیراز و دست‌انبوخراسان در بین سه رقم به ترتیب حسـاس‌تریـن و مقاوم‌ترین رقم نسبت به شوری و همچنین دارای بالاترین وپایین‌ترین درصد آلودگی ریشه به *P. melonis* بودند. برهمکنش شوری و آلودگی با *P. melonis*، وزن خشک اندام هوایی را در رقم مقاوم به شوری بیشتر از رقم حساس به شوری کاهش داد. شوری باعث افزایش آلودگی ریشه با *P. melonis* در مقایسه با شرایط غیرشور شد. افزایش شدت بیماری در اثر شوری در دو رقم شهد شیراز و خربزه مشهدی معنی دار نبود. به علت تحمل بیشتر رقم دست انبوخراسان نسبت به *P. melonis*، شوری باعث افزایش معنی دار درصد آلودگی ریشه‌ی این رقم در نتیجه‌ی کاهش مقاومت میزبان در برابر تنش-های شوری شد.