International Journal of Natural and Engineering Sciences 5 (3): 37-40, 2011
ISSN: 1307-1149, E-ISSN: 2146-0086, www.nobel.gen.tr

The Effect of Water Stress and Fusarium Oxysporum F. Sp. Lycoperseci on Leaf Water Potential and Soil Matric Potential in Tomato Under Different Levels Of Water Stress on Greenhouse Condition

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Received: June 29, 2011
Accepted: July 08, 2011

Abstract

The effect of water stress and *Fusarium oxysporum* f. sp. *lycoperseci* (*Fol*) on growth of tomato was studied in a greenhouse experiment. Treatments consisted of five levels of water stress (1, 3, 5, 7 and 9 days irrigation intervals). Infested soil consisting of 400 chlamydospores g^{-1} of *Fol* and non- infested soil were used. The experiment was arranged in a randomized completely design with 8 replications (4 infested and 4 non-infested soil) under greenhouse condition (18- 35 ^{0}C). Six-week-old tomato seedlings cultivar Porimo after transferring to infest and non-infested soil were exposed to water stress. During the experiment leaf water potential and soil matric potential were measured. Disease symptoms appeared earlier in treatments with high water stress than the other treatments. Results showed that leaf water potential was reduced with increasing irrigation interval and also in infested soil. The values of soil matric potential in infected plants were higher than that in non-infected plants. Root colonization by *Fol* increased with increasing irrigation intervals, but differences were not significant.

INTRODUCTION

Vascular wilt diseases cause serious economic losses to many agricultural crops. *Fusarium* tomato wilt is one of the most prevalent and damaging diseases wherever these plants are grown intensively. The external symptoms develop unilaterally at the base of the stem on the afflicted side and progress upward. *Fusarium* causes stunting, wilting and finally plants die. In cross sections of the stem, near the base of the infected plant, a brown ring is evident in the area of vascular bundles. The soil- borne fungus infects plants through the roots via direct penetration or wound, after which the xylem vascular tissue of the plants is colonized. Xylem colonization by the fungus increases resistance to water flow within the plant, thus resulting in leaf water deficits that might lead to reductions in leaf photosynthetic and transpiration rates and leaf longevity. However, the extent to which water stress explains disease symptomology remains controversial [4,16].

Control of soil water potential either alone or in combination with other control measures could provide a means of disease control. Under unfavorable environmental factors to the host, various physiological processes in plant including disease resistance are interrupted [1,6,11]. The effect of stress is a cause of predisposing of initial establishment of the pathogen in the host and development of infections. The pathogenicity of *Macrophomina phaseolina,* cause of charcoal rot on many plant species, is apparently dependent on plant water stress. In sorghum [9] and cotton [13] production of typical severe disease in the greenhouse was possible only if plants were grown in heated beds, subjected to water stress.

The results of a number of studies, implicate a high resistance to water flow in xylem as the cause of wilting in plants with vascular wilt diseases [7,17]. In case of *Fusarium* wilt of tomato, steady-state measurements of transpirations and water potential have shown that xylem resistance becomes very high as wilting occurs [8]. However, it has been suggested that vascular wilt pathogens produce products in the host which are toxic to leaves and thus cause wilting [12,14]. Measurements of transpiration and leaf water potential have shown that the resistance to water flow in the petioles of *Fusarium*- infected plants approaches infinity as wilting occurs [8].

Various vital systems in plants are damaged during fusarium wilt. The primary target in presumably is the plant water balance. Insufficient water supply leads to the decrease in turgor of leaves and of a whole plant, thus transferring its physiology to a qualitatively new state. Other vitally important systems are also damaged after this transition.

Photosynthesis is a process related to plant productivity; it is quite sensitive to various stress factors of both abiotic and biotic nature [15]. It is known from literature that the decrease in the water potential of leaf suppresses photosynthesis activity of plants lowers the rate of CO_2 fixation, activity of electron-transport chain in chloroplasts, and the quantum yield of O_2 evolution and suppresses activity of ATP-synthetase [10,20].

sThe objective of present study (*Fol*) was to investigate the effect of *Fusarium oxysporum* f. sp. *lycoperseci* on on leaf water potential and soil matric potential in tomato under different levels of water stress on greenhouse condition**.**

MATERIALS AND METHODS

Source of Soil

The soil used in this study was selected from non-cultivated soil in Bajgah 15 km from Shiraz. It had sandy clay texture, pH=7.9, EC=0.83 dc/m, with 2.2 percent organic matter and was sieved with 3-mm mesh screen.

Inoculum Production

Mycelium from a 4-day-old, single spore, sporodochial culture of *Fol* race 1 was transferred into a 250-ml flask containing 50 ml of potato dextrose broth (extract of fresh potato 300 g, dextrose 20 g, and distilled water 1000 ml) at pH 6.5. Cultures were incubated at room temperature on a reciprocal shaker (60 strokes /min) for 3-4 days. The conidia were centrifuged down at low speed and washed three times with sterile distilled water. The inoculum suspension consisted mainly of microconidia with a few mycelial fragments and hyaline chlamydospores. The inoculum was mixed with sterile sand and incubated at 20 °C for 4-6 weeks and at 4 °C to reach stable population [3 & deZeeuw, 1973) and checked periodically by soil dilution method [2& deZeeuw, 1969). The initial population of *Fol* was 2.44×10^8 CFU/g sand.

Soil Infestation and Transplanting

A proportion of sand inoculum was mixed with 120 kg of field soil to obtain about 400 CFU of *Fom*/ g soil. Seven liter plastic pots were used. The lower portion of 50% of the pots was filled with 3500 g infested soil and the rest with non-infested one. Six- week- old tomato seedlings cultivar Porimo grown in small pots were transferred with the soil block to infested and non- infested pots and filled with 3500 g of non-infested soil. Soil dry weight in each pot was adjusted similarly in all treatments.

Treatments

All of the plants were irrigated similarly for five days prior to water treatments for root establishment. Five levels of water stress (1, 3, 5, 7 and 9 day's irrigation intervals) were imposed. To measure soil water content at field capacity, cell pressure was employed at suction 0.33 bars and weighed of each pot was determined. At each irrigation interval, pots were weighed and water was added to reach field capacity.

The experiment was arranged in a randomized completely design with 4 replications under greenhouse condition (18- 35 ^{0}C). During the experiment leaf water potential and soil matric potential in all the plants were measured.

Measuring Soil Matric Potential

Weighing all the pots daily, weight water content was obtained. Applying RETC vin model presented by Van Genuchten et al. [18] the parameters of equation presented by Van Genuchten [19] for predicting soil water retention curve were measured. For this a soil sample of used soil in the study was put under different suctions and weight water content was measured. For suctions less than 200 cm, hanging water column and for suctions 0.3, 0.5, 1, 5, 10, 15 bar Cell pressure were used in laboratory.

Applying Van Genuchten' s equation for predicting soil water retention curve, soil matric potential was daily estimated. Eq 1 is equation presented by Van Genuchten (1980) for predicting soil water retention curve:

$$\frac{\theta-\theta_r}{\theta_s-\theta_r}=\left(\frac{1}{1+(\alpha.h)^n}\right)^m \quad (1)$$

where θ_r is residual moisture fraction, θ_s is saturated moisture fraction and α, m and n are coefficients of the equation where:

$$m=1-\frac{1}{n}$$

Measuring Leaf Water Potential

Leaf water potential in all the plants were measured by pressure bomb four times in during the experiments (seventh, twenty third, forty second and sixty first days after treatment start).

Isolation and Identification of The Pathogen

Acidified PDA consisted of potato-dextrose agar (extract of 300 g potato, 16 g agar, 20 g dextrose and 1000 ml distilled water) with 500 ppm of the surfactant (TMN) added prior to autoclaving. The medium were acidified to pH 4-4.2 with 50% lactic acid, (Banihasheni and deZeeuw, 1969). Roots were washed and Surface sterilized 1-2 min in 0.5 % sodium hypochlorite .Root pieces of 2-3 mm were randomly selected and placed on the medium using 15 segments per plate and five plates were used for each plant. Plates were incubated at 25 °C for 4-7 days and colonized segments in each plate were counted.

RESULTS AND DISCUSSION

Soil Water Retention Curve Equation

Table (1) shows the parameters estimated by RETC vin model presented by Van Genuchten [18]. Substituting these parameters in equation presented by Van Genuchten [19] this equation was determined for used soil in this study (Eq (2)) . Fig (1) shows the soil water retention curve plotted by equation (2).

Table 1. Parameters estimated by RETC vin model presented by Van Genuchten et al. (1991)

n	α	θ_s	θ_r
1.225	0.0271	0.387	0.0107

$$\frac{\theta-0.0107}{0.376}=\left(\frac{1}{1+(0.0271h)^{1.225}}\right)^{0.183} \quad (2)$$

Symptoms

The disease symptoms appeared first with vein clearing and drooping of the petioles and yellowing of the lower leaves. One or more branches may be affected while others remain symptomless. Plant growth was reduced roughly in proportion to the severity of the symptoms (table 2)

Disease symptoms in treatments with high water stress appeared earlier than the other treatments.

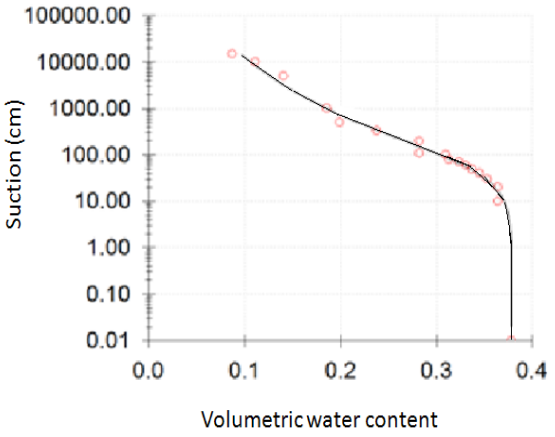

Figure1. Soil water retention curve plotted by equation (2) for used soil in the study

Table2. The time of initial symptoms, disease development and initial mortality in Fusarium infected plants after inoculation

Irrigation intervals (days)	Time of initial symptoms (days)	Time of disease development (days)	Time of initial mortality (days)
1	60	73	-
3	55	69	-
5	46	60	72
7	34	47	63
9	23	43	58

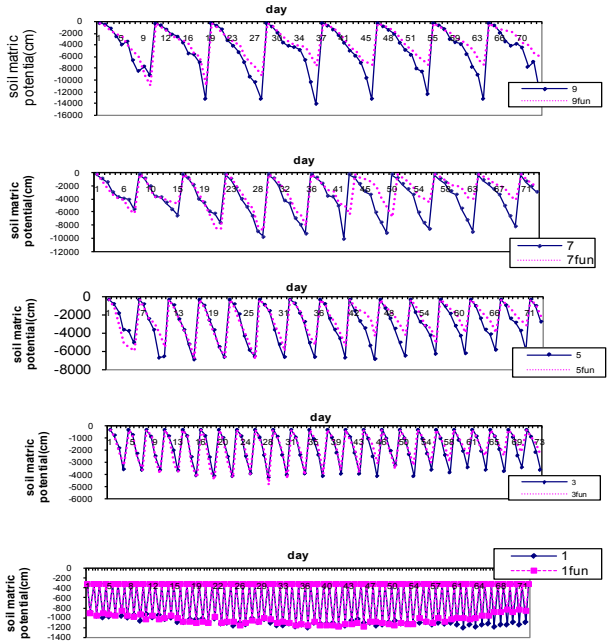

Figure 2. Soil matric potential for different irrigation intervals in infected and non-infected plants

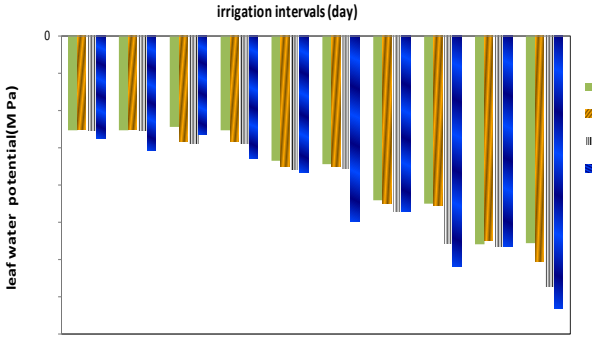

Figure 3. Leaf water potential of infected and non-infected plants under different irrigation intervals

Soil Matric Potential

Fig.2 Shows soil matric potential for different irrigation intervals. In this figure the sign fun is for infected plants. With comparison soil matric potential between infected and non-infected plants it is clear that soil matric potential in infected plants is higher than that in non-infected plants. It can be concluded that infected plants were not able to absorb water from soil as much as non- infected plants and then there was more moisture in infected plants' pots than non-infected.

Leaf Water Potential

Fig.3 shows that water stress caused a decline at leaf water potential. High water stress caused lower leaf water potential than lowers water stress. With comparison of leaf water potential between infected and non-infected plants it is clears that fusarium disease also decreased leaf water potential. In first measurement there was no significant difference between leaf water potential in infected and non-infected plants in all treatments at 5% level according to Duncan Multiple Range Test.

In the second measurement this difference became significant only in treatment with irrigation interval 9. In third measurement this difference became significant in treatment with irrigation interval 7 in addition to 9. And in last measurement the difference between leaf water potential in infected and non-infected plants in all the treatments became significant.

Therefore significant differences in leaf water potential between infected and non-infected plants varied among treatments. Under high water stress this time occurred earlier.

Root Colonization

Most colonies of *Fol* on root segments developed within 2-3 days at room temperature (Fig. 4). Percent colonization of root increased by increasing irrigation interval but the differences was not significant (Fig. 5).

Figure 4. Root segments of tomato colonized by *Fusarium oxysporum* f. sp. *lycoperseci*

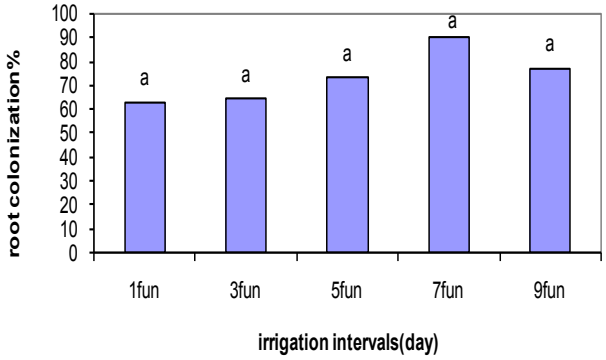

Figure 5. Root colonization by *Fusarium oxysporum* f. sp. *Lycoperseci* under different irrigation intervals

CONCLUSION

Water stress because of negative effects on plant physiology, predisposed plants for infection by *Fol.* Water stress decreased production of photosynthesis substance and plant growth. Therefore defensive ability of plants against the pathogens was diminished. On the other hand, water stress reduced activity of some enzymes and secondary metabolites. Decrease in the production of secondary metabolites caused collapsing the defensive system of plant against aggression of the pathogens [5].

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