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Full Length Research Paper

Trends of sudden wilt syndrome in sesame plots irrigated with delayed intervals

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In this work, sudden wilt syndrome in sesame was investigated during varying irrigation treatments. For the four irrigation intervals numbers of infected plants and infected rows were determined in experiments conducted during growing periods. The resulting data were transformed to percent values and regressed against the irrigation intervals. The correlations between the rates of infected plants and irrigation intervals and between the rates of infected rows and irrigation intervals were assessed separately in replicate and total plots following testing. Positive increases were observed for both categories within total plots. The correlations for the two years were r^2 = 0.86 and r^2 = 0.85 for the wilted plant category, and r^2 = 0.99 and r^2 = 1 for the infected row category. *Fusarıım oxysporum* fsp *sesame* and *Macrophomina phaseolina* were two of the parasitic pathogens isolated from samples. In addition, parasitic pathogens were not isolated from some of the samples that displayed sudden wilt symptoms. Depending on delays in irrigation within irrigated crops grown in drought and hot regions, sudden wilt syndrome of sesame may increase. The causes of sudden wilt syndrome appear to be parasitic pathogens, drought stress, or the combined effect of both.

Key words: Sesame, irrigation intervals, sudden wilt.

INTRODUCTION

Sesame (*Sesamum indicum* L) is an important oilseed crop commonly grown in tropical and sub-tropical regions of the world. The cultivation of sesame is generally performed in irrigated, and sometimes in non-irrigated, areas. The anliurfa Province contains 20,886 hectares of farmland yielding 6,810 annual tons of production, and constitutes the largest area of cultured sesame in Turkey (Anonymous, 2005). Sesame production is restricted by many parasitic or non-parasitic factors. Unsuitable climate and cultivation (Majumdar and Roy, 1992; Tomar et al., 1992; Tiwari et al., 1994), with additional stress factors (Hassanzadeh et al., 2009) may drastically decrease sesame yields. Parasitic pathogens infecting the roots, the stem roots, the stems, and the foliar components of the plant may also decrease yields (Abd-El-Ghany et al., 1974; Dinakaran et al., 1994).

Sudden wilt is a death syndrome of sesame that occurs from the time of seedlings until the time of maturing stages. Sudden wilt is an important disease of sesame that has been observed in the Harran plain for several years (Kavak and Boydak, 2006). In past studies, the causal agent of sudden wilt was determined to be *Fusarıım oxysporum* fsp *sesame* (Kavak and Boydak, 2006). However, later surveys and findings have determined that sudden wilt in sesame may result from other parasitic or non-parasitic factors. An excess of retarded irrigation or an unsuitable irrigation regime during irrigated cultivation may lead to or cause sudden wilt in sesame during droughts and hot climates. Symptomatic plants have been observed at various frequencies in fields and in many stages of plant development. Sudden wilt observed during later stages of sesame development is easier to notice. Determining the effect of delayed irrigation periods on sudden wilt syndrome in sesame was the main goal of this study.

MATERIALS AND METHODS

Site and experimental properties

Sesame experiments related to irrigation intervals were established

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at the experimental station of the Agricultural Faculty at Harran University. A local variety of dark sesame was sown into plots on the same day. As suitable to four irrigation intervals - viz. 5, 10, 15, 20 day/intervals - experiments were planned as a split–plot design in three replicates. Each plot was 5 x 7 m and included 20 sesame rows with 25 plants per line/row. The required irrigation of the plots was performed using an irrigation trench method according to the determined day intervals listed above. The site's soils, in which the experiments were established, were silted–clay with a pH of 7.5 (Grewelling and Peech, 1960) . The organic matter content of the soil was 11, 200 ppm (Hizalan, 1963), and the soil did not present a salinity problem (Peech, 1965). The irrigation water was C2S1 (classification). The experimental site has an arid climate with a summer that is hot, dry, and long. No rainfall occurs during summer and almost all rainfall occurs during the winter. The altitude from sea level varies between 464 and 467 m and is located at 37^{o} – 08 N and 38^{o}- 46 E.

Sterilization and isolation of wilted plants

Isolations from wilted plants were made from their main root and from below stem sections. Roots of wilted plants were washed under tap water for 5-10 min in order to remove attached soil particles. Plant pieces of 1- 2 cm in length were surface sterilized by immersion (for 3 min) in a solution of 5% sodium hypochlorite and 70% ethyl alcohol (for 2 min), rinsed several times with sterile distilled water, and blotted with sterile paper towels. Either directly or after they were chopped longitudinally, some specimens were incubated in a humid chamber, within a sterile medium, at 25 °C for 96 h. Isolations from the tips of developed mycelium were made on a PDA (Potato Dextrose Agar) medium. Alternatively, plant sections of 2-5 mm. with or without a necrotization were derived from the center of sterilized larger plant sections, placed on PDA (Potato Dextrose Agar) medium, and incubated at 25°C for up to five weeks. Microbial developments were periodically observed. For the identification of pathogens, macroscopic and microscopic morphology, and pathogenicity tests were utilized. After confirming the actual infection agent, infected plants displaying a similar symptomatic appearance were accepted as the same plant bearing the same pathogen.

Assessment of the infection and the test procedure

The sudden wilting of plants was counted for three months from young seedlings in order to determine the seed formation stage of the sesame. Complete wilted plants were separately assessed and tested both within replicate plots and within total plots. Wilted plants were counted in each row of each plot and the number of infected plants in a plot was determined. In a similar manner, infected rows were counted in each plot, and the number of infected rows in a plot was determined. Sesame rows, including any infected plants, were labeled as infected rows and sesame plots including any infected rows were labeled as infected plots.

Observations began 30 days after sowing and continued for 100 days with 20 day intervals. Wilted plants were culled and removed from plots for the possible identification of the causal pathogen species. The raw data derived from the sum of wilted plant numbers within plots were transformed to a % value and used in the regression analyses which were used in various disease mea-surements in previous studies (Kavak, 2004; 2005). Two categories of infection incidence were deter-mined - namely the infected-plant rate and the infected-row rate in plots which were regressed against the four different irrigation intervals. The best regression equations and interactions between the infection rates and the irrigation intervals were determined after the data were tested. For the regression equations, the infection rate (y) was the independent variable and the time interval of irrigation (x) was the dependent variable.

RESULTS

Macroscopic symptoms of sudden wilted plants

Plants subjected to sudden wilt syndrome displayed wilting signs. The wilting symptom was observed in many plants at the same time. However, for some plants, wilting began locally and resulted in the death of the entire plant. Some chlorose signs on the edge of leaves were also present. Depending on the time, all of the green sections of wilted plants became brown and black. Secondary roots that were nearer to the soil surface and dark brown or black discolorations on the main vascular tissue were symptoms of these plants. In addition, rotting on the main and lateral roots was observed with the addition of the growth of some mycelia heaps. Sclerotial spots were present on the main surface of some plants. On some wilted plants, typical symptoms were not detected with the exception of general wilting.

Isolations and biotic pathogens

F. oxysporum fsp *sesame* was identified based on the following microscopic morphology: 1) macro conidia with three to five septets, with four septets being the most common; 2) curved or sickle shaped; and 3) 2.5-4.5 µm x 26-39 µm in length and width. *F. oxysporum* fsp *sesame* was isolated from necrotized sections within the vascular vessels of sesame, and its pathogen status was con-firmed through inoculation tests. Test seedlings that were immersed in a pathogen suspension became diseased within a few days, and pathogens were also re-isolated from the seedlings.

Macrophomina phaseolina was identified according to the following microscopic morphology. Black sclerotia of pathogens were present on the surfaces of the main roots. On PDA cultures, mycelia initially developed as hyaline and later as gray in color. Sclerotia were minute, round to oblong, or irregular in shape and black in color with mycelia appendages.

Course of the infection in rows and plots

Based on delayed irrigation intervals, the number of infected plants from sudden wilt increased in plots. The increase rates of wilted plants were significant in two replicates (r^2 = 0.94, y = $0.57e^{045}$; r^2 = 0.99, y = $024x^2$ - 036x - 1.7), and insignificant in one replicate (r^2 = 024; y = $2.2x^{0375}$) in 2008. In treatments during 2009, the correlation was significant in one replicate (r^2 = 088, y = $1.34x^2$ - 052x + 2.5), and less for another replicate (r^2 = 0.68, y = $-015x^2$ + 0.96x + 035). Wilted plant rates

Table 1. Interaction data for wilted plant rates and irrigation intervals as well as their significance levels.

Replicate plot average*	Irrigation intervals (day) 5	10	15	20	2008
	Infected plant rates %	Infected plant rates %	Infected plant rates %	Infected plant rates %	
1	1.62	2.12	2.73	4.18	$y = 024x^2 - 036x - 1.7$ $R^2 = 0.99$
2	1.96	4.08	2.13	3.74	$Y = 2.2x^{0375}$ $R^2 = 0.24$
3	0.92	1.22	2.64	3.15	$y = 057e^{045}$ $R^2 = 94$
Total plot average	1.5	2.47	2.5	3.69	$y = 39Ln(x) + 1.44$ $R^2 = 86$
					2009
1	2.12	1.86	2.26	2.55	$y = 1.34x^2 - 052x + 2.5$ $R^2 = -088$
2	2.18	2.43	1.95	2.52	$y = 0.08x^2 + 035x + 2.5$ $R^2 = 0.20$
3	1.25	1.42	2.16	1.74	$y = -015x^2 + 0.96x + 035$ $R^2 = 0.68$
Total plot average	1.85	1.90	2.12	2.27	$y = 0.3Ln(x) + 1.80$ $R^2 = 85$

*=Each plot contained 20 rows and each row contained 30 plants.

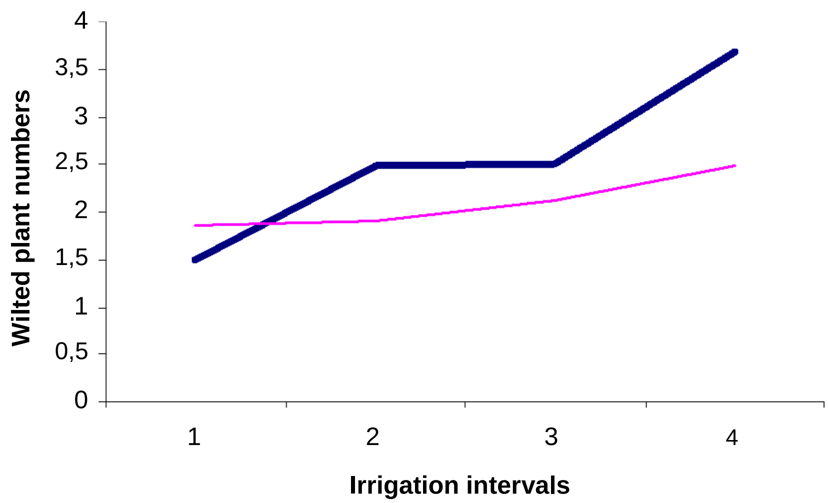

Figure 1. Interactions between wilted- plant rates and irrigation intervals (the dark line indicates 2008; the light line indicates 2009).

increased statistically based on delayed irrigation during both years ($r^2 = 0.86$, $y = 39Ln(x) + 1.44$ in 2008 and $r^2 = 0.85$, $y = 0.3Ln(x) + 1.80$ in 2009) in total treatments (Table 1 and Figure 1). The infected row numbers

Table 2. Interaction data for infected row rates and irrigation intervals as well as their significance levels.

Replicate plot average*	Irrigation intervals (day) 5	10	15	20	2008
	Infected row rates %	Infected row rates %	Infected row rates %	Infected row rates %	
1	15.2	18.8	20.8	18..5	$y = -1.48x^2 + 8.6x + 8$ $R^2 = 0.98$
2	18.4	23.2	28.4	28.6	$y = 1.15x^2 + 9.3x + 1$ $R^2 = 0.98$
3	12..3	10..2	14..2	21..5	$y = 2.4x^2 - 9x + 18$ $R^2 = 0.99$
Total plot average	15..3	18.06	20.46	22.86	$y = 2.5x + 13$ $R^2 = 0.99$
					2009
1	20.2	19.6	23.3	18.6	$y = -1.03x^2 + 5x + 16$ $R^2 = 0.35$
2	18.3	19.7	25.2	32.4	$y = 1.5x^2 - 2.5x + 19$ $R^2 = 0.99$
3	18.5	17.1	20..2	42.4	$y = 5.9x^2 - 22x + 35$ $R^2 = 0.97$
Total plot average	19	18.8	22.9	31.1	$y = 2.1x^2 - 6.5x + 23$ $R^2 = 1$

*=Each plot contained 20 rows.

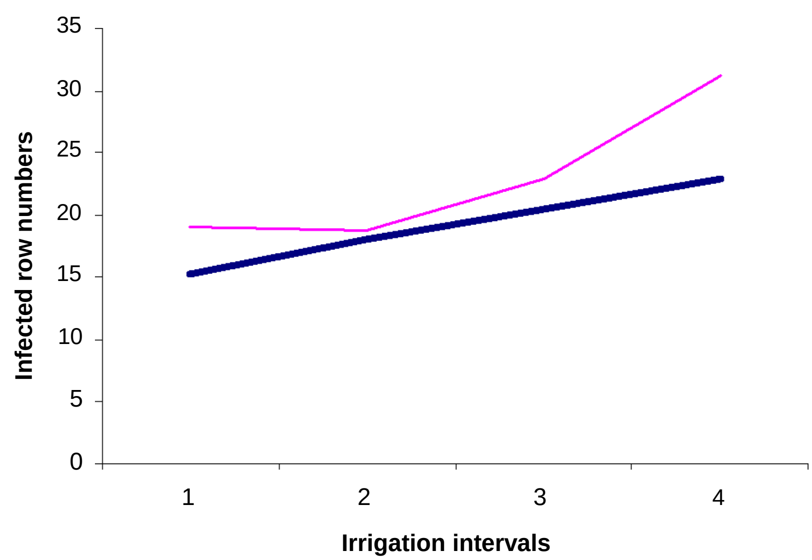

Figure 2. Interactions between infected-row rates and irrigation intervals (the dark line indicates 2008; the light line indicates 2009).

Increased statistically in replicate and total treatments based on delayed irrigation (Table 2 and Figure 2).

DISCUSSION

In the current study, repeated during the two year duration, important interactions between sudden wilt number and irrigation intervals were determined on sesame plants, and there was a positive correlation between them. The numbers of infected plants and infected rows increased statistically in plots when irrigation was delayed for the described periods. In a separate assessment of each replicate plot, a lesser correlation was also present. However, both wilted plant and row numbers increased during the two years when total data were taken into consideration in experiments.

According to the results of a regression analyses, quantitative increases in infected plant or row numbers were largely exponential and polynomial in their nonlinear relationships (Snedecor and Cochran, 1989). The results indicate that sudden wilt disease of sesame caused by parasitic or non- parasitic factors may increase during delayed irrigation intervals under arid conditions similar to those for this study performed in the Harran plain district. The syndrome may have resulted from one or several disease agents associated with parasiter, nonparasiter, or both. *M. phaseolina* and *F. okysporum* fsp. *sesame* were two of the parasitic pathogens determined in many of the samples. The importance of both pathogens has been reported for sesame (El-Bramavy and Abdul-Wahid, 2006; Kavak and Boydak, 2006). However, the only cause of sesame sudden wilt was not found to be a parasitic pathogen. Symptomatic plant samples not isolated to any biotic pathogen confirm the hypothesis.

Drought stresses depending on delayed irrigation may also be another reason of sudden wilt. In addition, the combined effect of parasitic and non-parasitic factors may have increased the death rate. As reported by Agrios (1997a), plants exposed to drought stress are more predisposed to pathogen attacks. Parasitic patho-gens that cause sudden wilts block the xylem vessel system by reproducing in or stimulating the thylene. As a result of this growth, plants cannot obtain the required water and wilt within a short period of time. Delayed irrigation may also accelerate the wilting time. Agrios (1997b) stressed that when plants were diseased by *Fusarium* or similar pathogens, water flowing through the stem xylem was reduced to a mere 2-4% of that flowing through the stems of healthy plants.

Due to these findings, researchers consider that sesame plants may be more predisposed to sudden wilt syndrome when irrigation is delayed in dry climates. Therefore, regular irrigation plans, as well as other cultivation procedures should be performed in fields in order to decrease sudden wilt rates in sesame.

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