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Research Article

Evaluations of partial resistance of native sesame germplasms to Fusarium wilt disease

Mousa Najafiniya[1] and Ahmad Aien[2]

1. Plant Protection Research Department, South Kerman Agricultural and Natural Resources Research and Education Center, AREEO, Jiroft, Iran.
2. Seed and Plant Improvement Research Department, South Kerman Agricultural and Natural Resources Research and Education Center, AREEO, Jiroft, Iran.

Abstract: *Sesamum indicum* L. is an important oil seed in Iran which is cultivated as summer crop in alternation with cereals and cucurbits, playing an important role in sustainable agriculture. Sesame wilt disease caused by *Fusarium oxysporum* f. sp. s*esami* is one of the limiting factors in its cultivation. Application of genetic improvement of disease resistance is one of the effective strategies to solve the disease problems in sesame. In this project, the partial resistance of 24 genotypes including, some commercial cultivars and promising lines were tested against Fusarium wilt disease. The experiments were conducted in three different conditions (greenhouse, micro plot and field). In greenhouse and micro plot experiments, artificial inoculation was used while in field experiment, no artificial inoculum was used. For evaluating results, the infection percentage (wilted plants) was recorded on a scale of 1-6 scoring system. The results showed that in artificial inoculation conditions, none of sesame genotypes were immune. Infection mean percentages of sesame genotypes were calculated to be 58.34, 28.6 and 15.96, in greenhouse, micro-plot and field, respectively. Total results of the three experiments showed that 29.1% of the sesame genotypes (JL1, Jl14, JL10, JL11, JL13, Jl18 and Darab1) fell in resistant (R) category and 37.5% of the genotypes (JL2, Varamin37, Local, Yekta, JL29, JL16, JL6, JL14-1 and Darab2) fell in moderately resistant (MR) group. The resistant and moderately resistant genotypes can be used for breeding programs and development of resistant varieties, however further efforts are needed to identify highly resistant genotypes from among more native germplasms via screening program.

Keywords: genotype, oil seed, promising line, resistance, root rot

Introduction

Sesame as an oil-bearing crop is valuable and important in many countries. In Iran, sesame is cultivated mainly in Fars, Kerman, Bushehr, Sistan and Baluchistan, Golestan, and Hormozgan provinces. In most countries where sesame is cultivated, insects, diseases and environmental conditions may affect its production and among the diseases, Fusarium wilt caused by *Fusarium oxysporum* f. sp. *sesami* (*Fos*) is one of the most important diseases which limits the cultivation of sesame (El-Bramawy *et al*., 2008). The disease was first reported from North America in the 1950's (Armstrong and Armstrong, 1950). Sesame Fusarium wilt disease is known as fusarium stem

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* **Corresponding author:** m.najafinia@areeo.ac.ir
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and root rot as well as "one-side rots" disease of sesame. Wilt symptoms first appears in the lower leaves and gradually they tend to yellowish wilting, and more intensive leaf dropping, and finally death. Vessels turn brown from root upward (Katan *et al.,* 1983). The disease was reported in Iran for the first time from Bushehr (Ershad, 1995), and seed borne nature of the disease has been proved (Basirnia and Banihashemi, 2006). Besides the agricultural and chemical control methods, use of resistant cultivars is one of the best control methods of soil borne diseases (Jae *et al.,* 1999). The production of superior genotypes have been developed by different methods such as genetic engineering, mutations or collecting masses of native populations and screening against disease in controlled/field conditions (El-Bramawy *et al*., 2001; Silme and Cagirgan, 2005; El-Bramawy and Abdul Wahid, 2006; Kavak and Boydak, 2006; Chamandoosti, 2017). The results of the conducted research have shown that the resistance is transferable to the next generations (El-Bramawy, 2006). Investigations on the resistance of 26 native varieties and wild types of sesame in India indicated that, the cultivars were not immune, but the TC45 and Punjab Ti11 showed tolerant reaction and cultivar TC25 was resistant in field conditions (Goyal *et al*., 1980).The resistance of 35 sesame genotypes against sesame Fusarium wilt disease was examined in another research in India, and the results showed that none of the cultivars were safe against disease (Jyothi *et al*., 2011). The resistance of 25 genotypes of sesame in Turkey against the fungus *Fos* showed that Ws-313, Ws-143, Camdibi and Birkan were resistant cultivars but WS-131 showed medium sensitivity reaction (Silme and Cagirgan, 2010). In Iran, the relative sensitivity of 10 varieties of sesame plant against Fusarium wilt disease in Golestan province, northern Iran, were examined and cultivars Darab-14, local-99 and Darab-1 expressed extreme sensitivity, Varamin-2822, Panama and Local-2 showed medium sensitivity and Darab-237 was less sensitive (Gulzar, 1989). In another study the relative resistance of 20 sesame germplasms against Fusarium wilt disease was determined and results showed the Asfij Bahabad was resistant and Kahnouj local mass was highly susceptible (Fallahpori *et al.,* 2013). In the southern region of Kerman, Iran, the Fusarium wilt is very important disease and imposes heavy loss annually. In some cases, the damage reaches up to 20-30% (field observations and survey of authors). Due to the soil borne nature of the disease successful chemical control is currently not available. Use of resistant cultivars is one of the most important strategies for reducing the sesame wilt damage. Unfortunately, access to seeds of resistant and compatible sesame varieties at the international level is not feasible. Therefore this research was conducted to evaluate and screen 24 native and commercial genotypes for resistance against the sesame Fusarium wilt disease in south of Kerman, Iran.

Materials and Methods

Sesame genotypes: 24 sesame genotypes including seven domestic and imported varieties, 13 top-lines from among the local mass of Jiroft sesame (Aien *et al.,* 2016), two Darab lines and two Borazjan lines were selected to check their reaction against Fusarium wilt caused by *Fusarium oxysporum* f. sp. *sesame* (Table 1).

Planting: For greenhouse experiments, seeds were surface sterilized using commercial sodium hypochlorite and planted in 15 cm pots containing sterile sandy loam soil. Ten to 12 days after planting, seedlings were thinned down to six to eight plants per pot and used for inoculation.

Preparation of inoculums: Fusarium fungus from infected fields of sesame which showed wilt symptoms (Fig. 1) was isolated and identified. For this purpose, the infected parts were surface sterilized using 0.5% sodium hypochlorite for two minutes, then immersed in alcohol 70% for one minute, then rinsed several times with sterilized distilled water, dried and cultured on PDA medium at 24 to 26 °C.

Table 1 Sesame germplasms used for evaluation of their resistance against Fusarium wilt disease caused by *Fusarium oxysporum* f. sp. *sesame*.

Genotype	Source	Branch type	Seed color	1000-Seeds weight (g)
JL2	Jiroft	Multi-branch	Dark brown	3.2
B5	Borazjan	Multi-branch	White brown	3.2
Varamin37	Varamin	Multi-branch	Dark brown	3.0
JL1	Jiroft	Multi-branch	Light brown	3.3
JL14	Jiroft	Multi-branch	Dark brown	3.2
Varamin 2822	Varamin	Multi-branch	Dark brown	2.9
JL10	Jiroft	Multi-branch	Dark brown	3.4
Local	Jiroft	Multi-branch	Light brown	3.2
B2	Borazjan	Multi-branch	Light brown	3.3
Varamin 237	Varamin	Multi-branch	Light brown	2.8
Yekta	unknown	Multi-branch	Light brown	2.9
JL29	Jiroft	Multi-branch	Light brown	3.3
Darab 14	Darab	Multi-branch	Light brown	3.3
JL5	Jiroft	Multi-branch	Dark brown	3.5
Darab 1	Darab	Multi-branch	Light brown	3.3
JL13(Halil)	Jiroft	Multi-branch	Dark brown	3.5
JL11	Jiroft	Multi-branch	brown	3.5
Nazetak	Mazandaran	Single branch	white	2.8
TS3	unknown	Multi-branch	white	3.3
JL6	Jiroft	Multi-branch	brown	3.2
Darab 2	Darab	Multi-branch	brown	3.3
JL16	Jiroft	Multi-branch	brown	3.5
JL18	Jiroft	Multi-branch	brown	3.5
JL14-1	Jiroft	Multi-branch	brown	3.5

Figure 1 Wilt of sesame, early (a) and advanced (b) stages of wilting caused by *Fusarium oxysporum* f. sp. *sesame*.

Obtained isolates were screened for pathogenicity using susceptible variety Darab-14 (Gulzar, 1989) and confirmed forma speciales using different hosts. Highly pathogenic isolate was selected and used to prepare inoculum for further work. Thus, about 20 ml sterilized distilled water was added to the seven days growth of the fungus in each petri dish and spore mass was suspended by a sterilized brush, collected in the beaker after passing through tiffany material, and the suspension was adjusted by RBC counter lam at the concentration of 10^6 propagules/ml for greenhouse tests (Omar *et al.,* 1988). In micro plot condition, inoculation was done by well blended corn kernels inoculated with Fos. Hence, modified Kavak and Boydak (2006) method (corn instead of wheat) was used. For this purpose, 300 g of corn grain per flask were autoclaved and after 24 hours, inoculated with mycelial discs of Fusarium, kept for 7-10 days. After air drying, the contents of the flask were blended well to make a powder for inoculation near root area of each seedling using the following experimental designs:

The greenhouse experiment (Experiment1) was conducted in a completely randomized design (Fig. 2a) using 25 treatments (including negative control) in four replicates (Each pot containing eight plants was considered as one replication). Greenhouse experiments were repeated two times. In micro-plot experiment (Experiment 2), seedlings were planted in rows (1.5 m long, seedlings in a row were spaced 15 cm apart and the distance between the rows was 30 cm). Each 1.5 m long row was considered as one replication (Fig. 2b) and three replications for each cultivar were considered (EL-Bramawy and Abdul-Wahid, 2009).The terminal part of each micro-plot (0.5 m) considered as control and separated from treated parts by inserting vertical plastic sheet deep into soil, to stop the movement of any spore via irrigation. The micro-plot experiment was conducted in a completely randomized design. In field experiment (Experiment 3), the reaction of sesame cultivars against Fusarium was evaluated in naturally infected soil (Fig. 2c). For this experiment, a piece of land with sandy loam soil texture, EC 2 mm and pH 7.6 and 0.19% total nitrogen, naturally infested with Fusarium was selected. The field experiment was conducted in randomized complete block design with three replicates. The area of each experimental plot was 3 m^2.

Inoculation: In greenhouse experiment for artificial inoculation, one-month old seedlings of sesame were inoculated using root dip method in spore suspension (10^6 propagules per ml) for five minutes (Banihashemi, 1982) and then planted in 15 cm pots containing sterilized sandy loam soil. For inoculation of control plants, sterilized distilled water was used without any pathogen. In micro-plots, inoculation was done one month after planting by adding 10 grams of corn meal inoculated with Fusarium nearby root zone of all seedlings in the rows and then covering by soil (Kavak and Boydak, 2006). Field experiment was conducted in 2017 in naturally infested farm at Agricultural Research Station of Jiroft without any artificial inoculation.

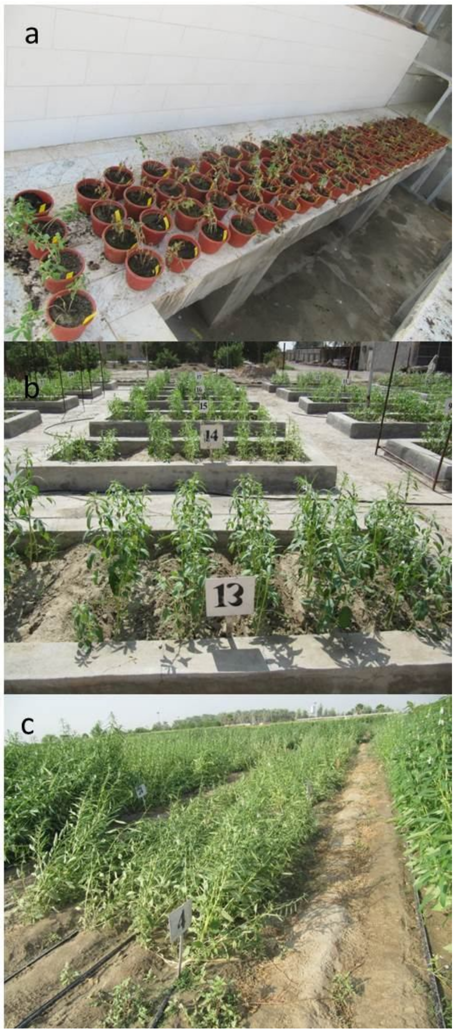

Figure 2 The layout of experiments in greenhouse (a), micro-plot (b) and field conditions (c).

Evaluation of reaction: many methods and scoring systems have been developed by different researchers to determine the reaction of sesame to Fusarium wilt (El-Bramawy *et al.,* 2001). The reaction of different sesame cultivars to fusarium wilt disease (sensitive to immune) was recorded using scoring system one to six based on the method as shown in table 2 using 20 plant samples at random. The infection percentage of each genotype was calculated by counting the number of wilted plants, then transformed to arcsine values and analyzed by the SAS statistical software (Kavak and Boydak, 2006). The severity of disease symptoms was recorded weekly but the

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final assessment was reported at harvesting time as plant infection percentage. On the basis of the symptoms of infection including wilting and death, the reaction type of different genotypes was determined. The average percentage of infected plants was compared using LSD test at probability level 1 and 5%. Some agronomic traits such as root dry weight, plant height, and yield were statistically measured and compared in micro plot and field assays.

Table 2 Evaluation and scoring system 1-6 based on Kavak and Boydak (2006) method.

Score	Infection (%)	Category
1	0.0	Immune (I)
2	0.1-20	Resistant (R)
3	20.1-40	Moderately resistant (MR)
4	40.1-60	Moderately susceptible (MS)
5	60.1-80	Susceptible (S)
6	80.1-100	Highly susceptible (HS)

Results

Highly pathogenic isolate of *F. oxysporum* f. sp. *sesame* was selected based on pathogenicity and host specificity tests in greenhouse condition and genotypes reaction experiments were carried out. The experimental results of the greenhouse, micro-plot and field conditions are shown in following tables. In the greenhouse experiments, the disease symptoms appeared one week after inoculation. The results of the analysis of variance of greenhouse experiment (Table 3) indicated a significant difference between treatments and control ($P \leq 0.01$). Most of planted seedlings wilted before bearing stage and it was not possible to compare agronomic traits in greenhouse condition.

Table 3 Analysis variance of different sesame genotypes infection percent against Fusarium wilt in greenhouse conditions.

Source of Variation	df	SS	MS
Genotypes (Treatments)	24	42392.61	1766.35**
Error	75	17148.15	228.64
CV	19.86		
Mean infection = 58.34%			

** = significant at 1% level.

The analysis variance of infection percent and some agronomic traits of different sesame genotypes against Fusarium wilt in micro-plot experiment are shown in Table 4. The results show there was a significant difference among sesame germplasms.

The results of the analysis variance of tests conducted in micro plot (Table 4) indicate there was a significant difference in root dry weight between the genotypes at the level of 5 percent. The yield, plant height and mortality percentage of genotypes inoculated with Fusarium, were significantly different at the level of one percent.

The results of analysis of variance in field experiment showed that there was a significant difference between disease incidences of different genotypes (Table 5). The lowest incidence was 2.48 percent (in JL18) and the highest was 42.22 percent (in Darab14). The average of disease incidence in field condition without artificial inoculation grouped the JL1, JL2, JL5, JL10, JL11, JL13, JL14-1 and Darab1 in R category; the JL16, B5, Varamin37, Varamin237, Local, B2, Yekta, NazTak, Ts3 and Darab2 in MR category; Darab14 and Varamin2822 in MS category (Table 6).

Table 4 Mean squares of percent infection and some agronomic traits of different sesame genotypes against fusarium wilt in micro plot condition.

Source of variation	df	Root dry weight	Yield	Height	Disease infection
		131.96*	348283.55**	924.36**	267.25 **
Error	50	44.37	64957.44	18.48	1.90
CV%		24.62	26.79	4.58	11.26
Mean		27.05	951.22	93.73	

* = significant at 5% level, ** = significant at 1% level.

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Table 5 Mean squares of percent infection and agronomic traits of different sesame genotype against Fusarium wilt in field condition (natural infection).

Source of variation	df	Root dry weight	Yield	Height	Disease infection
Block	2	41.34^{ns}	36927.38**	266.10*	0.48
genotype	23	125.14**	355715.56**	2848.17*	1.85**
Error	46	52.63	0.50	756.54	0.44
CV%		27.22	23.26	18.47	27.86
Mean		26.65	961.15	148.81	15.96

* = significant at 5% level, ** = significant at 1% level, ns = non-significant.

Table 6 Mean of disease infection of Fusarium wilt in sesame germplasms in three different experimental conditions.

Genotype	Disease infection (%)						
	Field	Reaction	Micro-plot	Reaction	Greenhouse	Reaction	Final reaction
JL2	12.49e	R	20.23de	MR	38.8bcd	MR	MR
B5	28.8c	MR	48.83a	MS	81.88a	HS	Variable
Varamin37	26.48c	MR	26.16d	MR	79.88a	S	MR
JL1	8.93f	R	17.3e	R	36.75bcd	MR	R
JL14	3.56g	R	8.33g	R	39.3bcd	MR	R
Varamin 2822	41.52a	MS	58.66a	MS	97.5a	HS	MS
JL10	4.47fg	R	9.16g	R	37.1cd	MR	R
Local	32.37b	MR	34.2c	MR	72.83ab	MS	MR
B2	23.37c	MR	48.46a	MS	77.77ab	S	Variable
Varamin 237	24.91d	MR	24.03de	MR	38bcd	MS	MR
Yekta	28.20c	MR	23.36de	MR	66.6bc	MS	MR
JL29	2.71gh	R	25.53de	MR	39.65d	MR	MR
Darab 14	42.22a	MS	58.9a	MS	88.6a	HS	MS
Jl5	2.58gh	R	22.96de	MR	55bc	MS	Variable
Darab 1	6.4fg	R	18.8de	R	57bc	MS	R
JL13(halil)	2.61gh	R	8.1g	R	28d	MR	R
JL11	3.30g	R	13.8f	R	30.8d	MR	R
Nazetak	34.23b	MR	48.93a	MS	87.5a	HS	Variable
TS3	24.94d	MR	45.1a	MS	55.7bc	MS	MS
JL6	24.95d	MR	35.20c	MR	48.7cd	MS	MR
Darab 2	22.73d	MR	34.1c	MR	71.4ab	S	MR
JL16	22.06gh	MR	24.4de	MR	77.7ab	S	MR
JL18	2.48gh	R	17.23e	R	45.7cd	MR	R
Jl14-1	2.98gh	R	24.83de	MR	38cd	MR	MR
control	-	-	0h	-	0e	-	-

Immune (I), Resistant (R), Moderately resistant (MR), Moderately susceptible (MS), Susceptible (S), Highly susceptible (HS).
Means followed by the same letters in each column are not significantly different (LSD, P < 0.05).

The results of the reviews for the greenhouse experiments and artificial inoculation (Table 6) showed that sesame genotypes used in this work are not immune or resistant to Fusarium wilt disease of sesame. The range of infection percentage of sesame genotypes to wilt disease in the greenhouse conditions was 28 to 98%. The lowest percentage of infection was for JL13 and JL11 with 28 and 30.8%, respectively, which were placed in the moderately resistant (MR) category. The JL1, JL2, JL10, JL14, JL14-1, JL18 and JL29 fell also in MR category. The JL5, Varamin- 237, Yekta, Ts3, JL6, Local and Darab1 fell in moderately susceptible (MS) category. The

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cultivars B2, Varamin 37, Darab2, and JL16 showed susceptible (S) reaction and the cultivars Varamin 2822, B5, Naz-Tak and Darab14 were highly susceptible (HS) according to Kavak and Boydak (2006) method. In micro-plot, the average disease infection percentage of sesame genotypes (Table 6) ranged from 8.1 percent (in JL 13) to 58.9 percent (in Varamin 2822 and Darab 14).The cultivars Jl1, Jl10, JL11, JL13, JL14, Jl18 and Yekta fell in R category. The cultivars Jl2, Jl5, JL6, Jl14-1, JL16, JL29, Local, Varamin 37, Varamin 237 and Darab2 showed MR reaction and the cultivars B5, Varamin2822, B2, Darab14, Naz Tak and Ts 3 showed MS reaction. The lowest root dry weight was observed in Yekta and Varamin-2822 cultivars with the mean of 14.33 gram and the maximum (39.66 gram) belonged to Jl10 and Jl13, two native genotypes of Jiroft. The minimum plant height, 80 cm, was observed in cultivar of Varamin2822 and the maximum height belonged to Jl10 with 186.66 cm (details of data on agronomic traits are not presented here). The results of artificial inoculation in micro-plot condition showed that, the JL1, JL10, JL11, JL13, JL14, JL18 and Darab1 were resistant, the JL2, JL5, JL6, JL14-1, JL16, Yekta, Varamin 237 and Local fell in MR category and the Varamin2822, B2, Darab14, NazTak and Ts3 fell in MS category.

The average seed yields in micro-plot and field conditions were recorded at 951.15 and 961.22 kg/ha, respectively (Table 7). The maximum amount of yield in field condition was recorded for Varamin37 (1520 kg/ha), local (1493 kg/ha), JL14 (1460 kg/ha) and the minimum for JL6 (357 kg/ha). In term of root dry weight, the maximum was recorded for JL10 (39.66 g/10 plants), JL14 (39.33 g/10 plants) and the minimum was in Yekta (14.33 g/10 plants). Regarding plant height in field condition, the maximum was recorded for JL14 (190 cm), JL10 (186 cm) and the minimum was for Varamin 2822 (80 cm).

Table 7 Mean comparison of some agronomic traits in different sesame genotypes in field naturally infected with *Fusarium oxysporum* f. sp. *sesami* based on LSD test.

Genotype	Yield (kg/ha)	Height (cm)	Root dry weight (g / 10 plants)
JL2	980.3efg	156a-e	32.66abc
B5	974.7efg	146a-e	22cdef
Varamin37	1520.3ab	173abc	27bcde
JL1	566.7hij	116e-h	18.33ef
JL14	1460.3abc	190a	39.33a
Varamin 2822	984.0efg	80h	26.66b-e
JL10	1360.0bcd	186ab	39.66a
Local	1493.0abc	181abc	31.66a-d
B2	1131.3cde	136c-g	20.33ab
Varamin 237	1732.7a	176abc	28.66a-e
yekta	808.0e-i	143b-f	14.33f
JL29	699.3f-j	136c-g	18.66ef
Darab 14	1015.0def	170abcd	23b-f
Jl5	962.3efg	93gh	23b-f
Darab 1	770.7e-j	146a-e	25b-f
JL13(halil)	1043.0def	156a-e	33.66abc
JL11	765.0e-j	123e-h	22.66a-f
Nazetak	754.0e-j	156a-e	27b-e
TS3	919.0e-h	183ab	23b-f
JL6	357.0j	136c-g	34.33ab
Darab 2	804.0e-i	173abc	23.33a-f
Jl16	620.3g-j	100fgh	32a-d
JL18	521.3ij	180abc	24.33b-f
Jl14-1	821.7e-i	110d-g	29b-f

Means followed by the same letters in each column are not significantly different (LSD, $P < 0.05$).

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Discussion

The results of this study showed that there was a significant difference among sesame genotypes in terms of resistance against Fusarium wilt disease. The results of greenhouse and micro-plot experiments (Table 6) showed that sesame genotypes used in this study are not immune to Fusarium wilt disease of sesame. The findings of this research for some of tested genotypes are in agreement with the result of other researchers in the greenhouse condition with artificial inoculation (Gulzar 1989; Jyothi *et al.,* 2011; Goyal *et al.,* 1980).

Studies have shown that there is a correlation between some agronomic traits (such as mode of branching and seed color) of sesame cultivar and the infection percentage by *Fusarium* and *Macrophomina* fungi. The resistant cultivars have the medium branching with milky or bright seed colors (El-bramawy *et al.,* 2008). In our study, most of used cultivars (Table 1) were multi branched except Naz-takshakhe (single branch) with brown to dark seed color (except Naz-takshakhe and Ts-3). Results of this study in greenhouse condition showed that the cultivars which were multi-branched with dark seed color, were sensitive to the Fusarium wilt disease. These results are in agreement with those of similar research in China (Shengyu, 1991). The results of this study under artificial inoculation with fusarium, showed that sesame varieties used in this study are not immune to fusarium wilt. Results are also in agreement with those of Sadeghi Garmarudi and Mansuri (2014) on *Macrophomina* fungi.

In this study, it was not possible to take a statistical average among the three experiments, in order to make an overall categorization of genotypes because the conditions of the experiments were different. So, for finding overall resistance category comprising the three experimental results, while two results showed same resistance class, we considered that as reaction of related genotype, otherwise we consider as variable reaction (Table 6). Combined results of the three experiments (Table 6) shows that 29.1 % of sesame genotypes (JL1, Jl14, JL10, JL11, JL13, Jl18 and Darab1) fell in resistant (R) category and 37.5% of sesame genotypes (JL2, Varamin37, Local, Yekta, JL29, JL16, JL6, JL14-1 and Darab2) fell in moderately resistant (MR) group. While 16.6% of genotypes (Darab14, TS3, Varamin2822 and Varamin237) fell in moderately susceptible category and the remaining 16.6% of genotypes (B2, B5, JL5 and Naz-Takshakheh) showed variable reactions and need to be evaluated again in future. The resistant and moderately resistant genotypes can be used for breeding programs. The results showed that although the selected land for field experiment was contaminated but the average of infection percentage to fusarium wilt of sesame in field condition (no artificial inoculation) was less than the greenhouse and micro plot conditions (artificial inoculation).The differences observed in the results of the reaction of sesame varieties to *Fusarium* fungus in terms of natural and artificial contamination are probably due to differences in the initial and primary inoculums. In field conditions there may be some biocontrol agents in soil which help decrease disease incidence (Ziedan *et al.,* 2011). The durability degree of resistance to wilt disease of sesame in some genotypes may vary from one year to another and the environmental conditions may affect it (Bakheit *et al.,* 1988). In this research some genotypes selected from native lines showed variable resistance due to their sensitivity to the environmental condition. A definitive comment in this regard needs additional research.

The vigor of plant to develop and grow new roots especially in the case of soil borne fungal diseases is one of the mechanisms of resistance and tolerance. In this research, despite the existence of a significant difference between the genotypes of sesame in measured agronomic traits, we did not find a specific relationship between agronomic traits (plant height, root dry weight) and disease infection percentage in case of *Fusarium* wilt of sesame. It has been shown that *Fusarium* reduces plant

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height in Ziziphus (Nejat *et al.,* 2013). Growth reduction caused by the interaction between *Fusarium* fungus and drought on cantaloupe has been reported (Maria *et al.,* 1989). Abd- El Moneem *et al.* (1997) tested some important commercial cultivars of sesame, obtained by tissue culture method, against *Fusarium* wilt disease and screened them for enzyme activity. They studied the activity of peroxidase, esterase, acid phosphatase, catalase, alcohol dehydrogenase and reported that the enzyme activity of peroxidase in infected tissues is higher than healthy ones. The rate of enzyme activity of peroxidase in case of infected plants, 14 days after inoculation with Fusarium has been increased up to 50 times compared to healthy ones (Abd- El Moneem *et al.,* 1997). Also results of study by Fallahpori *et al.* (2013) showed an increase up to 1.4 times in activity of the enzyme phenylalanine ammonia lyase (PAL) that plays an important role in the induction of resistance to fusarium in sesame cultivars. It has been reported that some anti-nutritional factors (phytic acid, trypsin inhibitor and tannins) in sesame seed genotypes have been used as screening criteria for fusarium wilt disease resistance (El-Bramawy, 2011). It has been shown there is a significant difference among sesame genotypes category (resistant, moderately resistant, moderately susceptible and susceptible) in their contents of the anti-nutrient factors (El-Bramawy, 2011). Resistant category possesses higher value of these factors than the susceptible one. It has also been reported that the content of anti-nutritional factors may be variable in two different growing seasons due to environmental changes (El-Bramawy, 2011). In this study we found variable reaction among sesame genotypes under different experimental conditions (greenhouse, micro-plot and field). This may be due to variability in anti-nutritional value of a given sesame genotypes under different conditions. Our results showed that the level of resistance of a given sesame genotype in field and micro-plot conditions was higher than greenhouse condition. It may be the content of anti-nutritional factors in field and micro-plot conditions are higher than those in greenhouse condition. Confirmation of this theory needs more research. In this study no immune cultivars were found, however, the use of resistant cultivars is one of the most important and most successful methods to control the disease. The susceptibility of most genotypes to Fusarium wilt disease in greenhouse trials under artificial inoculation might indicate the gene(s) responsible for resistance are not fully expressed in the seedling stage (El-Bramawy *et al.,* 2001).The genotypes of JL10 and Jl14 showed the maximum root dry weight, height and R reaction, so these genotypes can be used inbreeding programs owing to having good agronomic qualities. Use of resistant or tolerant cultivars combined with other control methods such as biological, agronomic and chemical methods can be helpful in controlling the disease, of sesame fusarium wilt. More of the native populations are suggested to be tested.

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Statement of conflicting interest

The authors state that there is no conflict of interest.

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ارزیابی مقاومت نسبی ارقام و توده‌های بومی کنجد به بیماری پژمردگی فوزاریومی

موسی نجفی‌نیا[1] و احمد آئین[2]

۱- بخش تحقیقات گیاه‌پزشکی، مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی جنوب استان کرمان، سازمان تحقیقات، آموزش و ترویج کشاورزی، جیرفت، ایران.
۲- بخش تحقیقات اصلاح و تهیه نهال و بذر، مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی جنوب استان کرمان، سازمان تحقیقات، آموزش و ترویج کشاورزی، جیرفت، ایران.
پست الکترونیکی نویسنده مسئول مکاتبه: m.najafinia@areeo.ac.ir
دریافت: ۱۶ شهریور ۱۳۹۸؛ پذیرش: ۸ اردیبهشت ۱۳۹۹

چکیده: کنجد با نام علمی *Sesamum indicum* L. به‌عنوان یک گیاه روغنی در تناوب با محصولات جالیزی و غلات، در ایران کشت شده و در توسعه کشاورزی پایدار اهمیت به‌سزایی دارد. یکی از عوامل محدودکننده کشت کنجد، بیماری پژمردگی فوزاریومی با عامل *Fusarium oxysporum* f. sp. *sesami* است. استفاده از ژنوتیپ‌های برتر و مقاوم یکی از بهترین راهبردهای مقابله با بیماری فوزاریومی کنجد است. در این تحقیق، مقاومت نسبی ۲۴ ژنوتیپ کنجد شامل ارقام تجاری و توده‌های بومی امیدبخش کنجد در برابر قارچ فوزاریوم در شرایط مختلف گلخانه، میکروپلات و مزرعه مورد ارزیابی قرار گرفت. در شرایط گلخانه و میکروپلات مایه‌زنی مصنوعی با قارچ فوزاریوم انجام ولی بررسی‌های مزرعه‌ای در زمین دارای سابقه آلودگی انجام پذیرفت. ارزیابی واکنش مقاومت ارقام و تعیین تیپ بیماری (حساس-ایمن) به‌صورت سیستم نمره‌دهی صفر تا شش برای هر تیمار انجام شد. نتایج نشان داد در شرایط مایه‌زنی مصنوعی، هیچ‌کدام از ارقام کنجد مورد استفاده در این تحقیق در برابر قارچ فوزاریوم عامل بیماری پژمردگی آوندی کنجد، ایمن نمی‌باشند. متوسط درصد آلودگی ارقام کنجد در شرایط گلخانه، میکروپلات و مزرعه به‌ترتیب ۵۸/۳۴، ۲۸/۶ و ۱۵/۹۶ درصد محاسبه گردید. نتایج کلی آزمایش‌ها در سه شرایط نشان داد، ۲۹/۱ درصد از ژنوتیپ‌ها (JL1, Jl14, JL10, JL11, JL13, Jl18 و Darab1) مقاوم (R) و ۳۷/۵ درصد از ژنوتیپ‌ها (JL2, Varamin37, Local, Yekta, JL29, JL16, JL6, JL14-1 و Darab2) مقاومت متوسط (MR) نشان دادند. ژنوتیپ‌های مقاوم و مقاومت متوسط می‌توانند در برنامه‌های اصلاح و توسعه ارقام مقاوم به بیماری فوزاریومی کنجد استفاده شوند. تحقیقات بعدی به‌منظور شناسایی ارقام ایمن و خیلی مقاوم با به‌کارگیری و غربال‌گری ژنوتیپ‌های بومی بیش‌تر ضروری است.

واژگان کلیدی: ژنوتیپ، دانه روغنی، لاین امیدبخش، مقاومت، پوسیدگی ریشه

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