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Full Length Research Paper

Mycelial compatibility groups and pathogenicity of *Sclerotinia sclerotiorum* (Lib.) De Bary causal agent of white mold disease of greenhouse grown cucumber in Antalya-Turkey

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Population variability of *Sclerotinia sclerotiorum*, the causal organism of white mold disease of greenhouse grown cucumber plants in Kumluca, Finike and Demre districts of Antalya, was determined by mycelial compatibility grouping (MCG) and isolate aggressiveness comparisons. MCG, host specificity and aggressiveness of *S. sclerotiorum* isolates were assessed. Isolate pairs were designated compatible when no barrage zone formed at sites of contact. They were designated incompatible when a clear zone and red line formed in the region of hyphae interaction. Among the 119 isolates tested, 20 MCGs consisted of two isolates, 5 MCGs of three isolates and 2 MCGs of seven isolates, 1 MCG of four isolates, 1 MCG of five isolates and the remaining 41 MCGs of one isolate each. Each district of Antalya was a mosaic of MCGs, but MCGs frequencies between the three districts. Variation in isolate aggressiveness was determined using a limited-term, plug inoculation technique. Isolate aggressiveness varied (P= 0.05) within and among MCGs. In each location (Demre, Kumluca and Finike), highly virulent and weakly virulent isolates were obtained. Even significant differences were determined in virulence of isolates within MCGs in the same location. Pathogen population structure and variability in isolate aggressiveness may be important considerations in disease management systems.

Key words: *Sclerotinia sclerotiorum,* white mold, mycelial compatibility grouping (MCG), cucumber.

INTRODUCTION

Sclerotinia sclerotiorum (Lib.) De Bary cosmopolitan pathogen, causes white mold, stem rot and fruit rot diseases in 408 plant species from 275 different families (Boland and Hall, 1994). *S. sclerotiorum* overwinters as sclerotia in soil or within the infected tissues, or as mycellia in dead or alive plant tissues (Agrios, 1997). The most important structure in the life cycle of the fungus is the sclerotium. The sclerotium is a compact mass of hardened mycelium containing food reserves (Ben-Yephet et al., 1993) and enables the fungus to survive environmental extremes for example, harsh winter conditions. These structures were reported to survive in the soil for more than 5 years (Adams and Ayers, 1979). Sclerotiums form apothecium via germination and ascospores coming out of apothecium cause infection in plants (Abawi and Grogan, 1979). Ascospores produced by sclerotiums, that are placed in the first 5 cm of soil have the initial importance of causing infection of pathogens (Steadman, 1974). The spread of the pathogen from plant to the plant only takes place through contact. Another characteristic of *S. sclerotiorum* differing from the other fungal pathogens is that ascospores need extra source of food to penetrate the host plant tissue via germination. Therefore, ascospores germinate better on wounded tissues or plant tissues that are nearly to die for example, flower petals nearly to wilt. First, they get colonized in these tissues and then, they spread the

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infection to the other healthy tissue (Abawi and Grogan, 1975). Abawi et al. (1975) and Cook et al. (1975) reported that primary infections of ascospore occur during the flowering.

A system was identified which allows mycelial compatibility between *S. sclerotiorum* isolates (Kohn et al., 1991). Usually, anastomose among hyphaes and vegetative compatibility among the isolates was observed within the colony of ascomycota. It was reported that anastomose and successful hetorakaryon among the isolates were formed generally by one or more than one vegetative compatibility locus (Glass and Kuldav, 1992).

The objectives of this study were to (1) identify MCGs among *S. sclerotiorum* isolates collected from green-house cucumber in Demre, Finike and Kumluca districts of Antalya; (2) assess variability in isolate and MCG aggressiveness; (3) determine if an isolate cultivar interaction exists.

MATERIALS AND METHODS

S. sclerotiorum isolates

One hundred nineteen (119) isolates of *S. sclerotiorum* were collected from infected greenhouse grown cucumbers in the growing seasons of 2007 to 2009. For isolation, a single sclerotium or infected host tissue, surface-sterilized by dipping in 1% sodium hypochlorite solution for 5 min and then rinsed three times with sterile distilled water, using dry out blotter for 3 min, was aseptically transferred into potato dextrose agar (PDA) plates. The plates were incubated at 25°C. Mycelial discs (diameter of 5 mm) taken from the edge of the actively growing colonies transferred to the Petri dishes containing PDA to obtain pure culture of the pathogen.

Mycelial compatibility groups

Isolates were paired in all possible combinations on modified Patterson's medium (MPM) according to Kohn et al. (1991). Mycelial plugs (2 mm in diameter) of each isolate were cut with the aid of sterile cork borer at the growing margin of 5 days old culture plates at 24°C and transferred to the opposite ends of MPM plate (35 mm apart). The compatibility/ incompatibility were scored 7 to 10 days after incubation at 24°C. Mycelial reactions were recorded as incompatible when an apparent line of demarcation, a barrage zone, was observed between the confronting paired isolates and there was compatibility among isolate pairs when no barrage zone was formed in the region of contact (Kohn et al., 1991). This experiment was replicated twice.

Host-specificity and pathogenicity tests

Host-specificity and pathogenicity of isolates were determined using a limited-term, agar-plug inoculation technique when the plants were at the beginning of flowering (five true leaf stage) (R_2 phase) (Nelson et al., 1988). Mycelial discs (diameter of 5 mm) removed from the advancing mycelial edge and singly placed as mycelia side down on the stem of the plants over 4 cm from the soil surface. Wet cotton was placed on it and then wrapped with parafilm to maintain the moisture wetness. Inoculated plants were transferred in air-conditioned greenhouse benches at 20 ± 2°C. At the end of three-day incubation period, inoculum was removed and then the plants were incubated for another additional 4 days. At the end of the 7 day-incubation period, light and dark brown lesions occurred on the stem beginning from the point of inoculation and the length of these lesions were measured with a digital caliper. Host-specificity tests were performed on the plant species such as tomato (Treat Fı), pepper (Farya Fı), bean (Legend) and cucumber (Halley Fı) as previously stated. Experimental design was randomized block design with four replication and experiment was repeated twice.

Statistical analysis

The data were analyzed using analysis of variance (PROC ANOVA; SAS Institute, Inc., Cary, NC) and means were compared by least significant differences (LSD) at P= 0.05.

RESULTS

Isolates

As a result of surveys conducted during 2007 to 2008 and 2008 to 2009 vegetation period, a total of 119 *S. sclerotiorum* isolates were collected (Table 1).

Mycelial compatibility groups

MCGs were determined among the pairs of isolates. Isolates collected from all the localities were compared with each other and with isolates in the other localities and 29 MCGs were obtained. Accordingly, 8 compatibility groups among 40 isolates collected from Demre, 12 compatibility groups among 42 isolates collected from Kumluca and 9 compatibility groups among 37 isolates collected from Finike were identified. Additionally, a total of 41 MCGs composed of one isolate each. Twenty (20) MCGs consist of 2 isolates (Table 2).

If two isolates could grow together without any obvious line between them then they were considered compatible with each other. Otherwise, if a line was formed between them, they were considered incompatible (Figure 1).

Host-specificity tests

A total of 60 isolates (24 isolates from Kumluca, 18 isolates from Finike and 18 isolates from Demre) representing 29 MCGs were tested for host-specificity to tomato (Treat Fı), pepper (Farya Fı), bean (Legend) and cucumber (Halley Fı) using a limited-term, plug inoculation technique (Tables 3, 4, 5 and 6). Isolates inoculated to the plants of tomato, pepper, bean which were used in host-specificity tests, formed a different lesion length in each plant. Both highly virulent and weakly virulent isolates in each locality were determined. There are statistically significant differences among the isolates in terms of virulence. Accordingly, no host-specificity was revealed the different virulent level of isolates (Tables 3, 4 and 5).

Table 1. According to the localities of *Sclerotinia sclerotiorum* isolate numbers obtained from the survey in Demre, Kumluca and Finike.

Locality	Number of isolate		
	2007-2008 (1st Survey)	2008-2009 (2nd Survey)	Total
Demre	18 (*D1-D18)	22 (D19-D40)	40 (D1-D40)
Kumluca	20 (*K1-K20)	22 (K21-K42)	42 (K1-K42)
Finike	16 (*F1-F16)	21 (F17-F37)	37 (F1-F37)
Total	54	65	119

*D; Demre*K; Kumluca*F; Finike locations.

Table 2. Mycelial compatibility groups identified in the survey areas in Demre, Finike and Kumluca.

MCGs	Isolate		
	Demre	Kumluca	Finike
Group I	D2, D5, D6, D12, D16, D17,D18	K2, K3	F13, F14, F15, F16
Group II	D8, D9	K1, K13	F7,F6
Group III	D3, D15	K7, K6	F9, F10, F12
Group IV	D10, D11	K17, K18	F1, F2, F3
Group V	D20, D24, D26, D29, D31, D34,D40	K11, K12, K14, K15, K16	F4, F5
Group VI	D27, D32	K9, K10	F21,F22,F33
Group VII	D30, D36, D37	K19, K20	F19,F20
Group VIII	D33, D35, D38	K25, K26	F23,F25
Group IX	-	K27, K28	F26,F27
Group X	-	K21, K30	-
Group XI	-	K23, K39	-
Group XII	-	K40, K42	-
Incompatibility within themselves	D1, D4, D7, D13, D14, D19, D21, D22, D23, D25, D28, D39	K4, K5, K8, K22, K24, K29, K31, K32, K33, K34, K35, K36, K37, K38, K41	F8, F11, F17, F18, F24, F28, F29, F30, F31, F32, F34, F35, F36, F37
Total	40	42	37

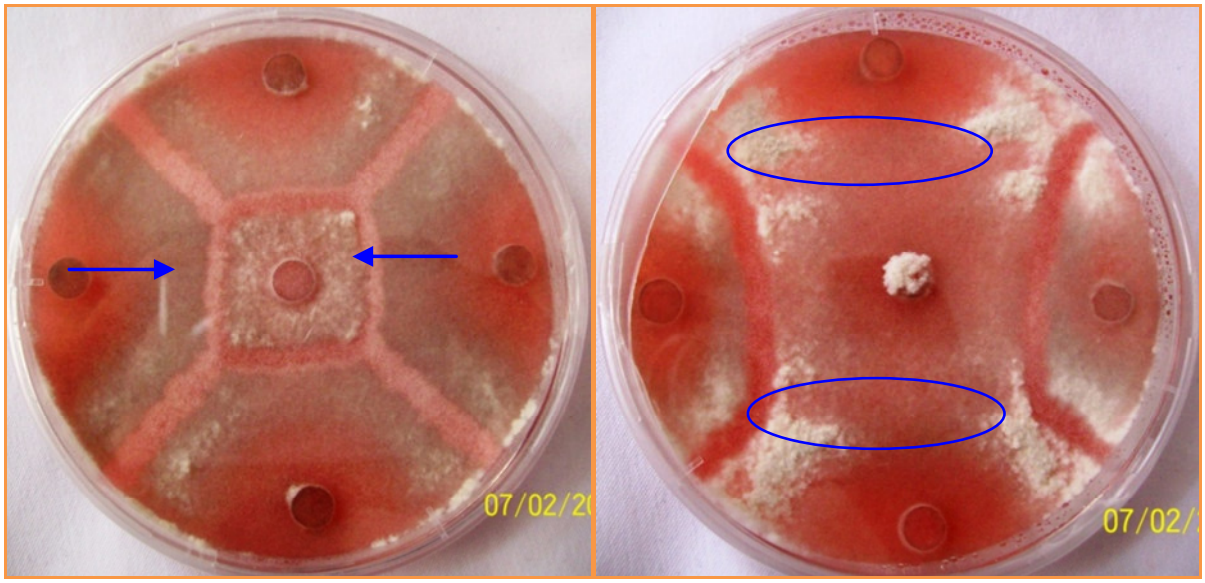

Figure 1. The reaction of the different (left) or the same (right) MCGs belonging to *S. sclerotiorum* isolates.

Table 3. Determination of the disease severity based on the host-specificity tests on tomato (Treat Fı) of *S. sclerotiorum* isolates.

Isolate	MCGs	Lesion length (mm)	Isolate	MCGs	Lesion length (mm)
D6	D-I	64.95^{a}*	D27	D-VI	42.26^{k-q}
K13	K-II	59.17^{ab}	F23	F-VIII	41.68l^{-r}
K30	K-X	58.13^{ab}	K39	K-XI	40.92^{m-s}
F9	F-III	55.83^{bc}	D34	D-V	40.89^{m-s}
D8	D-II	55.14^{bcd}	K21	K-X	40.88^{m-s}
F19	F-VII	54.61^{b-e}	D9	D-II	40.87^{m-s}
D26	D-V	53.89^{b-f}	D11	D-IV	40.60^{m-s}
D37	D-VII	53.51^{b-f}	K25	K-VIII	40.29^{n-s}
K20	K-VII	51.00^{c-g}	F25	F-VIII	39.59^{n-s}
D32	D-VI	50.65^{c-h}	D3	D-III	39.59^{n-s}
K23	K-XI	50.59^{c-i}	K6	K-III	39.34^{n-s}
F7	F-II	49.96^{c-j}	D10	D-IV	39.33^{n-s}
K17	K-IV	49.83^{c-j}	K10	K-VI	39.30^{n-s}
D24	D-V	49.11^{c-k}	F2	F-IV	39.13^{n-s}
D12	D-I	48.40^{d-l}	D35	D-VIII	38.79^{n-t}
K28	K-IX	47.95^{e-l}	F22	F-VI	38.51^{o-t}
D33	D-VIII	47.35^{f-m}	F26	F-IX	37.98^{p-u}
F5	F-V	45.55^{g-n}	K19	K-VII	37.79^{p-u}
K40	K-XII	45.50^{g-n}	K2	K-I	37.77^{p-u}
K12	K-V	45.23^{g-o}	D15	D-III	36.02^{q-v}
K7	K-III	44.60^{g-p}	K9	K-VI	35.58^{q-v}
D5	D-I	44.48^{g-p}	D36	D-VII	35.42^{q-v}
F10	F-III	44.35^{g-p}	F4	F-V	35.23^{r-v}
F3	F-IV	44.2^{1g-p}	K26	K-VIII	35.06^{r-v}
K42	K-XII	44.08^{g-p}	F14	F-I	34.79^{r-v}
K27	K-IX	43.98^{h-p}	K3	K-I	34.24^{s-v}
K1	K-II	43.72^{h-p}	F20	F-VII	31.90^{tuv}
F27	F-IX	43.66^{i-p}	K15	K-V	31.07^{uv}
F6	F-II	43.62^{i-p}	K18	K-IV	30.60^{v}
F15	F-I	43.38^{i-p}	F21	F-VI	29.38^{v}

*Means within a column followed by the same letter are not significantly different according to Fisher's least significant difference test, P= 0.05 (LSD: 6.97).

Pathogenicity tests

According to the results based on pathogenicity tests on cucumber (Halley Fı) which is sensitive to pathogens, it was revealed that there were significant differences in isolates in terms of disease severity. In all localities, both highly virulent and weakly virulent isolates were observed within and between MCGs. In all localities, statistically significant differences in virulance were found among isolates both in different groups and the same group (Table 6). The least aggressive isolates (D27 and D36) were obtained from cucumber plants in Demre and the most aggressive isolate (K6) were from cucumber plant in Kumluca.

DISCUSSION

White mold disease by *S. sclerotiorum* was seen widely in survey areas. Disease signs were encountered in tomato, cucumber, pepper and bean in these areas. The aim of this study was that the observation of the disease on the other greenhouse plants, as mentioned in previous studies, reveals that this disease has a wide host range. Indeed *S. sclerotiorum* was one of the most destructive plant pathogens, which was also not very specific to hosts. *S. sclerotiorum* formed disease in 64 family, 225 genera and 361 species (not compatible with the introduction section "408 plant species from 275 different families (Boland and Hall, 1994)") of plants such as

Table 4. Determination of the disease severity based on the host-specificity tests on pepper (Farya Fı) of *S. sclerotiorum* isolates.

Isolate	MCGs	Lesion length (mm)	Isolate	MCGs	Lesion length (mm)
D24	D-V	126.61^{a*}	F14	F-I	87.20^{h-q}
K17	K-IV	119.16^{ab}	K39	K-XI	86.96^{h-q}
K6	K-III	119.03^{ab}	F7	F-II	85.83^{i-r}
D9	D-II	118.81^{ab}	D11	D-IV	84.44^{j-s}
F10	F-III	117.99^{abc}	K21	K-X	83.77^{k-s}
K10	K-VI	117.76^{abc}	K3	K-I	82.54^{l-t}
D37	D-VII	115.88^{a-d}	D35	D-VIII	82.29^{l-t}
K13	K-II	114.57^{a-e}	D36	D-VII	81.47^{m-u}
K19	K-VII	107.17^{b-f}	K26	K-VIII	81.23^{m-u}
K12	K-V	105.84^{b-g}	F15	F-I	79.17^{n-v}
K28	K-IX	105.67^{b-g}	F4	F-V	78.31^{o-w}
F9	F-III	105.29^{b-g}	K27	K-IX	77.10^{p-x}
K7	K-III	103.56^{b-h}	D3	D-III	76.77^{p-x}
F5	F-V	101.73^{c-i}	F2	F-IV	73.14^{q-y}
D27	D-VI	101.65^{c-i}	D15	D-III	72.55^{q-y}
K42	K-XII	101.46^{c-i}	F26	F-IX	70.81^{q-z}
D8	D-II	100.75^{d-j}	F3	F-IV	69.86^{rs-z}
K23	K-XI	100.08^{d-k}	F22	F-VI	68.71^{s-a1}
K9	K-VI	98.32^{e-l}	D34	D-V	66.64^{t-a1}
K2	K-I	98.32^{e-l}	D10	D-IV	65.47^{u-a1}
D26	D-V	97.25^{f-m}	F6	F-II	63.50^{v-b1}
K1	K-II	95.51^{f-n}	D6	D-I	62.46^{w-b1}
K15	K-V	94.92^{f-o}	D12	D-I	60.56^{x-b1}
K25	K-VIII	94.19^{f-o}	K20	K-VII	56.88^{y-b1}
D33	D-VIII	92.05^{f-p}	K40	K-XII	55.69^{za1b1}
D32	D-VI	91.83^{f-p}	D5	D-I	54.95^{za1b1}
F19	F-VII	91.37^{f-p}	F21	F-VI	54.87^{za1b1}
F25	F-VIII	91.07^{f-p}	F27	F-IX	54.43^{za1b1}
F23	F-VIII	90.40^{g-p}	F20	F-VII	52.52^{a1b1}
K18	K-IV	90.16^{g-p}	K30	K-X	47.23^{b1}

*Means within a column followed by the same letter are not significantly different according to Fisher's least significant difference test, P= 0.05 (LSD: 16.68).

sunflower, bean, soybean, peanut, lettuce, cabbage, alfalfa, clover and other legumes (Pratt, 1993; Purdy, 1979). Based on the studies done in Turkey, *S. sclerotiorum* caused infection on cucumber, tomato and eggplant in Eastern Mediterranean Region where main greenhouse vegetable productions were performed (Aksay et al., 1991; Tuncer and Damdere, 1997). Additionally, Demirci and Kordali (1998) reported that the disease was determined on sunflower in Pasinler Plain in Erzurum, Onaran and Yanar (2009) on cucumber in Tokat and Amasya, Tok (2008), on sweet basil plants in commercial greenhouses in Demre and Antalya, and Soylu and Derviş (2009), on pea plants in Amik Plain in Hatay. According to the results of this study, 29 MCGs were determined among 119 isolates collected from the survey regions of *S. sclerotiorum.* There are 41 groups containing one isolate. Populations of *S. sclerotiorum* from Demre, Kumluca and Finike cucumber greenhouses were heterogeneous mix of MCGs. This corroborates with the reports of *S. sclerotiorum* MCG population structure on cucumber in Tokat and Amasya (Onaran and Yanar, 2009), sunflower in Erzurum (Tozlu and Demirci, 2008) and soybean (Hambleton et al., 2002) and canola (Kohli et al., 1992) in Canada. In our study, each location contained 10 or 11 MCGs composed of 2 or 7 isolates, but they contained about 23 MCGs composed of single isolate.

Based on the results of host-specificity tests, 60 *S. sclerotiorum* isolates representing 29 MCGs were found to be the pathogens of tomato, pepper and bean plants. Isolates of *S. sclerotiorum* caused different disease severity on each plant species and this indicates that fungus did not specialize on single host. As a result of host-specificity tests, in terms of disease severity, the

Table 5. Determination of the disease severity based on the host-specificity tests on bean (Legend) of *S. sclerotiorum* isolates.

Isolate	MCGs	Lesion length (mm)	Isolate	MCGs	Lesion length (mm)
F25	F-VIII	84.93^{a}*	K26	K-VIII	51.42^{j-q}
D37	D-VII	84.65^{a}	K3	K-I	51.29^{j-r}
F2	F-IV	83.91^{a}	D11	D-IV	50.63^{k-s}
D33	D-VIII	81.64^{ab}	D9	D-II	47.82^{l-t}
F19	F-VII	81.51^{ab}	D27	D-VI	46.35^{m-t}
K6	K-III	79.63^{abc}	K19	K-VII	45.88^{m-t}
K17	K-IV	74.14^{a-d}	K20	K-VII	45.23^{n-t}
D15	D-III	71.94^{b-e}	K10	K-VI	45.21^{n-t}
K42	K-XII	71.26^{b-e}	K13	K-II	45.08^{n-t}
K27	K-IX	68.63^{c-f}	D24	D-V	44.26^{n-t}
F14	F-I	66.85^{def}	K7	K-III	44.24^{n-t}
K12	K-V	65.09^{d-g}	F7	F-II	42.38^{p-u}
K15	K-V	64.49^{d-h}	F9	F-III	41.97^{p-u}
K25	K-VIII	63.87^{d-i}	D32	D-VI	41.90^{p-u}
D3	D-III	63.76^{d-i}	F6	F-II	41.56^{q-u}
D35	D-VIII	63.30^{d-i}	D5	D-I	39.60^{r-v}
F26	F-IX	63.06^{d-j}	D6	D-I	39.38^{s-v}
F5	F-V	62.72^{d-j}	D34	D-V	38.95^{s-v}
D10	D-IV	62.32^{e-k}	K39	K-XI	38.93^{s-v}
D12	D-I	61.97^{e-k}	F23	F-VIII	38.32^{tuv}
K1	K-II	60.94^{e-k}	D36	D-VII	38.29^{tuv}
F22	F-VI	59.07^{f-l}	F15	F-I	36.74^{t-w}
K18	K-IV	58.24^{f-l}	D26	D-V	32.07^{u-x}
K40	K-XII	57.42^{f-m}	K23	K-XI	30.76^{u-y}
K28	K-IX	54.21^{g-n}	F27	F-IX	28.20^{v-y}
F20	F-VII	54.20^{g-n}	K21	K-X	27.87^{v-y}
F4	F-V	53.85^{g-o}	F21	F-VI	25.44^{wxy}
F3	F-IV	53.45^{g-p}	D8	D-II	24.64^{xy}
K2	K-I	53.26^{h-q}	K30	K-X	19.61^{y}
F10	F-III	52.11^{i-q}	K9	K-VI	19.41^{y}

*Means within a column followed by the same letter are not significantly different according to Fisher's least significant difference test, P= 0.05 (LSD: 11.81).

Table 6. Determination of the disease severity based on the pathogenicity tests on cucumber (Halley Fı) of *S. sclerotiorum* isolates.

Isolate	MCGs	Lesion length (mm)	Isolate	MCGs	Lesion length (mm)
K6	K-III	122.80^{a}*	F6	F-II	78.03^{lmn}
D3	D-III	109.50^{b}	K17	K-IV	77.36^{l-o}
K7	K-III	107.19^{bc}	D37	D-VII	76.81^{l-o}
D11	D-IV	104.50^{bcd}	K10	K-VI	76.50^{l-o}
D15	D-III	101.81^{b-e}	K39	K-XI	76.29^{l-o}
K26	K-VIII	101.54^{b-e}	K27	K-IX	76.13^{l-o}
D24	D-V	101.21^{b-e}	D5	D-I	74.87^{l-p}
K13	K-II	100.74^{b-f}	F5	F-V	68.75^{m-q}
F9	F-III	97.86^{b-g}	F20	F-VII	65.61^{n-r}
K18	K-IV	97.66^{b-g}	D6	D-I	64.89^{o-s}
K21	K-X	95.90^{c-h}	D12	D-I	62.79^{p-t}
K2	K-I	95.79^{c-h}	F14	F-I	62.23^{p-t}
K15	K-V	95.71^{c-h}	F23	F-VIII	60.70^{q-u}

Table 6. Cont.

F2	F-IV	94.97^{c-i}	F22	F-VI	59.87^{q-u}
D34	D-V	93.36^{d-j}	D35	D-VIII	57.40^{q-v}
D26	D-V	93.32^{d-j}	F27	F-IX	57.13^{q-v}
F4	F-V	92.90^{d-j}	F3	F-IV	55.49^{r-w}
K12	K-V	91.89^{d-k}	K28	K-IX	54.79^{r-x}
K3	K-I	91.39^{e-k}	D32	D-VI	54.70^{r-x}
K9	K-VI	87.80^{f-l}	F21	F-VI	54.40^{r-x}
K40	K-XII	87.13^{g-l}	K42	K-XII	53.34^{r-y}
D33	D-VIII	87.07^{g-l}	K19	K-VII	52.58^{r-y}
D8	D-II	84.50^{h-l}	F26	F-IX	52.16^{s-y}
D10	D-IV	83.38^{h-l}	K20	K-VII	50.13^{t-y}
K1	K-II	82.36^{i-l}	F10	F-III	50.10^{t-y}
K30	K-X	82.12^{i-l}	F7	F-II	47.85^{u-y}
K25	K-VIII	81.43^{j-m}	F15	F-I	46.13^{v-y}
K23	K-XI	81.24^{j-m}	F25	F-VIII	42.47^{wxy}
D9	D-II	80.51^{j-m}	D27	D-VI	41.81^{xy}
F19	F-VII	79.49^{klm}	D36	D-VII	41.04^{y}

*Means within a column followed by the same letter are not significantly different according to Fisher's least significant difference test, P= 0.05 (LSD: 13.1).

highest virulence level of *S. sclerotiorum* was found in pepper with a lesion length of 126.61 mm, in bean with 84.93 mm and tomato with 64.95 mm. It was stated both in this study and in the previous studies that there were no host-specificity among the MCGs of *S. sclerotiorum* as it was seen in MCGs of *S. sclerotiorum* (Çarkaci and Maden, 1986; Yanar, 1997; Tozlu and Demirci, 2008; Onaran and Yanar, 2009).

Based on pathogenicity test on cucumber plant, virulent and non-virulent isolates were obtained among 60 isolates representing 29 MCGs in terms of disease severity. There were statistically significant difference among isolates and groups in all localities in terms of virulence. Highly virulent or weakly virulent isolates were obtained in the same group and also among the groups. These findings agree with the previous studies (Onaran and Yanar, 2009; Yanar, 1997) in which pathogenicities of 59 isolates on pepper and 23 isolates on cucumber were tested, respectively. In both studies, virulence levels of the isolates were different within and among the MCGs.

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