SCREENING OF SESAME GENOTYPES FOR RESISTANCE TO ROOT ROT CAUSED BY *Macrophomina phaseolina* AND YIELDING ABILITY

By

Abd El-Mohsen, A. A. and W. A. El-Murshedy

Agronomy Dept., Fac. Agric., Cairo University, Giza

ABESTRACT

This investigation was conducted in 2004, 2005 and 2006 seasons in a commercial field at Abo Rawash village, Giza governorate, Egypt, with a history of natural infection with the root rot pathogen and in another field, free of infection as a control. The main objective was to test 15 sesame genotypes (4 commercial cultivars, and 11 promising mutant lines originated *via* selection in a previous breeding program, for resistance to root rot caused by *Macrophomina phaseolina* (Tassi.) Goid, under artificial and natural infection conditions. All screened sesame genotypes varied significantly in the degree of infestation with the root rot pathogen. It is worthy to mention that some of sesame genotypes kept their moderate resistance (MR) or resistance (R) during the three successive seasons. The results revealed that, mutants No. 10, 45, 49, 57 and 58 were resistant to root rot disease across the three seasons, recording an average incidence of 6.43, 4.67, 7.42, 6.54 and 6.55 %, and gave a seed yield of 416.6, 419.6, 400.9, 400.7 and 420.4 kg/feddan, respectively under natural infection conditions. Also, their values of mean incidence were lower than those of checks Giza 25 (16.45%), Giza 32 (12.31%) and Toshka 1 (29.94%). It was clearly noticed that seed yield of these mutant lines surpassed all commercial cultivars under both conditions. Such genotypes may be helpful for breeding programs because of their root rot resistance as well as their seed yield superiority. The results also showed that the commercial cultivars (Giza 25, Giza 32) and the mutants (46 and 50) ranked as moderately resistant (10-20 %). These genotypes showed an average seed yield of 289.5, 320.6, 419.3 and 416.1 kg/feddan, respectively under natural infection conditions.

Key words: Sesame, mutants, root rot, *Macrophomina phaseolina*, resistance, yielding ability, *Sesamum indicum*.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the most important oilseed crops in Egypt. Although it has been cultivated for a long time, no significant increase in the productivity has been achieved yet. This low productivity (1145 kg/ha, Anonymous 2005) has been attributed to the occurrence of pests and diseases. The crop suffers from various fungal, bacterial, viral and mycoplasma diseases. Among the fungal diseases, root rot caused by *Macrophomina phaseolina* (Tassi.) Goid is the most devastating disease in Egypt and the world (Rajput *et al.* 1998; El-Barougy 1990; El-Shakhess 1998; Dinakaran and Mohammed 2001). The most common symptom of the disease is the sudden wilting of plants throughout the crop growth , mainly after the flowering phase, when due to severe infection, the stem becomes black and the root rots with a large number of black sclerotia being formed on the affected portions. The pathogen survives as sclerotia in the soil and in crop residues and it has also been reported to be seed-borne.

Root rot is very serious and destructive in all sesame growing areas and causes about 5–100% yield loss as estimated by Vyas (1981), while Maiti *et al.* (1988) reported an estimated yield loss of 57% at about 40% of disease incidence. In Pakistan, seed yield losses of 57% have been reported when sesame plants had reached infection levels of 40% (Maiti *et al.*, 1988), and in India, plant infection incidence can be found at over 50% (Chattopadyay and Kalpanas, 1999). Other authors reported that an increase of 1% on plant incidence reduced seed yield by 1.8 Kg/ha. Some attempts have been made to identify genetic susceptibility, resistance or tolerance in sesame cultivars against the most important diseases. In this matter, 35 varieties coming from five different countries were evaluated in India and *Alternaria solani*, *Leveillula taurica* and *Macrophomina phaseolina* were identified as the most important sesame diseases (Shambharkar *et al.*, 1997).

Screening of sesame genotypes against the root rot pathogen has already been done by several workers (Abdul Wahid and El-Bramawy , 2007; Ammar *et al.* 2004 ; Avila, 2003 ;Avila and Pineda , 1996; Dinakaran and Mohammed , 2001 ; Dinakaran *et al.*, 1996; El-Bramawy 1997and 2003 ; El-Bramawy *et al.*, 2001; El-Bramawy and Abdul Wahid 2006 ;El Deeb, 1989 ; El-Shazly *et al.*, 1999 ; Rajput *et al.*, 1998).

In this context, sesame breeding works could be effective by finding the best genotypes, which would be superior for having a high yield potential with high degree of resistance to the root rot disease. Thus, the aim of the present work was to screen the available sesame genotypes for resistance against the root rot pathogen (*M. phaseolina*) under both natural infection in the field experiment and artificial infection in the pot experiment .

MATERIALS AND METHODS

Three field trials were carried out twice in each season. Planting was done during May in 2004, 2005 and 2006 seasons in a commercial field at Abo Rawash village, Giza governorate with a history of natural infection by the root rot disease and in another field free of infection used as a control. The field study was conducted to evaluate fifteen sesame genotypes under natural infection by the root rot pathogen *Macrophomina phaseolina* (Tassi.) Goid during three successive seasons (2004, 2005 and 2006). These sesame genotypes are listed in Table 1 and include 4 commercial cultivars, and 11 promising mutant lines originated by selection practiced in a previous breeding program. These genotypes were characterized by being less branched , early flowering and having high yielding capacity due to the high number of capsules per axil. The field experiment was laid out in a randomized complete blocks design with four replications in a sandy loam soil. Each genotype was raised on a plot of 10 m^2 in five -row plots with 4 m row length and a spacing of 50 x 10 cm. The recommended cultural practices for sesame production, i.e. fertilizer doses, irrigation times and plant protection measures against insect pests, were performed at the proper times during the three seasons. Seed yield per plot was determined and the yield in kg per feddan was calculated according to these data (1 Feddan = 4200 m^2).

The reactions of these genotypes to the root-rot pathogen were classified as indicated in Table 2 using the scale suggested by Avila and Pineda (1996), which was developed for oilseed sesame cultivars in the same area. Percent incidence of root rot was assessed at regular intervals, and the final incidence was observed on 90 days after sowing (DAS). It was done by counting the affected plants (among the total number of plants in each plot) by visually assessing symptoms of the infection degree on each plant. The reaction of these entries was categorised as indicated below.

Table 1. Pedigree of the commercial cultivars and lines of sesame used in this study.

No.	Name	Pedigree
1	Giza 25	A line selected from Giza 23 X Giza weight
2	Giza 32	A line selected from B32 (CAN 114 x Type 29)
3	Toshka 1	A line selected from B11 x N.A 413
4	Shandaweel 3	A line selected from Giza 32 x N.A 130
5	Mutant 5	Selected mutant lines after seed – irradiation (Co^{60} - gamma source) of the commercial cultivar Giza 24 (Faculty of Agric . Cairo Univ., Giza , Egypt).
6	Mutant 10	
7	Mutant 44	
8	Mutant 45	
9	Mutant 46	
10	Mutant 47	
11	Mutant 49	
12	Mutant 50	
13	Mutant 56	Selected mutant lines induced *via* mutagenic treatments of the commercial cultivar Giza 32 with EMS (0.5 and 1.0 %) (Faculty of Agric., Cairo Univ., Giza , Egypt).
14	Mutant 57	
15	Mutant 58	

Table 2. The scale of evaluation used in this study.

Percent infection	Disease scale	Reaction
1-10	1	Resistant (R)
11-20	3	Moderately Resistant (MR)
21-30	5	Moderately Susceptible (MS)
31-50	7	Susceptible (S)
51-100	9	Highly Susceptible (HS)

Statistical analysis:

Normality distributions in each growing season were checked out by the Wilk Shapiro test (Neter *et al.,* 1996). The obtained data were converted into arcsin and subjected to the statistical analysis using the method outlined by Cochran and Cox (1957). An analysis of variance (ANOVA) was done for each season separately as randomized complete blocks design. Homogeneity test of variances (Bartlett's test) were used according to procedures reported by Snedecor and Cochran (1976). Thus, hypothesis that the three error variances are homogeneous can't be rejected and combined analysis of variance was computed. However, for those cases where the hypothesis was rejected indicating the presence of heterogeneity, the analysis of variance was not computed and data of individual seasons will be presented and discussed separately. The differences between mean values of crosses were compared by Duncan's Multiple Range (L.S.R) test at 0.05 level of probability (Duncan 1955). Data were statistically analyzed using ANOVA in the MSTAT-C software package (Freed *et al.,* 1989), and SPSS computer software (Release 9. 0. 0, SPSS Inc.).

Pot experiment:

A pot experiment was conducted during 2004 to confirm the field resistance of sesame entries to root rot pathogen. The inoculum of *Macrophomina phaseolina*, multiplied in a sand-maize medium was incorporated into unsterilised pot soil at 5 per cent (w/w). Each genotype was sown in five pots and replicated four times. In each pot, 10 plants were maintained. The incidence of root rot was recorded periodically and the final observation was made at 90 DAS.

RESULTS AND DISCUSSION

Mean squares and their statistical significance are presented in Table 3. In each growing season, variance analysis indicated high significant differences ($p < 0.01$) between treatments. The results (Table 3) showed significant differences with great variation in the level of infection by root rot disease. This indicates the presence of sufficient variability for all investigated genotypes, which could thus be valuable in a further breeding program for root rot disease resistance. These findings are similar to those of other investigators (El-Deeb *et al.,* 1987; El-Barougy 1990; El-Shakhess 1998; Chattopadhyay and Kalpanas 1998; Dinakaran and Mohammed 2001; Abdul Wahid and El-Bramawy, 2007) who worked with different sesame populations under natural and artificial infection by *Macrophomina phaseolina.*

Table 3. Mean squares and their statistical significance.

Source of variation	df	Mean squares		
		2004	2005	2006
Rep.	3	6.94	2.27	7.58
Genotypes	14	180.21**	233.99 **	225.30 **

** Statistical differences $P < 0.01$

The infection percentages ranged from 6.03 % (mutant 58) to 31.20 % (mutant 47) , 3.65% (mutant 45) to 34.37% (Toshka 1) and 4.38 % (mutant 45) to 33.92 % (Toshka 1) during 2004 , 2005 and 2006 growing seasons, respectively.

No combined analysis (growing seasons x percentage of infected plants) was performed because of the lack of uniformity in the variance errors in the analysis of variance according to the Bartlett test (Steel and Torrie, 1980). Instead of that, the cultivars were classified in accordance with the proposed scale of Avila and Pineda (1996), and the results are presented in Table 4. Differences between means of genotypes, in each growing season, were determined by LSR test ($p = 0.05$) and the results are presented in Table 4.

These genotypes reacted as resistant (R), moderate resistant (MR) and moderate susceptible (MS). Among 15 genotypes, root rot disease was noted on five genotypes including the commercial cultivar Toshka 1 (Table 4). The disease intensity was maximum in genotype Toshka 1 (29.94%) followed by mutant lines 47 (28.15%), mutant 56 (24.28%), mutant 44 (23.55 %) and mutant 5 (22.51%) as compared to the check cultivar Shandaweel 3 (6.40%).

Table 4. Infection percentages by *Macrophomina phaseolina* in fifteen sesame genotypes evaluated in the field under natural infection conditions.

Cultivar or Mutant	Growing seasons			Average root rot incidence %	Category of resistance / susceptibility
	2004	2005	2006		
	Mean root rot incidence (%)				
Giza 25	16.08 b	6.43 de	16.83 d	16.45	MR
Giza 32	11.07 b-d	13.55 e	12.30 e	12.31	MR
Toshka 1	26.66 a	1.90 a	31.25 a	29.94	MS
Shandaweel 3	6.75 de	5.98 fg	6.48 f	6.40	R
Mutant 5	21.58 a	21.70 c	24.25 bc	22.51	MS
Mutant 10	8.13 c-e	6.08 fg	5.08 f	6.43	R
Mutant 44	21.65 a	3.95 bc	25.05 bc	23.55	MS
Mutant 45	5.53 e	3.65 g	4.83 f	4.67	R
Mutant 46	15.15 b	6.40 cd	13.53 e	15.03	MR
Mutant 47	27.01 a	9.48 ab	27.95 ab	28.15	MS
Mutant 49	7.73 de	7.63 f	6.90 f	7.42	R
Mutant 50	12.38 bc	13.45 e	11.95 e	12.59	MR
Mutant 56	25.81 a	5.05 bc	21.98 c	24.28	MS
Mutant 57	7.28 de	6.10 fg	6.23 f	6.54	R
Mutant 58	6.03 e	7.25 f	6.38 f	6.55	R

Genotypes means with the same letter are not statistically different according to Duncan's Multiple Range (L.S.R) test at 0.05 level of probability.

Classification according to the scale suggested by Avila and Pineda (1996)

R = Resistance, MR= Moderately Resistance and MS= Moderately Susceptible

The results revealed that the genotypes, Shandaweel 3 (commercial cultivar), mutants No. 10, 45, 49, 57 and 58 were resistant to root rot disease (less than 10 %) across the three seasons recording an average incidence of 6.40, 6.43, 4.67, 7.42, 6.54 and 6.55 %, and gave a seed yield of 391.3, 416.6, 419.6, 400.9, 400.7 and 420.4 kg / feddan under natural infection conditions, respectively (Tables 4 and 5). Also these values of mean incidence were lower than the values of checks Giza 25 (16.45 %) and Giza 32 (12.31 %). These genotypes kept their resistance classes during the three successive seasons (Table 4).

The results showed that sesame commercial cultivars (Giza 25, Giza 32) and mutants (46 and 50) ranked as moderately resistant (between 10 - 20 %). These genotypes showed an average seed yield of 289.5, 320.6, 419.3 and 416.1 kg / feddan under natural infection conditions, respectively.

Such genotypes may be helpful for breeding programs because of their resistance or moderately resistance as well as their seed yield superiority. This finding was in agreement with the results obtained by Gupta (1995) and Munoz *et al.* (1996).

Out of 15 genotypes, 5 entries, i.e. Toshka 1, mutants no. 5, 44, 47 and 56 were found to be moderate susceptible genotypes to root rot under field conditions; they recorded an average root rot incidence of 29.94, 22.51, 23.55, 28.15 and 24.28 % and gave a seed yield of 238.6, 254.7, 354.9, 409.9 and 349.5 kg/feddan under natural infection conditions, respectively. Rajput *et al.* (1998) also identified few genotypes of sesame resistant to charcoal rot under field conditions. Our data were in agreement with the results reported by El-Marzoky (1982) and El-Shakhess (1998) on different sesame materials. The genotypes Shandaweel 3 (commercial cultivar), mutants No. 57, 58, 45, 49 and 10 also exhibited resistance or moderate resistance reaction under artificially inoculated pot culture conditions, recording a mean incidence of 9.73, 9.81, 9.67, 12.74, 13.44 and 15.65 percent, respectively, as compared with 67.22, 40.63 and 33.94 percent in Toshka 1, Giza 25 and Giza 32, respectively (Table 5).

Under the natural infection conditions, seed yield exhibited distinct and significant differences between all genotypes. Across the three seasons 2004, 2005 and 2006 (Table 6) the highest seed yield (420.4 kg/ fed.) was obtained from the mutant line 58, while the lowest yield of 238.6 kg / fed. From the commercial cultivar Toshka 1 . Some mutant lines combined a high yield and resistance (R) to root rot, they were mutants No. 10 , 45 , 49 , 57 and 58 . It was clearly noticed that these mutant lines surpassed all commercial cultivars under natural infection conditions and without a history of natural infection.

Table 5. Reaction of fifteen sesame genotypes to artificial infection with root rot disease in pot experiment , 2004 season .

Cultivar Or Mutant	Root rot (%) Pot culture Conditions	Category
Giza 25	40.63	S
Giza 32	33.94	S
Toshka 1	67.22	HS
Shandaweel 3	9.73	R
Mutant 5	60.32	HS
Mutant 10	15.65	MR
Mutant 44	62.41	HS
Mutant 45	12.74	MR
Mutant 46	40.69	S
Mutant 47	73.95	HS
Mutant 49	13.44	MR
Mutant 50	34.81	S
Mutant 56	76.40	HS
Mutant 57	9.67	R
Mutant 58	9.81	R

R = Resistance, MR = Moderately Resistance, MS = Moderately Susceptible, S = Susceptible, HS = Highly Susceptible.

The superiority of mutant lines in their seed yield over the commercial cultivars is ascertained by the fact that all yield component characters in these lines were much improved. The improved length of fruiting zone and total number of capsules/plant, which are the major traits contributing directly to sesame seed yield are responsible for the observed yield increase.

It is concluded from the previous results that some of tested sesame genotypes kept their moderately resistance or resistance reaction during the three successive seasons as well as satisfactory seed yield. They could be utilized on a large scale cultivation or in hybridization programs to develop resistant varieties with good yield potential. Screening under artificial infection or in a field with a history of natural infection is a good for choosing sesame genotypes that have high resistance to root rot pathogen, *Macrophomina phaseolina*, and high seed yield potential.

Table 6: Mean seed yield (kg/feddan) for 11 mutants and four commercial cultivars of sesame under natural infection and free of infection conditions in 2004, 2005 and 2006 seasons.

Cultivar or Mutant	Seed yield (kg) / feddan in a field without a history of natural infection				Seed yield (kg) / feddan in a field with a history of natural infection			
	2004	2005	2006	Average	2004	2005	2006	Average
Giza 25	310.7	330.5	322.5	321.2 f	285.4	292.9	290.2	289.5 f
Giza 32	369.0	353.4	353.1	358.5 e	309.3	316.2	336.5	320.6 e
Toshka 1	269.1	289.2	277.6	278.6 h	225.7	239.9	250.2	238.6 h
Shandaweel 3	398.5	401.1	406.9	402.1 c	382.3	390.7	400.8	391.3 c
Mutant 5	285.8	296.1	290.9	290.9 g	228.4	273.5	262.1	254.7 g
Mutant 10	421.8	433.3	440.4	431.8 b	400.2	413.1	436.6	416.6 a
Mutant 44	350.2	380.8	388.8	373.2 d	315.6	375.7	373.6	354.9 d
Mutant 45	438.2	421.6	443.5	434.4 b	422.0	403.9	432.9	419.6 a
Mutant 46	422.8	441.8	448.7	437.8 ab	400.1	419.4	438.3	419.3 a
Mutant 47	446.2	441.4	442.8	443.4 ab	395.8	423.3	410.7	409.9 ab
Mutant 49	400.9	401.3	426.4	409.5 c	385.5	396.0	421.1	400.9 bc
Mutant 50	423.5	445.5	435.2	434.7 b	408.9	408.5	430.8	416.1 ab
Mutant 56	390.0	405.9	409.1	401.7 c	254.4	398.0	396.2	349.5 d
Mutant 57	444.0	446.5	454.5	448.3 a	411.5	408.6	382.0	400.7 bc
Mutant 58	438.7	432.7	447.6	439.7 ab	408.9	415.2	437.2	420.4 a

Genotypes means followed by the same letter are statistically equal according to Duncan's Multiple Range (L.S.R) test at 0.05 level of probability .

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الملخص العربي

غربلة التراكيب الوراثية للسمسم من حيث المقاومة لعفن الجذور والقدرة المحصولية

أشـــرف عبد الأعلى عبد المحسن ، وجيه عبد العظيم المرشدى
قسم المحاصيل- كلية الزراعة- جامعة القاهرة

تم اجراء هذا البحث فى مواسم ٢٠٠٤ ، ٢٠٠٥ ، ٢٠٠٦ فى حقل تجارى بقرية ابورواش – محافظة الجيزة وهو حقل له تاريخ بالعدوى الطبيعية بمرض عفن الجذور وفى حقل آخر خالى من الاصابة كمقارنة .كان الهدف هو اختبار ١٥ تركيب وراثى من السمسم (٤ اصناف محلية و ١١ سلالة من الطفرات الواعدة ناشئة بالانتخاب فى برنامج تربية سابق) للمقاومة لمرض عفن الجذور المتسبب عن الفطر تحت ظروف العدوى الصناعية والطبيعية.اختلفت كل التراكيب الوراثية المختبرة اختلافا معنويا فى درجة الاصابة بالفطر المسبب لعفن الجذور. من الجـدير بالذكر أن بعض التراكيب الوراثية المختبرة من السمسم احتفظت بدرجة مقاومتها كمتوسطة في المقاومة أو مقاومة خلال المواسم الثلاثة المتعاقبة .

أظهرت النتائج ان الطفرات ارقام ١٠ ، ٤٥ ، ٤٩ ، ٥٧ ، ٥٨ كانت مقاومة لمرض عفن الجذور (اقل من ١٠%) كنسبة اصابة عبر المواسم الثلاثة حيث سجلت متوسطات اصابة قدرها ٦,٤٣ ، ٤,٦٧ ، ٧,٤٢ ، ٦,٥٤ ، ٦,٥٥ % وأعطت محصول بذور قدره ٤١٦,٦ ، ٤١٩,٦ ، ٤٠٠,٩ ، ٤٠٠,٧ ، ٤٢٠,٤ كيلو جرام للفدان على التوالى تحت ظروف العدوى الطبيعية . ايضا كانت هذه القيم لمتوسط نسبة الاصابة اقل من تلك المتحصل عليها من اصناف المقارنة جيزة ٢٥ (١٦,٤٥%) و جيزة ٣٢ (١٢,٣١%) و توشكى ١ (٢٩,٩٤ %) . كان واضحا ان محصول بذور هذه الطفرات تعدى كل الاصناف التجارية تحت كل من ظروف العدوى الصناعية والطبـيعية . مثل هذه التراكيب الوراثية ربما قـد تكون نافعة في برامج التربـية بسبب مقاومتهـا لمرض عفن الجذور وكذلك تفوقها في محصول البذور.

أظهرت التجارب أيضا أن الأصناف التجارية جيزة ٢٥ و جيزة ٣٢ والطفرات ارقام ٤٦ ، ٥٠ كانت متوسطة المقاومة (بين ١٠- ٢٠ %) كنسبة إصابة . أظهرت هذه التراكيب الوراثية متوسط محصول قدره ٢٨٩,٥ ، ٣٢٠,٦ ، ٤١٩,٣، ٤١٦,١ كيلو جرام للفدان على التوالي تحت ظروف العدوى الطبيعية .