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FIELD EVALUATION OF SOME *STREPTOMYCES* ISOLATES TO SUPPRESS POWDERY MILDEW OF FLAX (SAKHA 1 CULTIVAR)

Mansour, M.T.M.[1], Sonya H. Mohamed[2,3], S.M.E. Zayed[1] and A.Z.A. Ashour[1]

[1]PlantPathol. Res. Instit., ARC, Giza, 12619, Egypt, [2]Soil, Water and Environment Res. Instit., ARC, Giza, 12619, Egypt, [3]Department of Biology, Faculty of Science, Taif University, KSA

ABSTRACT

Evaluation of 16 isolates of *Streptomyces*, as biological agents for controlling powdery mildew (PM) of flax was carried out under field conditions in El-Gemmeiza and Sakha Agricultural Research Stations in 2006 growing season. The isolates were used as foliar application. Disease incidence (DI), disease severity (DS), seed yield, and straw yield were used as criteria to evaluate the efficiency of the tested isolates. In El-Gemmeiza, Streptomyces isolates Qa-51, Sc-11, Qa-44, S16, Sc-2, and Si-1 significantly decreased DI compared with the control and the efficiency of the isolates were 31, 25.40, 19.74, 15.45, 14.77, and 12.61%, respectively. Isolates Sc-2, Sc-11, and Qa-51 reduced DS by 25.54, 23.50, and 19.85% respectively. None of Streptomyces isolates significantly affected both seed yield and straw yield. In Sakha, none of Streptomyces isolates significantly affected DI. Isolates Sc-2, Si-1, Ma-13, and Qa-44 significantly reduced DS by 18.05 to 22.65%, and isolates Qa-51, Qa-53, Qa-84, and Da-3 reduced DS by 23.38 to 28.36%. Streptomyces isolates Is-10, Da-3, and Qa-53 significantly increased seed yield by 2.35 to 3%. All Streptomyces isolates were ineffective in increasing straw yield in Sakha. Correlation between disease intensity variables (DI and DS) and yield (seed yield and straw yield) showed that DI negatively correlated (r = - 0.735, P = 0.001) with seed yield and with straw yield (r = - 0.630, P = 0.007), disease severity also negatively correlated (r = - 0.469, P = 0.05) with seed yield and straw yield (r = - 0.736, P = 0.001) in El-Gemmeiza.

INTRODUCTION

Powdery mildew (PM) of flax (*Linum usitatissimum* L.) is caused by the obligate parasite *Oidium lini* Škoric. The fungus attacks all the aboveground parts of flax (Aly *et al*., 1994). Early infection may cause severe defoliation of the flax plant and reduce quantity and quality of yield (Mansour, 1998). Aly *et al*., (2001) reported that all commercially grown flax cultivars in Egypt were susceptible to the disease, although field observations indicated that some experimental lines were more susceptible than others. Foliar application of fungicides has become the only comercially available management practice for controlling the disease and minimizing associated losses in seed and straw yield (Aly *et al*., 1994 and Mansour, 1998). Complete dependence on fungicides for the disease control carries risks for the producers, in that accurate coverage and distribution of fungicides may not be achieved and there are potential problems with timing of application. Furthermore, increasing concern for the environment will likely mean greater regulation of fungicide usage (Pearce *et al*., 1996). Biological control is a nonchemical measures that has been reported in several cases to be as effective as chemical control (Elad and Zimand, 1993 and Dik and Elad, 1999). *Streptomyces* spp. are gram-positive, filamentous, soil borne bacteria that also occur in the phylloplane (Narula and Mehrotra, 1987), especially on dust-covered leaves (Manning, 1971).

Hodges *et al*. (1993) used *Streptomyces* spp. to control leaf pathogens of *Poa pratensis* in the greenhouse. The ability of bacteria, especially actionmycetes, to parasitize and degrade spores of fungal plant pathogens is well established (Gohel *et al*., 2006). Lysis of the host structure by secretion of extracellular lytic enzymes is one of the important mechanisms that are involved in the antagonistic activity of biocontrol agents (Saksirirat and Hoppe, 1991; Mathivanan *et al*., 1997 and Kim *et al*., 2001). Among these, chitinase (EC 3.2. 1.14), which was isolated from the culture filtrate of *Streptomyces* sp., plays a vital role in the biological control of many plant diseases by degrading the chitin polymer in the cell walls of fungal pathogens (Haran *et al*., 1993). An exogenous chitinase from *Streptomyces griseus* was introduced into coleoptile cells of barley by microinjection and the effect of injected exogenous chitinase on the growth and development of the PM pathogen (*Erysiphe graminis* f.sp. *hordi*) was effective in completely digesting and suppressing the subdequent formation of secondary hyphae of the pathogen (Toyoda *et al*., 1991). Houstoria of *Sphaerotheca pannosa* on rose, *S. fuliginea* on melon and *S.humuli* (*S macularis*) on straw berry leaves were digested by 0.1% chitinase from *Streptomyces griseus*, confirming that chitin is a major component of the houstorial cell wall (Ikeda *et al*., 1992).

The objective of this study was to evaluate the potential of *Streptomyces* isolates to control PM disease of flax exposed to natural infection of *Oidium lini* in the field.

MATERIALS AND METHODS

Antagonistic activities of *Streptomyces* isolates: In this experiment, the antagonistic activities of a set of 16 *Streptomyces* isolates obtained from soils of different Governorates, i.e., Alexandria (Sc-2,Sc-11 and Ma-13), El- Fayoum (Qa-44, Qa- 51, Qa-53 and Qa-84); Damiatta (Da-3); Ismailia (Is-10); Port Said (PS-12) and Sinai (Si-1, Si-4, Si-6, Si-8, Si-9, and S16) were carried out as described by Mansour and Mohamed (2007). The mixture of mycelium and spores were suspended in water and used for foliar spray.

Field evaluation of *Streptomyces* isolates to suppress PM of flax: Field trials were conducted in 2006 growing season at two Agricultural Research Stations (El-Gemmeiza and Sakha). The experiment consisted of a randomized complete block design of four replications (plots). Plots were 2x3 (6 m^2). Seeds of Sakha 1 cultivar of flax were sown by hand at a rate of 70g/plot. Planting date was in the first week of December at both El-Gemmeiza and Sakha. PM was allowed to develop naturally, and the initial *Streptomyces* application to the flax cultivar coincided with the first sing of disease twice with intervals 10 days. Foliar sprays of *Streptomyces* isolates were applied at the rate of 1 ml/liter of water. Disease incidence (DI) and disease severity (DS) were rated visually in the last week of April (Natter *et al*., 1991). DI was measured as percenttage of infected plants in a random sample of fifty plants per plot. DS was measured as percentage of infected leaves/plant in a random sample of ten 10 plants per plot. At harvest, seed yield and straw yield were recorded for each plot.

Statistical analysis: Analysis of variance (ANOVA) of the data was performed with the MSTATC Statistical Package (A Microcomputer Program for the Design, Management and Analysis of Agronomic Research Experiments, Michigan State Univ., USA). Least significant difference (LSD) was used to compare the individual *Streptomyces* isolate means. DI and DS data were transformed into arc sine angles before carrying out the analysis of variance to produce approximately constant variance. Correlation and regression analysis were performed with a computerized program.

RESULTS AND DISCUSSION

Mansour and Mohamed (2007) studied the effect of the same 16 *Streptomyces* isolates under investigation on PM incidence (PMI), PM severity (PMS), seed yield and straw yield of flax cv. Sakha 2 under greenhouse conditions in two growing seasons (2005 and 2006).

The present study was conducted in 2006 growing season in El-Gemmeiza and Sakha Agricultural Research Stations, to evaluate sixteen isolates of *Streptomyces* as biocontrol agents for controlling flax PM under field conditions. The isolates were used as foliar application. DI, DS, seed yield and straw yield were used as criteria to evaluate the efficiency of the tested isolates under field conditions.

LSD was used to compare the individual *Streptomyces* isolates means in El-Gemmeiza (Table-1). Due to these comparisons,*Streptomyces* isolates Qa-51, Sc-11, Qa-44, S16, Sc-2, and Si-1 significantly decreased DI compared with the control and the efficiency of the isolates were 31, 25.40, 19.74, 15.45, 14.77, and 12.61%, respectively. Isolates Sc-2, Sc-11, and Qa-51 reduced DS by 25.54, 23.50, and 19.85%, respectively. None of *Streptomyces* isolates significantly affected both seed yield and straw yield. It is noteworthy that isolates Sc-2, Sc-11, and Qa-51 were effective in controlling both DI and DS in El-Gemmeiza. The mode of *Streptomyces* action could be due to the production of antifungal antibiotics (Smith *et al*., 1990; Gupte and Naik, 1999). Competition for iron through production of siderophore and production of degradative enzymes such as chitinase and gluconase using chitinolytic bacterium and actinomycetes were reported by El-Tarabily *et al*. (2000).

In Sakha, none of the *Streptomyces* isolates significantly affected DI. Isolates Sc-2, Si-1, Ma-13, and Qa-44 reduced DS by 12.71 to 14.91%; isolates Sc-11, Ps-12, and Is-10 reduced DS by 18.05 to 22.65% and isolates Qa-51, Qa-53, Qa-8, and Qa-3 reduced DS by 23.38 to 28.36%. *Streptomyces* isolates Is-10, Da-3, and Qa-53 significantly increased seed yield by 2.35 to 3%. All *Streptomyces* isolates were ineffective in increasing straw yield in Sakha (Table-2). Correlation between disease intensity variables (DI and DS) and yield (seed yield and straw yield) showed that DI negatively correlated ($r = -0.735$, $P = 0.001$) with seed yield and ($r = -0.630$, $P = 0.007$) with straw yield. DS also negatively correlated ($r = -0.469$, $P = 0.05$) with seed yield and straw yield ($r = -0.736$, $P = 0.001$) in El-Gemmeiza (Table 3 and Figs. 1 and 2).

Spencer (1978), in the USA reported a yield reduction up to 10% when *Oidium lini* infects linseed before flowering. This reduction was due to smaller numbers of seed per capsule and shriveled seed. Thus the increase in seed yield by foliar application of *Streptomyces* isolates could be attributed to the suspension of *O. lini* and consequently, its negative impact on seed yield. The ineffectiveness of the isolates in reducing DI or increasing straw yield in Sakha indicated that environmental conditions play an important role in determining the efficiency of *Streptomyces* as biocontrol agents. Therefore, it could be concluded that *Streptomyces* isolates should be tested in as many locations as possible as this will improve the chance of identifying *Streptomyces* isolates, which are effective under different environments.

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Table-1: Effect of 16 *Streptomyces* isolates on PM intensity variables (DI and DS), seed yield and straw yield of flax under field conditions in El-Gemmeiza.

Isolates	DI		DS		Seed yield (kg/feddan)	Straw yield (ton/feddan)
	%	**Transformed**	**%**	**Transformed**		
Sc-2	67.50	(55.70)[a]	64.73	(53.87)	802.750	5.460
Sc-11	57.00	(48.75)	66.82	(55.35)	999.250	5.087
Ma-13	74.00	(59.57)	89.40	(73.51)	945.000	5.020
Qa-44	62.50	(52.45)	77.16	(62.19)	1050.000	4.847
Qa-51	49.00	(44.48)	71.04	(57.99)	1065.750	5.303
Qa-53	90.00	(71.79)	97.61	(82.61)	798.000	3.553
Qa-84	77.00	(61.45)	81.08	(64.67)	901.250	4.363
Da-3	73.50	(60.42)	82.14	(65.30)	889.000	4.130
Is-10	72.00	(58.40)	81.60	(65.73)	945.000	3.920
Ps-12	73.50	(59.15)	88.98	(71.06)	907.750	4.673
Si-1	70.50	(57.11)	79.91	(64.35)	991.750	4.783
Si-4	83.50	(66.23)	87.06	(71.35)	828.250	4.428
Si-6	78.00	(62.11)	90.82	(72.58)	803.250	3.063
Si-8	71.00	(57.43)	81.01	(65.36)	990.500	4.690
Si-9	80.00	(64.26)	82.46	(66.37)	795.750	4.725
S16	67.50	(55.44)	90.77	(72.32)	833.000	4.095
Cont.	82.25	(65.35)	90.12	(72.35)	870.250	4.130
L.S.D. (P<0.05)	7.756			11.85	N.S.	N.S.

[a]Percentage of infected plants were transformed into arc-sine angle before carrying out analysis of variance. Transformed means are shown in parentheses. Each value is a mean of 4 replicates.

Table-2: Effect of 16 *Streptomyces* isolates on PM intensity variables (DI and DS), seed yield and straw yield of flax under field conditions in Sakha.

Isolates	DI		DS		Seed yield (kg/feddan)	Straw yield (ton/feddan)
	%	Transformed	%	Transformed		
Sc-2	74.75	(61.20)[a]	23.03	(4.74)[b]	630.500	3.417
Sc-11	73.00	(62.95)	19.95	(4.45)	620.00	3.435
Ma-13	77.75	(62.22)	21.63	(4.64)	641.750	3.695
Qa-44	62.50	(52.57)	21.40	(4.62)	618.750	3.403
Qa-51	73.50	(62.89)	17.35	(4.16)	627.500	3.520
Qa-53	85.50	(71.29)	16.85	(4.08)	648.250	3.600
Qa-84	68.00	(59.46)	17.28	(4.14)	628.250	6.532

Da-3	58.50	(49.98)	15.15	(3.89)	650.500	3.637
Is-10	71.50	(61.74)	17.73	(4.20)	652.500	3.572
Ps-12	85.25	(69.18)	18.38	(4.28)	619.750	3.452
Si-1	87.50	(73.30)	21.80	(4.66)	619.750	3.427
Si-4	92.25	(78.64)	25.75	(5.17)	621.000	3.575
Si-6	79.00	(67.00)	25.58	(5.05)	622.500	3.540
Si-8	80.50	(70.88)	28.15	(5.30)	640.500	3.410
Si-9	93.00	(79.46)	23.98	(4.86)	629.750	3.472
S16	96.75	(82.66)	27.45	(5.22)	624.250	3.565
Cont.	95.00	(79.56)	29.30	(5.43)	633.000	3.600
L.S.D. (P<0.05)		N.S.		0.6115	14.96	N.S.

[a]Percentage of infected plants were transformed into arc-sine angle before carrying out analysis of variance.

[b]Percentage of disease severity of plants were transformed into $\sqrt{X}$ before carrying out analysis of variance. Transformed means are shown in parentheses. Each value is a mean of 4 replicates.

Table-3: Correlation between disease intensity variables (DI and DS) and yield parameters (seed yield and straw yield).

Locations	Variables	Yield parameters	
		Seed yield (kg/feddan)	Straw yield (ton/feddan)
El-Gemmeiza	DI	- 0.735[a] (P = 0.001)	- 0.630 (P = 0.007)
	DS	- 0.469 (P = 0.05)	- 0.736 (P = 0.001)
Sakha	DI	- 0.257 (P = 0.318)	- 0. 063 (P = 0.810)
	DS	- 0.311 (P = 0.225)	- 0.131 (P = 0.617)

[a]Pearson's correlation coefficient.

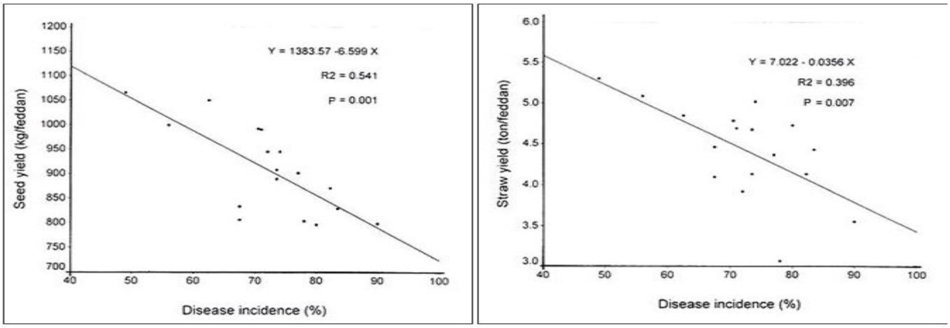

Fig.-1: Relationship between DI and each of seed yield straw yield under field conditions in El-Gemmeiza.

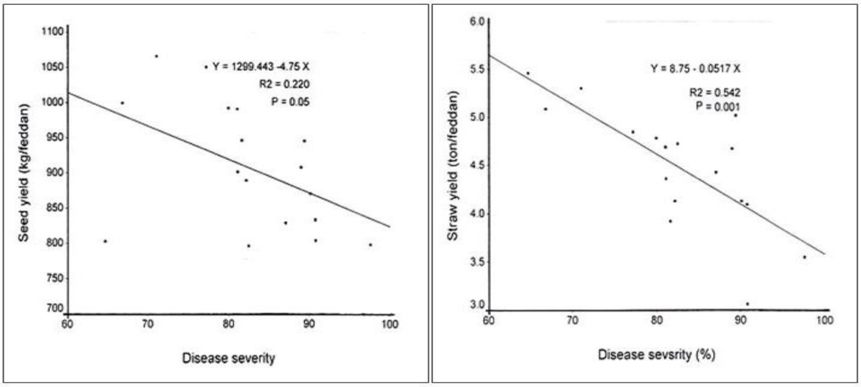

Fig.-2: Relationship between DS and each of seed yield straw yield under field conditions in El-Gemmeiza.

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