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VARIATION IN SENSITIVITY TO FUNGICIDES AMONG ISOLATES OF *Rhizoctonia spp.* INVOLVED IN DAMPING-OFF OF COTTON SEEDLINGS

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ABSTRACT

Five isolates of multinucleate *Rhizoctonia solani* and one isolate of binucleate *Rhizoctonia* sp. were evaluated *in vitro* for sensitivity to certain fungicides i.e., Rizolex T, Monceren T, Maxim, Premis, Beret MLX, and Tachigaren. All the *R. solani* isolates were tolerant to Tachigaren, while the binucleate isolate of *Rhizoctonia* sp. was sensitive. In the contrary, all the isolates were highly sensitive to Rizolex T. The efficiencies of the same fungicides in reducing damping-off of cotton cultivar Giza 89 were evaluated under greenhouse conditions in soil infested with each individual isolate at two inoculum densities. Analysis of variance showed highly significant effects of both fungicides and isolate, while the fungicide x isolate interaction was a nonsignificant source of variation in percentage of seedling mortality, regardless of the inoculum density. Due to the nonsignificant interaction between fungicide and isolate, a least significant difference was used to compare between the general means of fungicides. These comparisons showed that Rizolex T and Beret MLX were the most effective fungicides in controlling damping-off at the lower inoculum density, while Rizolex T and Premis were the most effective ones at the higher inoculum density. Tachigaren was effective in controlling the disease only at the higher inoculum density; however, it was the least efficient fungicide. There was no correlation between the *in vitro* efficiencies of the fungicides and their *in vivo* efficiencies when fungicidal efficiency was evaluated based on the effects of each fungicide on individual isolates. On the other hand, a highly significant correlation between *in vitro* and *in vivo* efficiencies of the fungicides was observed only when fungicidal efficiency was expressed as the mean efficiency of each fungicide over all the tested isolates. Regression analysis showed that *in vitro* mean of fungicidal efficiency accounted for 88 and 86% of the explained (model) variation in mean of fungicidal efficiency under greenhouse conditions when the inoculum densities were 0.1g and 0.5g/Kg soil, respectively.

INTRODUCTION

Rhizoctonia solani Kühn [*Thanatephorus cucumeris* (Frank) Dank] is a soilborne plant pathogen having a worldwide distribution, a great ecological diversity and a vast host range. The pathogen usually attacks cotton seed or seedlings during germination and initial establishment of plants in the soil (Brown and Mc Carter, 1976; Watkins, 1981) and is considered to be a major factor affecting cotton stand in Egypt (Moustafa –Mahmoud *et al.* 1993). The use of fungicides is a common strategy used to control diseases caused by *R. solani* and it is axiomatic that fungicides should be active against all the anastomosis groups (AGs) involved in cotton seedling damping-off (Kataria *et al.*, 1991). In recent studies with isolates of known AG, significant variability in sensitivity to fungicides has been observed, not only among different AGs of *R. solani* but also within isolates of the same AG (Martin,

1978; Martin *et al.*, 1984; Roberts and Stephens, 1984; Jones and Pettit, 1987; and Sumner, 1987).

Regarding *R. solani* of cotton seedling damping-off, Hillocks *et al.* (1988) tested Quintozene, Benodanil, Captan, Carboxin, Fenfuram, Iprodione, Pencycuron, Procymidone, Thiophanate-methyl, Thiram, and Tolclofos-methyl against *R. solani* in the laboratory and were then evaluated for the control of seedling disease in cotton in field plots. Both seed dressing and in-furrow applications gave some control with all fungicides tested, but in-furrow treatments were more effective, especially against post-emergence damping-off. Best control was given by Tolclofos-methyl as a seed dressing and Pencycuron plus Captan in-furrow, reflecting results from the laboratory test. Alagarsamy and Jeyarajan (1989) tested 5 fungicides against growth of *R. solani* in culture. Of the tested fungicides, Tolclofos-methyl was the most inhibitory, followed by Carbendazim. In seed treatment trials with the same fungicides, Carbendazim gave the best germination followed by Tolclofos-methyl; post-emergence mortality was the least with Carboxin. In a soil drenching experiment, Carbendazim was superior to the other fungicides in improving germination and controlling post-emergence mortality. Yield of seed cotton was improved by Carbendazim and tolclofos-methyl soil treatment. In Iraq, Ahmed and Ali (1990) evaluated Benlate (Benomyl), Vitavax Thiram (Carboxin + Thiram), Homai (Thiophanate-methyl + Thiram), Ridomil (Metalaxyl), Rizolex (Tolclofos-methyl), and Dithane-S-60 (Mancozeb) for control of seed rot and damping-off of cotton caused by 2 isolates of each of *R. solani*, *Pythium ultimum*, and *P. aphanidermatum*. Benomyl, Tolclofos-methyl and Carboxin + Thiram at 0.2% controlled *R. solani* and Metalaxyl (0.1%) and Carboxin + Thiram (0.2%) controlled *Pythium* spp. The mixtures Benomyl + Metalaxyl, tolclofos-methyl + Metalaxyl, and Carboxin + Thiram reduced disease in seeds receiving a mixed inoculum of these pathogens. None of the seed treatments resulted in visible phytotoxicity. Aly *et al.* (1992) evaluated the efficiency of Monceren Euparen, Monceren Combi, Vitavax 200 FF, Provax FF, Quinolate Pro, Tecto TM, Bay M, Vincit P, and Rizolex T as seed treatments against *R. solani* or *Sclerotium rolfsii* under greenhouse conditions. None of the fungicides stimulated emergence. In terms of surviving seedlings, the fungicides showed variation in their effectiveness against damping-off caused by *R. solani*. Provax FF and Tecto TM were ineffective, while Bay M increased surviving seedlings to a level comparable to that of the uninoculated control. Vitavax 200 FF and Rizolex T were the only fungicides which gave significant control of pre-emergence damping-off caused by *S. rolfsii*; however, their effectiveness was lost beyond this stage. In a greenhouse test, Abdel-Aziz *et al.* (1996) reported that the application of Tolclofos-methyl, Tolclofos-methyl + Thiram, and Pencycuron + Dichlofluanid as seed treatments gave excellent control of cotton seedling disease in soil infested with *R. solani* (AG4), S. *rolfsii*, and *Macrophomina phaseolina* singly or in a mixture.

The main objective of the present study was to evaluate variability among isolates of *Rhizoctonia* spp. of cotton in their *in vitro* and *in vivo* sensitivity to some fungicides commonly used for controlling *Rhizoctonia* spp.

MATERIALS AND METHODS

***Rhizoctonia* spp. isolates:**

Five isolates of *R. solani* AG4 (multinucleate) and one binucleate isolate of *Rhizoctonia* sp. (isolate no.3) were obtained from the fungal collection of Cotton & Fiber Crops Diseases Research Section, Plant Pathology Research Institute, A.R.C.

Fungicides:

Six fungicides were used in this study. These fungicides are listed in Table (1).

***In vitro* fungicidal activity:**

Sensitivity of *Rhizoctonia* spp. to fungicides was tested in the laboratory by the poisoned food technique (Grover and Moore, 1961) using PDA medium. The fungicides were used at 0.5, 1.0, 5, 10, 50, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, and 1500 ppm of active ingredient. Stock solutions of fungicides were freshly prepared by dissolving the chemicals in sterile distilled water. Stock solutions were pipetted into proper volumes of sterile distilled water in Erlenmeyer flasks to give 50ml of the fungicides at twice the final desired concentration. The diluted fungicides were added to partially cooled medium (about 45°C) in serum bottles, formerly prepared at twice the final concentration, and shacked well. The emended medium was poured into sterilized 9-cm-diameter Petri dishes (20ml/dish) and allowed to gel. Three plates were used as replicates for each treatment. Unamended medium was used as control. After solidification, each plate was inoculated with 5mm disc of fungal growth, taken from the periphery of 7 day old culture. Inoculated plates were incubated at 25°C. Data were recorded when the growth in one treatment approached the edge of the plate. Linear growth was determined by measuring the two diameters of each colony and the average was calculated. The percentage of growth in each treatment relative to the control was determined. The ED_{50} values were determined by regression analysis of the log-probit transformed data (Finny, 1952).

Greenhouse Test:

Substrate for growth of each isolate was prepared in 50ml flasks; each flask contained 15g of sorghum grains and 25ml of water. Contents of flasks were autoclaved for 30min. Fungal inoculum, taken from one week old culture on PDA, was aseptically introduced into the flasks and allowed to colonize sorghum for 7days. The sorghum- fungus mixture of each isolate was used to infest sterile soil at rates of 0.1g/Kg soil and 0.5g/Kg soil. Infested soil was dispensed in 10-cm- diameter clay pots. The pots were planted after a week. Five fungicidal-treated cotton seeds were planted in each pot with five replicates for each isolate at each inoculum density. Untreated cotton seeds were planted in the infested-soil pots as controls (5 replicates for each inoculum density). All pots were placed in the greenhouse where the temperature ranged from 25 to 35°C. Forty days after planting, the percentage of surviving seedlings in each pot was recorded.

Table (1): Fungicides used in the present study.

Trade name	Common name	Chemical name	Company	Application rate
Rizolex T 50%w.p.	Tolclofos-methyl + Thiram	O-(2,6-Dichloro-4-methylphenyl) O,O-dimethyl-Phosphorothioate (IUPAC). Tetramethyl thiuram disulphide (IUPA).	Sumitomo Chem-Co.	3g/Kg seeds
Monceren T 47%w.p.	Pencycuron + Thiram	N-[(4-Chlorophenyl)methyl]-N-Cyclopentyl-N-phenylurea (CAS). Tetramethyl thiuram disulphide (IUPA).	Bayer Chem-Co.	3g/Kg seeds
Maxim 35%f.s	Fludioxonil	4-(2,2-difluoro-1,3-bezodioxol-4-yl)-1H-pyrrole-3-carbonitrile (IUPAC).	Novartis	2ml/Kg seeds
Premis 2.5%f.s.	Triticonazole	(±)-(E)-5-(4-Chlorobenzylidene)-2,2-dimethyl-1-(1H-1,2,4-triazol-1-yl methyl) cyclopentanol (IUPAC)	Rhone-Poulenc	2ml/Kg seeds
Tachigaren 30%liqued	Hymexazole	3-Hydroxy-5-methylisoxazole-3-ol.	Sankyo Co.	1ml/liter
Beret MLX 36%f.s.	Fenpiclonil + Metalaxyl	4-(2,3-dichlorophenyl)-1H-pyrrol-3-carbonitrile (IUPAC). N-(2,6-dimethylphenyl)-N-(methoxyacetyl)-DL-Alanine methyl ester (CAS).	Novartis	2ml/Kg seeds

Statistical analysis of the Data:

A completely randomized block design with 5 replications (greenhouse experiments) or 3 replications (laboratory experiments) was used in the present study. Percentage data were transformed into arc sine angles before carrying out analysis of variance (ANOVA) to produce approximately constant variance. Least significant difference (LSD) was applied for comparing treatment means. ANOVA of the data and correlation and regression analyses were performed with computerized programs.

RESULTS AND DISCUSSION

When six isolates of *Rhizoctonia* spp. were tested for *in vitro* sensitivity to six fungicides, the isolates varied in their sensitivity (Table 2). All the isolates were tolerant to Tachigaren especially isolate no. 2 (ED_{50}=802.48), while isolate no.3 (binucleate) was the most sensitive isolate to this fungicide (ED_{50}=36.33). On the contrary, all the isolates were highly sensitive to Rizolex T such that ED_{50} ranged from 0.14 for isolate no.1 to 3.34 for isolate no.5. There were some contradictory responses between some of the isolates such as isolate no.1 and isolate no.5. Thus, while isolate no.1 was very sensitive to Rizolex T (ED_{50}=0.19) and was less sensitive to Monceren T (ED_{50}=13.29), isolate no.5 was very sensitive to Monceren T (ED_{50}=0.11) and was less sensitive to Rizolex T (ED_{50}=3.34). Also, while isolate no.1 was sensitive to Premis (ED_{50}=2.49), Isolate no.4 was moderately sensitive (ED_{50}=46.15). Another example, isolate no.4, which was sensitive to Monceren T and isolate no.1, was less sensitive to this fungicide. While isolates no.2 and no.6 were highly sensitive to Rizolex T, they were moderately sensitive to Premis. However, they were different in their sensitivity to Maxim. Regarding the mean of ED_{50} of each fungicide over isolates, it is clear that the isolates exhibited high sensitivity to Rizolex T (ED_{50}=0.83). On the contrary, all the isolates exhibited high tolerance to Tachigaren (ED_{50}=372.19). It is noteworthy that the means of ED_{50} of Beret MLX (3.37), Maxim (4.16), and Monceren T (4.90) were very close, and this means that the isolates were similar in their sensitivity to these fungicides. This variability in sensitivity of isolates of *Rhizoctonia* spp. to different fungicides is in agreement with the results of Carling *et al.* (1990), Frisina and Benson (1988), Jones *et al.* (1987), Sumner (1987), and Martin *et al.* (1984). The efficiencies of the same fungicides in reducing damping-off of cotton, under greenhouse conditions, were evaluated in soil infested with each of the *Rhizoctonia* spp. isolates.

Table (2): ED_{50}[a] values of fungicides based on linear growth response of *Rhizoctonia* spp.

Fungicides	Isolates of *Rhizoctonia* spp.						Mean
	S1	S2	S3	S4	S5	S6	
Rizolex T	0.14	0.19	0.30	0.33	3.34	0.65	0.83
Monceren T	13.29	8.32	5.50	1.51	0.11	0.69	4.90
Beret MLX	1.63	1.40	1.83	13.88	0.30	1.18	3.37
Premis	2.49	20.34	3.92	46.15	12.28	21.56	17.79
Maxim	1.50	16.90	1.02	2.69	2.07	0.79	4.16
Tachigaren	195.99	802.48	36.33	102.82	564.44	531.07	372.19

[a] Median effective dose.

ANOVA (Table 3) showed that the percentage of seedling mortality was significantly affected by both the isolate and the fungicide, while the interaction between the isolate and fungicide had no significant effect on the percentage of seedling mortality. This means that the efficiency of a fungicide was not affected by the tested isolates. The isolates of *Rhizoctonia* spp. showed variability in their virulence on cotton seedlings of cultivar Giza 89 under greenhouse conditions by using an inoculum rate of 0.1g/Kg soil (Table 4). Isolates no.1and no.6 were the most pathogenic ones. They caused 77.71% and 77.14% seedling mortality respectively, while isolates no.3 and no.4 were the least pathogenic ones causing 44.57% and 46.29% seedling mortality, respectively. Isolates no.2 and no.5 were moderately pathogenic.

Table (4) showed that all the tested fungicides significaly reduced the seedling mortality except Tachigaren. It is noteworthy that Rizolex T and Beret MLX were the most effective fungicides in controlling damping-off.

When the inoculum density were increased from 0.1g/Kg soil to 0.5g/Kg soil, ANOVA (Table 5) showed that each of fungicide and isolate had significant effect on disease incidence, while the interaction between the fungicide and isolate had no significant effect on the disease incidence.

The increase of inoculum density from 0.1 to 0.5g/Kg soil did not change the ranking of pathogenicity of isolates.

All fungicides were effective in reducing seedling mortality when inoculum density increased to 0.5g/Kg soil (Table 6).

Premis and Rizolex T showed the highest efficiencies (54.47 and 53.73%, respectively). Tachigaren significantly reduced the mortality only when the inoculum density increased from 0.1 to 0.5g/Kg soil; however, this fungicide was the least efficient one. Efficiency of Premis increased from 42.14% to 54.47% when the inoculum density increased. These results indicate that some fungicides become more effective under high disease pressure. These results are in agreement with the results of Garber *et al.* (1979) who found that a beneficial response from seed-dressing fungicides effective against *R. solani* occurred when there were high populations of *R. solani* in soil.

The results also indicate that Rizolex T had high efficiency both *in vitro* and *in vivo*. These results are in concert with the results of Kataria et al. (1991) who found that Rizolex was highly effective against all AG4 isolates and provided over 90% control of damping-off in pots infested with any of 11 AG4 isolates. Rizolex T provided excellent control of both pre-emergence damping-off and post-emergence seedling root rot because it shows little or no systemic movement to aerial parts, and therefore accumulates in larger amounts in and around the roots and hypocotyl, providing long-term control of damping-off and seedling root rot. Moreover Rizolex T composed of two non-systemic compounds, which provide more protection to the seeds and seedlings (Kataria and Verma, 1990). On the contrary, Tachigaren is a systemic fungicide translocates in the body of the plant very rapid (Anonymous, 1997) and this lead to decreasing in its concentration around the roots and hypocotyl. Thus, the seedlings become more exposed to

Table (3): Analysis of variance of effects of fungicides, isolates of *Rhizoctonia* spp., and their interaction on percentage of cotton seedlings (culture Giza 89) infected with damping-off under greenhouse conditions when *Rhizoctonia* spp. isolates were used at a rate of 0.1g/Kg soil.

Source of variation	D.F.	M.S.	F.[a] value
Replicate	4	77.82	0.19
Fungicide (F)	6	9699.26	23.73**
Isolate(S)	5	4751.98	11.63**
SXF	30	439.20	1.08
Error	164	408.67	

[a]F. value is significant at P ≤ 0.01 (**)

Table (4): Effects of fungicides, isolates of *Rhizoctonia* spp., and their interaction on percentage of cotton seedlings (cultivar Giza 89) infected with damping-off under greenhouse conditions when *Rhizoctonia* spp. isolates were used at rate of 0.1g/kg soil.

Fungicides[a]	Isolates of *Rhizoctonia* spp.						Mean	Efficiency [c]
	S1	S2	S3	S4	S5	S6		
Bert MLX	56[b] (51.69)	32 (33.94)	24 (29.10)	28 (28.63)	56 (51.47)	68 (61.85)	44.00 (42.78)	52.86%
Maxim	80 (72.00)	44 (41.31)	28 (31.63)	36 (33.47)	64 (53.53)	88 (79.85)	56.67 (51.96)	39.28%
Monceren-T	64 (53.53)	64 (56.31)	28 (31.63)	40 (38.78)	48 (43.85)	44 (41.31)	48.00 (44.23)	48.57%
Premis	84 (71.53)	48 (40.84)	52 (46.38)	20 (23.79)	44 (41.31)	76 (63.83)	54.00 (47.92)	42.14%
Rizolex T	60 (51.22)	28 (28.63)	36 (36.47)	28 (25.62)	20 (20.78)	68 (58.84)	40.00 (36.93)	57.14%
Tachigaren	100 (90.0)	84 (74.53)	68 (58.84)	76 (66.46)	100 (90.0)	96 (84.69)	87.33 (77.42)	..... [d]
Control	100 (90.0)	88 (76.84)	76 (66.69)	96 (84.96)	100 (90.0)	100 (90.0)	93.33 (83.04)	
Mean	77.71 (68.57)	55.43 (50.34)	44.57 (42.96)	46.29 (43.06)	61.71 (55.85)	77.14 (68.60)		

LSD (Transformed data) for fungicide = 10.23 (p ≤ 0.05) or 13.45 (p ≤ 0.01).

[a] All fungicides were used as seed-dressing except Tachigaren which used as soil drenching.

[b] percentage data were transformed into arc sine angles before carrying out analysis of variance. Transformed data are shown in parentheses

[c] Efficiency was calculated based on percentage data according to the following formula :[(IC-IF)/IC]x100 where IC =Infection of the control and IF= infection of the designated fungicide.

[d] Efficiency was not calculated because the lack of significant differences between the fungicide and the control.

Table (5): Analysis of variance of effects of fungicides, isolates of *Rhizoctonia* spp., and their interaction on percentage of cotton seedlings (cultivar Giza 89) infected with damping-off under greenhouse conditions when *Rhizoctonia* spp. isolates were used at a rate of 0.5g/Kg soil.

Source of variation	D.F.	M.S.	F.[a] value
Replicate	4	337.55	0.93
Fungicide (F)	6	7495.50	20.63**
Isolate(S)	5	4618.75	12.71**
SXF	30	433.52	1.19
Error	164	363.38	

[a]F. value is significant at P ≤ 0.01 (**)

Table (6): Effects of fungicides, isolates of *Rhizoctonia* spp., and their interaction on percentage of cotton seedlings (cultivar Giza 89) infected with damping-off under greenhouse conditions when *Rhizoctonia* spp. isolates were used at rate of 0.5g/kg soil.

Fungicides[a]	Isolates of *Rhizoctonia* spp.						Mean	Efficiency [c]
	S1	S2	S3	S4	S5	S6		
Bert MLX	44[b] (41.54)	28 (31.63)	44 (41.54)	24 (26.32)	48 (43.85)	80 (72.00)	44.67 (42.81)	49.99%
Maxim	68 (58.84)	60 (54.00)	44 (41.31)	24 (26.32)	40 (36.00)	84 (71.53)	53.33 (48.00)	40.30%
Monceren-T	40 (41.79)	64 (56.53)	48 (41.07)	24 (23.31)	48 (44.07)	64 (53.53)	48.00 (43.38)	46.27%
Premis	56 (45.68)	48 (43.85)	36 (33.69)	24 (26.09)	32 (31.16)	48 (46.85)	40.67 (37.89)	54.47%
Rizolex T	28 (25.85)	36 (33.47)	44 (41.54)	32 (31.16)	36 (36.25)	72 (61.37)	41.33 (38.27)	53.73%
Tachigaren	88 (79.85)	80 (69.22)	40 (39.01)	56 (48.69)	92 (82.15)	96 (84.69)	75.33 (67.27)	15.67%
Control	100 (90.0)	96 (84.69)	72 (61.37)	72 (61.37)	96 (84.69)	100 (90.0)	89.33 (78.69)	
Mean	60.57 (54.79)	58.86 (53.34)	46.86 (42.79)	36.57 (34.75)	56.00 (51.17)	77.71 (68.57)		

LSD (Transformed data) for fungicide = 10.23 ($p \leq 0.05$) or 13.45 ($p \leq 0.01$).

[a] All fungicides were used as seed-dressing except Tachigaren which used as soil drenching.

[b] percentage data were transformed into arc sine angles before carrying out analysis of variance. Transformed data are shown in parentheses

[c] Efficiency was calculated based on percentage data according to the following formula :[(IC-IF)/IC]x100 where IC=Infection of the control and IF =infection of the designated fungicide.

infection. However, one should keep in mind that Tachigaren is effective against some strains of *Rhizoctonia* spp. (Anonymous, 1997).

The binucleate isolate (no.3) did not show noticeable differences from multinucleate isolates of AG4 in regarding its sensitivity to the tested fungicides either *in vitro* or *in vivo*. This result is in agreement with the findings of Frisina and Benson (1988) who reported that binucleate *Rhizoctonia* spp. did not differ from *R. solani* in sensitivity to fungicides either *in vitro* or under greenhouse conditions. It is noteworthy that the binucleate isolate was the most *in vitro* sensitive isolate to Tachigaren. However, it is difficult to generalize from this single isolate and conclude that sensitivity to Tachigaren is a common trait in binucleate *Rhizoctonia* spp.

Data in Table (7) indicate that there was no correlation between the *in vitro* efficiency of any of the tested fungicides and efficiency of the same fungicide under greenhouse conditions when soil was infested with *Rhizoctonia* spp. inoculum at a rate of 0.1g/Kg soil. This lack of correlation may be attribute to the fact that *in vivo* efficiency of a fungicide is an outcome of a direct interaction between the chemical composition of the fungicide and the genotype of the pathogen. Under greenhouse conditions, other factors may interfere modifying the outcome of the *in vitro* interaction. These factors may include stability of the fungicide in the soil (Huppatz *et al.*, 1984; Buchenauer, 1975; and Snel *et al.*, 1970), activity of fungicide against infective propagules of the isolate (Huppatz *et al.*, 1983; Kataria and Grover, 1975; and Weinhold and Bowman, 1974), the host cultivar (Kataria and Verma, 1990), and the inoculum density (Garber *et al.*, 1979). These results indicate that *in vitro* performance of fungicides cannot be used to predict their *in vivo* performance under greenhouse conditions.

The *in vitro* correlations among fungicidal efficiencies were unrelated to the *in vitro* correlations among efficiencies of the same fungicides (Table 7). For example, there was *in vitro* significant correlation between Premis and Beret MLX; however, this correlation was absent under greenhouse conditions. Also, there were significant correlations between Maxim and Beret MLX and between Rizolex T and Premis under greenhouse conditions although these significant correlations were not found under laboratory conditions. Under the high inoculum density (0.5g/Kg soil) there was no significant correlation between *in vitro* efficiency of any fungicide and its *in vivo* efficiency (Table 8). Also, there was no correlation between efficiency of fungicides under greenhouse conditions. These results indicate that the inoculum density affected the degree of association between fungicidal efficiency such that the significant correlations between efficiency of some fungicides, when the low inoculum density was used disappeared when the inoculum density was increased to 0.5g/Kg soil. A highly significant correlation between *in vitro* and *in vivo* efficiencies of fungicides was observed only when fungicidal efficiency was expressed as the mean efficiency of each fungicide over all the tested isolates (Table 9).

Linear correlation coefficient (r) between ED_{50} of fungicides and their efficiencies were $r = -0.9396$ ($p \leq 0.01$) or $r = -0.9275$ ($p \leq 0.01$) for the first and second inoculum densities, respectively.

Table (7): Correlation between efficiencies of fungicides under pure culture conditions expressed as ED_{50} value and their efficiencies under greenhouse conditions when *Rhizoctonia* spp. isolates were used at a rate of 0.1g/Kg soil.

Treatment	Tachigaren (green house efficiency)	Rizolex T (green house efficiency)	Premis (green house efficiency)	Monceren T (green house efficiency)	Maxim (green house efficiency)	Beret MLX (green house efficiency)	Tachigaren (ED_{50})	Maxim (ED_{50})	Premis (ED_{50})	Beret MLX (ED_{50})	Monceren T (ED_{50})
Rizolex T (ED_{50})	-0.39[a]	0.53	0.28	0.19	-0.16	-0.37	0.32	-0.22	-0.13	-0.29	-0.55
Monceren T (ED_{50})	-0.32	-0.33	-0.55	-0.69	-0.11	-0.10	-0.11	0.30	-0.51	-0.25	
Beret MLX (ED_{50})	0.90*	0.30	0.74	0.32	0.52	0.57	-0.48	-0.11	-0.84*		
Premis (ED_{50})	0.74	0.35	0.79	0.20	0.33	0.34	0.01	0.15			
Maxim (ED_{50})	-0.08	0.37	0.17	-0.75	0.26	0.34	0.68				
Tachigaren (ED_{50})	-0.54	0.21	-0.02	-0.59	-0.34	-0.37					
Beret MLX (greenhouse efficiency)	0.74	0.51	0.56	0.09	0.97**						
Maxim (greenhouse efficiency)	0.72	0.62	0.64	0.25							
Monceren T (greenhouse efficiency)	0.50	-0.05	0.23								
Premis (greenhouse efficiency)	0.66	0.83*									
Rizolex T (greenhouse efficiency)	0.24										

[a] Linear correlation coefficient (r) is significant at P ≤0.05 (*), or P ≤0.01 (**)

Table (8): Correlation between efficiencies of fungicides under pure culture conditions expressed as ED_{50} value and their efficiencies under greenhouse conditions when *Rhizoctonia* spp. isolates were used at a rate of 0.5g/Kg soil.

Treatment	Tachigaren (green house efficiency)	Rizolex T (green house efficiency)	Premis (green house efficiency)	Monceren T (green house efficiency)	Maxim (green house efficiency)	Beret MLX (green house efficiency)	Tachigaren (ED_{50})	Maxim (ED_{50})	Premis (ED_{50})	Beret MLX (ED_{50})	Monceren T (ED_{50})
Rizolex T (ED_{50})	-0.46[a]	0.17	0.61	0.07	0.39	-0.12	0.32	-0.22	-0.13	-0.29	-0.55
Monceren T (ED_{50})	0.18	0.50	-0.84*	0.05	-0.32	0.38	-0.11	0.30	-0.51	-0.25	
Beret MLX (ED_{50})	0.23	0.07	0.50	0.66	0.63	0.42	-0.48	-0.11	0.84*		
Premis (ED_{50})	-0.11	-0.05	0.64	0.39	0.48	0.32	0.01	0.15			
Maxim (ED_{50})	-0.03	0.35	-0.12	-0.36	-0.01	0.61	0.68				
Tachigaren (ED_{50})	-0.63	0.17	0.05	-0.45	-0.24	0.08					
Beret MLX (greenhouse efficiency)	0.10	0.80	0.15	0.44	0.62						
Maxim (greenhouse efficiency)	0.16	0.43	0.77	0.60							
Monceren T (greenhouse efficiency)	-0.21	0.57	0.31								
Premis (greenhouse efficiency)	-0.14	-0.02									
Rizolex T (greenhouse efficiency)	-0.32										

[a] Linear correlation coefficient (r) is significant at $P \leq 0.05$ (*).

Table (9): Correlation between ED_{50} of fungicides under laboratory conditions and their efficiencies (%) under greenhouse conditions.

Fungicide	ED_{50}	Efficiency at an inoculum density of 0.1g/Kg soil	Efficiency at an inoculum density of 0.5g/Kg soil
Rizolex T	0.825[a]	57.14	53.73
Monceren T	4.903	48.57	46.27
Beret MLX	3.370	52.86	49.99
Premis	17.790	42.14	54.47
Maxim	4.162	39.28	40.30
Tachigaren	372.188	6.43	15.67

[a]Each value is the mean of six isolates.

Regression analysis showed that *in vitro* fungicidal efficiency accounted for 88% and 86% of the explained (model) variation in fungicidal efficiency under greenhouse conditions when the inoculum densities were 0.1g and 0.5g/Kg soil, respectively (Fig.1 A and B).

In fact, the expression of fungicidal efficiency as the mean efficiency of each fungicide over all the tested isolates correspond to what actually happens under field conditions where a fungicide exerts its antifungal activity against a mixture of pathogen isolates.

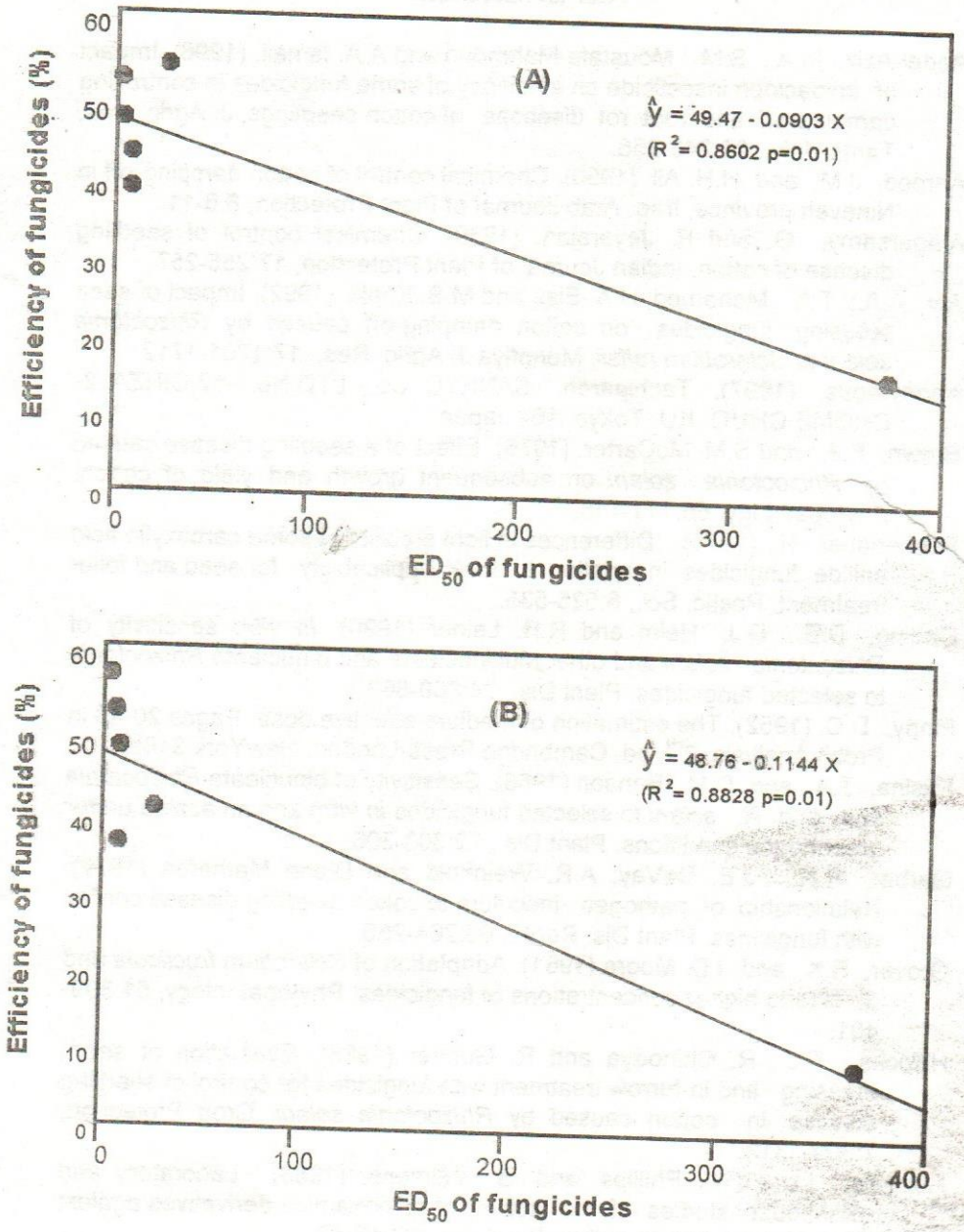

Fig. (1): Regression equations that describe the relationship between ED_{50} of fungicides under pure culture conditions and efficiency of these fungicides in controlling *Rhizoctonia* spp. under greenhouse conditions. Soil was infested with isolates of *Rhizoctonia* spp. at a rate of 0.1 g/Kg. Soil (A) or 0.5 g/Kg soil (B).

REFERENCES

Abdel-Aziz, M.A.; S.M. Moustafa-Mahmoud and A.A. Ismail. (1996). Impact of imidaclopri insecticide on efficiency of some fungicides in controlling damping-off and root rot diseases of cotton seedlings. J. Agric. Res. Tanta Univ., 22:243-255.

Ahmed, J.M. and H.H. Ali. (1990). Chemical control of cotton damping-off in Ninevah province, Iraq. Arab Journal of Plant Protection, 8:6-11.

Alagarsamy, G. and R. Jeyarajan. (1989). Chemical control of seedling disease of cotton. Indian Journal of Plant Protection, 17:255-257.

Aly, A.A.; T.A. Mohamed; H.A. Eisa and M.S. Khalil. (1992). Impact of seed dressing fungicides on cotton damping-off caused by *Rhizoctonia solani* or *Sclerotium rolfsii*. Menofiya J. Agric. Res., 17:1701-1712.

Anonymous. (1997). Tachigaren. SANKYO Co., LTD.No.7-12.GINZA 2-CHOME CHUO- KU. Tokyo. 104 Japan.

Brown, E.A. and S.M. McCarter. (1976). Effect of a seedling disease caused by *Rhizoctonia solani* on subsequent growth and yield of cotton. Phytopathlogy, 66:111-115.

Buchenauer, H. (1975). Differences in light stability of some carboxylic acid anilide fungicides in relation to their applicability for seed and foliar treatment. Pestic. Sci., 6:525-535.

Carling, D.E.; D.J. Helm and R.H. Leiner (1990). *In vitro* sensitivity of *Rhizoctonia solani* and other multinucleate and binucleate *Rhizoctonia* to selected fungicides. Plant Dis., 74:860-863.

Finny, D.C. (1952). The estimation of medium effective dose. Pages 20-48 in Probit Analysis. 2nd. ed. Cambridge Press-London. NewYork 318pp.

Frisina, T.A. and D.M. Benson (1988). Sensitivity of binucleate *Rhizoctonia* spp. and *R. solani* to selected fungicides *in vitro* and on azalea under greenhouse conditions. Plant Dis., 72:303-306.

Garber, R.H.; J.E. DeVay; A.R. Weinhold and Diane Matheron (1979). Relationship of pathogen inoculum to cotton seedling disease control with fungicides. Plant Dis. Reptr., 63:264-250.

Grover, R.K. and I.D. Moore (1961). Adaptation of *Sclerotium fructicola* and *S. laxa* to higher concentrations of fungicides. Phytopathology, 51:399-401.

Hillocks, R.J.; R. Chinodya and R. Gunner (1988). Evaluation of seed-dressing and in-furrow treatment with fungicides for control of seedling disease in cotton caused by *Rhizoctonia solani*. Crop Protection, 7:309- 313.

Huppatz, J.L.; J.N. Phillips and B. Witrzens (1983). Laboratory and glasshouse studies of the activity of carboxamide derivatives against *Rhizoctonia solani* in cotton. Plant Dis., 67:45-47.

Huppatz, J.L.; J.N. Phillips and B. Witrzens (1984). Structure-activity relationship in a series of fungicidal pyrazole carboxanilides. Agric. Biol. Chem., 48:45-50.

Jones, R.K.; S.B. Belmar and M.J. Jeger (1987). Evaluation of benomyl and propiconazole for controlling sheath blight of rice caused by *Rhizoctonia solani*. Plant Dis., 71:222-225.

Jones, R.W.; and R.E. Pettit (1987). Variation in sensitivity among anastomosis groups of *Rhizoctonia solani* to the antibiotic gliotoxin. Plant Dis., 71:34-36.

Kataria, H.R. and R.K. Grover (1975). Inhibition of infection structures of *Rhizoctonia solani* by fungitoxicants. Z. Pflkrank. PflSchutz, 82:226-232.

Kataria, H.R. and P.R. Verma (1990). Efficacy of fungicidal seed treatments against pre-emergence damping-off and post-emergence seedling root rot of growth chamber grown canola caused by *Rhizoctonia solani* AG-2- 1 and AG-4.Can. J. Plant Pathol., 12:409-416.

Kataria, H.R.; P.R. Verma and U. Gisi (1991). Variability in sensitivity of *Rhizoctonia solani* anastomosis groups to fungicides. J. Phytopathology, 133:121-133.

Martin, R. (1978). Fungitoxicity and translocation of the systemic fungicide α-butyl-α-phenyl-1H-imidazole-1-propanenitrile (RH 2161). MSc. Thesis, University of Guelph, Canada.

Martin, S.B.; C.L., Campbell and L.T. Lucas (1984). Response of Rhizoctonia blights of tall fescue to selected fungicides in greenhouse Phytopathology, 74:782-785.

Moustafa-Mahmoud, S.M.; D.R. Sumner; M.M. Ragab and Mona M. Ragab (1993). Interaction of fungicides, herbicides, and planting date with seedling disease of cotton caused by *Rhizoctonia solani* AG4. Plant Dis. 77:79-86.

Roberts, D.L. and C.T. Stephens (1984). Sensitivity of *Rhizoctonia solani* to experimental fungicide NTN 19701. Phytopathlogy, 74:854.

Snel, M.; B. Von Schmeling and L.V. Edginton (1970). Fungitoxicity and structure-activity relationships of some oxathiin and thiazole derivatives. Phytopathology, 60:1164-1169.

Sumner, D.R. (1987). Efficacy of pencycuron against isolates representing different anastomosis groups of Rhizoctonia solani and Rhizoctonia-like binucleate fungi. Plant Dis., 71:515-518.

Watkins, G.M. (1981). Compendium of Cotton Diseases. American Phytopathological Society, St. Paul, MN. 87pp.

Weinhold, A.R. and T. Bowman (1974). Repression of virulence in *Rhizoctonia solani* by glucose and 3-*o*-methyl glucose. Phytopathology, 64:985-990.

التباين في الحساسية للمبيدات الفطرية بين عزلات فطر الريزوكتونيا المسببة لمرض موت بادرات القطن

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اختبرت خمس عزلات من فطر الريزوكتونيا سولانى متعدد الأنوية و عزلة واحدة من فطر الريزكتونيا ثنائي الأنوية وذلك من حيث الحساسية ، تحت ظروف المعمل ، للمبيدات الفطرية ريزولكس تى ومونسرين تى وماكسيم وبريميس وبيريت ام ال اكس و تاتشيجارين. أظهرت جميع عزلات الريزوكتونيا سولانى درجة عالية من التحمل للمبيد تاتشيجارين ، في حين كانت عزلة الريزوكتونيا ثنائية الأنوية هي الوحيدة الحساسة لهذا المبيد. أظهرت جميع العزلات المختبرة درجة عالية من الحساسية للمبيد ريزولكس تى. اختبرت نفس مجموعة المبيدات من حيث الكفاءة في مقاومة مرض موت بادرات القطن على صنف جيزة ٨٩ ، وذلك تحت ظروف الصوبة، باستعمال مستويين من اللقاح لكل عزلة من العزلات سالفة الذكر. أظهر تحليل التباين أن المبيدات والعزلات كانت مصادر عالية المعنوية للتباين في النسبة المئوية للبادرات الميتة، في حين كان تفاعل المبيدات × العزلات مصدرا غير معنويا للتباين وذلك بصرف النظر عن مستوى اللقاح المستخدم. نظرا لعدم معنوية تفاعل المبيدات × العزلات، فان أقل فرق معنوي استعمل للمقارنة بين المتوسطات العامة للمبيدات، أظهرت هذه المقارنات أن الريزولكس تى والبيريت ام ال اكس كانا أكثر المبيدات فعالية في مقاومة المرض الناجم عن الإصابة بمستوى اللقاح المنخفض، في حين كان الريزولكس تى والبريميس هما أكثر المبيدات فعالية في مقاومة المرض الناجم عن الإصابة بمستوى اللقاح المرتفع. أما مبيد التاتشيجارين فبالرغم من أنه كان فعالا فقط عند مستوى اللقاح المرتفع، إلا أنه ظل أقل المبيدات كفاءة. كفاءة المبيدات تحت ظروف المعمل لم ترتبط بكفاءتها تحت ظروف الصوبة عندما تم تقييم الكفاءة بناء على تأثيرات كل مبيد على العزلات المنفردة. على العكس من ذلك، أظهرت الدراسة وجود ارتباط عالي المعنوية بين كفاءة المبيدات تحت ظروف المعمل وكفاءتها تحت ظروف الصوبة وذلك عندما تم تقييم الكفاءة بناء على متوسط تأثير كل مبيد على العزلات مجتمعة. أظهر تحليل الانحدار أن متوسط الكفاءة تحت ظروف المعمل يفسر ٨٨% و ٨٦% من التباين في متوسط الكفاءة تحت ظروف الصوبة وذلك عند استعمال اللقاح الفطري بتركيز ٠,١ جم/ كجم تربة و ٠,٥ جم / كجم تربة على التوالي.