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Disease management of rose powdery mildew using some fungicides and biofungicides

El-Naggar A. S., El-Sheikh Aly M. M., El-Emary F. A., Hegazy M. G. A.*

Agricultural Botany Department, Faculty of Agriculture, Al-Azhar University, 71524 Assiut, Egypt

Abstract

Powdery mildew, caused by the fungus *Sphaerotheca pannosa* var. *rosae* is a major pathogen in growing rose gardens. The conidia of the causal pathogen were isolated and collected from Assiut and Sohag governorates, Egypt. The pathological capacity of four fungal isolators was tested on the Eiffel Tower (*Rosa hybrida*) cultivar, the isolate obtained from Assiut was the most severe infection isolate and the sensitivity reaction of the cultivars were tested using four cultivars of roses *i.e*., Eiffel Tower (*R. hybrida*), Multiflora rose (*Rosa polyantha*), Pine rose (*Rosa pinetorum*) and Dwarf rose (*Rosa gymnocarpa*). The cultivars showed varying degrees of significant responses to powdery mildew infection. *R. polyantha* had the highest disease severity, whereas R. pinetorum had the lowest severity. Greenhouse experiments were conducted to confirm the effectiveness of these fungicides. Six fungicides were tested: Bellis® 38% WG, Collis 30% SC, Dovex 50% SC, Montoro 30% EC, Tilt 25% EC, and Topsin M 70% WP. Both Dovex 50% SC and Montoro 30% EC, fungicide were completely suppressed the disease severity (0.00%) on *R. polyantha* and *R. pinetorum* after 45 days in both seasons compared to the control. Two commercial bio-fungicides were used, Bio-Arc 6% and Bio-Zeid 2.5%, which completely suppressed the disease severity (0.66 and 0.83%) and (0.33 and 0.83%) on *R. polyantha*, (1.16 and 1.16%) and (0.00 and 0.00%) on *R. pinetorum*, respectively, after 45 days in both seasons compared to the control.

Keywords: rose, powdery mildew, *Sphaerotheca pannosa*, fungicide, biofungicide.

*Corresponding author: Hegazy M. G. A,
E-mail address: mohamedhegazy.5419@azhar.edu.eg

1. Introduction

Rose is one of the most popular flowering ornamentals in the world. It was thought to have been cultivated 4,000–5,000 years ago in northern Africa. Today, it is a favorite ornamental for landscapes as well as the most important commercial cut flowers. Rose (*Rosa hybrid* L.) is classified as the most important ornamental species of Rosaceae and has the highest world production among the 10 commercial cut flowers (Synge, 1971). The fungus *Podosphaera pannosa* (previously referred to as *Sphaerotheca pannosa*) causes powdery mildew in roses. The vase life of cut rose flowers is typically short. Rose powdery mildew, caused by *Podosphaera pannosa*, is a fungal disease that affects leaves, young shoots and stems, buds, and flowers. It is characterized by grayish or white powdery growth on plants (Eken 2005). The first signs of PM appear on young leaves, which hold their color, but begin to crinkle. Subsequently, the disease appears as a whitish powder covering the foliage, stems, and buds. Severe PM outbreaks can make entire crops unmarketable through damage such as leaf chlorosis and necrosis, bud distortion, defoliation, leaf rolling, stunted growth, and twisted new stems (Morgan, 2010). Powdery mildew causes leaf curling, yellowing, premature defoliation, and, in some cases, plant death. Squash, cucumbers, grapes, lilacs, crab apples, monarda, phlox, and roses are all likely targets of powdery mildew. Under commercial conditions, the currently available control methods include the use of fungicides. However, the constant use of fungicides can result in environmental pollution and selection of resistant populations of pathogens (McGrath *et al.,* 1996). The control of powdery mildew depends mainly on the use of fungicides as the most effective method to limit disease severity and the cultivation of disease-resistant varieties (Kiss, 2003). The other chemical compound was Score 25% EC, a systemic fungicide containing 25% difenoconazole, a commonly used triazole that treats plant diseases caused by fungi. It inhibits fungal ergosterol biosynthesis by targeting sterol-1-4-demethylase (Elansky *et al.* 2016). Chemical control plays an important role in disease minimization. Rose powdery mildew is a disease of roses caused by the fungus Sphaerotheca pannosa. Bupirimate (25% EC) could control rose powdery mildew. The present study was initiated with the bioefficacy and phytotoxicity of bupirimate 25% EC against powdery mildew disease in rose (Adhikary *et al.,* 2017). Additionally, fungicides have negative effects on beneficial microorganisms and insects; therefore, the search for environmentally sound alternatives to fungicides is required. Recently, biofungicides have been used to manage powdery mildew (Eken, 2005). The ability of mycoparasites to control powdery mildew depends on their intrinsic

properties and environmental conditions (Toppo and Tiwari, 2015). Verhaar *et al.* (1999) studied the effectiveness of mycoparasites to control rose powdery mildew under selected environmental conditions. Natural substances, such as bioproducts obtained from plants, algae, and microorganisms, have been suggested as promising and safe alternatives (Masheva *et al.*, 2014). The commercial management of powdery mildew relies on fungicides, such as carbendazim, triazoles, and chlorothalonil (Linde and Shishkoff, 2003). The use of microbial biocontrol agents has the potential to effectively replace fungicides in integrated disease management (McGrath, 1991). Powder mildew in commercial greenhouse roses is typically controlled by synthetic chemical products (Scarito *et al.*, 2007). The objectives of this study were to assess the susceptibility of some rose cultivars to powdery mildew disease and to evaluate chemical and bio-fungicides for controlling the disease under field conditions.

2. Materials and methods

2.1 Fungal pathogen isolates and its sources

Four conidial isolates of *Sphaerotheca pannosa* var. *rosae*. were obtained from naturally infected plants at all four sites (Table 1). Fungal pathogen isolates were obtained from a greenhouse in Assuit and Sohag governorates, Egypt by collecting samples of rose plants infected with disease on leaves, stems, and flowers using soft brushes, in sterile and preserved tubes until they were inserted into the laboratory cooler (10 liters capacity) until used for artificial according to Cárdenas *et al.* (2016) with some modifications. Fungal (mycelia and spores) were obtained from Tahta and Tema (Sohag governorate), Assiut and Abnob (Assiut governorate), in Egypt. The used rose cultivars in this experiment were, Eiffel Tower (*Rosa hybrida*), Multiflora rose (*Rosa polyantha*), Pine rose (*Rosa pinetorum*) and Dwarf rose (*Rosa gymnocarpa*), One-year-old transplants of each cultivar were grown in a mildew-free greenhouse. Transplants were transplanted into 30 cm plastic pots (one transplant in each pot) filled with a soil mixture of clay and sand (2:1, v:v). Cultural practices, irrigation, and fertilization were performed as recommended in the program to improve rose production. A randomized complete block design with three replicates was used. Four replicate pots were used for each treatment group.

2.2 Pathogenicity tests

Experiments were carried out at the Agricultural Research Center, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt, during the 2021 growing season using the Eiffel Tower (*R. hybrida*) and isolates (SP1, SP2, SP3, and SP4) preserved as previously described. Infection was performed on rose cultivars

using isolation SP2 obtained from the pathological experiment under greenhouse conditions using the conidia suspension method with a simple scratch on the surface of the leaves, which were pollinated with a soft brush and a thin needle. With four complete collective designs randomized with four replicates per cultivar, each replicate contained 16 plants (four plants of the same type in each basin), and the plants were then covered with plastic bags for 48 h to create favorable environmental conditions for completing the infection. Evaluation of disease severity on a scale from (0 - 4) the severity of the disease was recorded on rose plants in each cultivars for 40 days, once every 10 days The plants were visually evaluated for powdery mildew resistance using a class scale:0 = no leaf lesions; 1 = 25% or less; 2 = 26–50%; 3 = 51–75%; and 4 = 76–100% of the mature leaf area covered by mildew, according to Linde *et al.* (2006) with some modifications. was calculated using the following equation, according to Abdel-Kader *et al.* (2012):

$$DS\ (\%) = \sum [(n \times c) / N] \times 100$$

where DS = disease severity (%), n = number of infected leaves per category, c = category number, and N = total examined leaves.

2.3 Cultivar-sensitivity reactions

Sensitivity experiments were conducted on rose plants at the nursery of the Agricultural Research Centre of Al-Azhar University, Assiut, Egypt, during the 2021 growing season using four cultivars: Eiffel Tower (*R. hybrida*), Multiflora rose (*R. polyantha*), pine rose (*R. pinetorum*), and dwarf rose (*R. gymnocarpa*). To determine which cultivars are sensitive to diseases that are not susceptible to powdery mildew caused by *Sphaerotheca pannosa* var. *rosa*. Infection was carried out for the cultivars, as previously stated in the pathogenicity test using the pathogen. Powdery mildew disease was assessed seven days after inoculation by examining both sides of the leaves and rating disease intensity as the extent of leaf cover by the fungal mycelium on 100 randomly selected leaves of each plant for eight weeks (56 days). A scale was used to assess disease severity and the equations were applied as previously reported.

2.4 Evaluation of fungicides and bio-fungicides for controlling rose powdery mildew

Greenhouse experiments were carried out at the Experimental Field of the Nursery of the Agricultural Research Center of Al Azhar University, Assiut, Egypt during the 2021 and 2022 growing seasons. Sensitive (*R. polyantha*) and non-susceptible (*R. pinetorum*) rose cultivars were selected for this experiment on powdery mildew disease based on their interactions in a previous experiment conducted during the 2021 and 2022

growing seasons. The greenhouse plots consisted of eight squares (each square consisted of 10 rows potted at a distance of 1 m between rows and 50 cm between plants) and were arranged in a split plot design with three replicates per treatment. One plot was specified for each tested compound and one plot was left for the control treatment. The plants were fertilized and irrigated as required.

Table (1): Common names, group names, active ingredients, chemical groups, manufacturer suppliers, and concentrations of tested fungicides.

Common name (Trade name)	Group name	Active ingredient (Common Name)	Chemical group	Manufacturer supplier	Concentration
Bellis 38% WG	Succinate dehydrogenase inhibitors	Boscalid	Carboxamide	BASF™	50 gm /100 L
	Quinone outside inhibitors (Strobilurins)	Pyraclostrobin	Methoxy carbamates		
Collis 30% SC	Succinate dehydrogenase inhibitors	Boscalid	Carboxamide	BASF™	50 cm^3/ 100 L
Dovex 50% SC	Quinone outside inhibitors (Strobilurins)	Azoxystrobin 20%	Methoxyacrylates	STARCHEM	25 cm^3/ 100 L
	DeMethylation inhibitors	Tebuconazole 30%	Triazoles		
Montoro 30% EC	DeMethylation Inhibitors	Propiconazole 15%	Triazoles	STARCHEM	50 cm^3 /100 L
		Difenoconazole 15%	Triazoles		
Tilt 25% EC	DeMethylation inhibitors	Propiconazole 25%	Triazoles	Syngenta	15 cm^3/100 L
Topsin M 70% WP	Methyl Benzimidazole Carbamates	Thiophanate-methyl	Thiophanates	Nippon Soda Co.	65 gm /100 L

A large area around the plots was left untreated to avoid contamination by chemicals from neighboring fields (Gado, 2013). Treatment was initiated before the first signs of the disease appeared. Plants were sprayed three times during each season at 15 days intervals. Sanitized distilled water was used for spraying check plants (control), and disease severity was determined (three times) in order to evaluate the treatments 15 days after each spraying time of the tested compounds for 45 days. Solutions of each tested compound were applied using a hand sprayer at a volume of 1 litre of tap water per compound (until runoff). Sanitized distilled water was used to spray control plants, (control) and three plants for each treatment. DS (%) values were calculated as previously described. This experiment was conducted to study the effects of Bellis® 38% WG, Collis 30% SC, Dovex 50% SC, Montoro 30% EC, Tilt 25% EC, and Topsin M 70% WP on the disease severity of rose powdery mildew in rose plants under greenhouse conditions during the 2021 and 2022 growing seasons. The common names, group names, active ingredients, chemical groups, manufacturer suppliers, and concentrations of the tested fungicides are listed in Table (1). The common names, bioagents (density /ml), types of biochemicals, and concentrations of the tested biofungicides are explained in Table (2).

Table (2): Common name, bio-agents (density/ml), types of biochemicals, and concentrations of tested biofungicides.

Biofungicides (Common Name)	Bio-agents (density/ml)	Type of agents	Concentration
Bio-Arc 6% WP	*Bacillus megaterium* (25×10^6 cell/g)	Antibacterial	1 g/L
Bio-Zeid 2.5% WP	*Trichoderma album* (10×10^6 spores/g)	Antifungal	1 g/L

2.5 Statistical analysis

Collected data were subjected to a split-plot analysis of variance (One-way ANOVA) using the statistical software package "Statistics 8.1" to look at the variations between the means, Duncan's multiple-range test was used at the level of significance 5% (Gomez and Gomez, 1984).

3. Results

3.1 Collection of casual pathogen inocula

Four isolates of the causal pathogen of rose powdery mildew were obtained from Tahta and Tema (Sohag governorate), and Assuit and Abnob (Assuit governorate) (Table 3). The isolates were SP1, SP2, SP3, and SP4. Data show the codes, sources, and disease severity of the isolates.

3.2 Pathogenicity tests

The data in Table (3) represent the pathogenic capabilities of fungal isolates and their sources in different districts of Assiut and Sohag governorates, Egypt. During the 2021 growing season, the data showed that the highest disease severity value was detected in SP2, followed by SP1, while the lowest disease severity value was found in SP3 and SP4.

Table (3): Pathogenic capability of isolated fungi and their sources.

Isolate No.	Code	Sources	Disease severity (%)
Isolate 1	SP1	Abnob (Assuit)	22.25 b
Isolate 2	SP2	Assuit (Assuit)	35.75 a*
Isolate 3	SP3	Tema (Sohag)	19.00 d
Isolate 4	SP4	Tahta (Sohag)	21.50 c

*Means followed by the same letters (s) in a column are not significantly different at ($p\leq0.05$) according to Duncan's multiple range test.

3.3 Cultivar-sensitivity reaction

Four cultivars were examined for their reaction to infection by the casual pathogen. These cultivars were Eiffel Tower (*R. hybrida*), Multiflora rose (*R. polyantha*), Pine rose (*R. pinetorum*), and Dwarf rose (*R. gymnocarpa*). The results of this experiment are listed in Table (4). Data showed that most of the tested roses, Eiffel Tower (*R. hybrida*), Multiflora rose (*R. polyantha*), Pine rose

(*R. pinetorum*) and Dwarf rose (*R. gymnocarpa*) significantly responded with varied degrees to powdery mildew infection Multiflora rose (*R. polyantha*), followed by Pine rose (*R. pinetorum*), was most susceptible, as was Eiffel Tower (*R. hybrida*), respectively. The dwarf rose (*R. gymnocarpa*) showed resistance to powdery mildew during the 2021 growing season. Data also showed that *R. polyantha* had the highest disease severity, whereas *R. pinetorum* had the lowest disease severity.

3.4 Evaluation of fungicides for controlling rose powdery mildew

A greenhouse experiment was conducted to confirm the effectiveness of fungicides against powdery mildew on roses caused by *Sphaerotheca pannosa* var. *rosae*. This experiment was conducted under greenhouse conditions during the 2021 and 2022 growing seasons.

Table (4): Sensitivity of the varieties to powdery mildew disease during the 2021 growing season.

Cultivar	Disease severity (%)							
	After one week	After two weeks	After three weeks	After four weeks	After five weeks	After six weeks	After seven weeks	After eight weeks
Rosa hybrida	0.00 d*	2.06 cd	4.93 c	8.18 c	9.00 d	11.18 c	14.00 c	14.12 c
Rosa polyantha	0.00 d	11.00 a	14.93 a	18.43 a	25.37 a	26.93 a	27.00 a	32.75 a
Rosa pinetorum	0.00 d	0.00 d	0.00 d	0.00 d	0.00 e	0.00 d	0.00 e	0.00 d
Rosa gymnocarpa	0.00 d	0.75 d	3.87 c	5.87 c	7.75 d	9.75 c	11.75 d	13.37 c

*Means followed by the same letters (s) in a column are not significantly different at ($p \leq 0.05$) according to Duncan's multiple range test.

The data in Tables (5 and 6) indicate that six fungicides were used to control powdery mildew on the roses. Bellis® 38% WG, Collis 30% SC, Dovex 50% SC, Montoro 30% EC, Tilt 25% EC and Topsin M 70% WP were used as recommended by the manufacturer on the disease severity of rose powdery mildew, caused by *Sphaerotheca pannosa* var. *rosae*. Data also, indicated that fungicides can decrease the disease severity of powdery mildew on rose cultivar (*R. polyantha*), Both fungicides, Dovex 50% SC and Montoro 30% EC, had the lowest percentage of disease severity (0.00%) in both seasons after 45 days compared with the control. As described in Table (5), the rose cultivar (*R. pinetorum*) fungicides Collis 30% SC, Dovex 50% SC, and Montoro 30% EC had the lowest percentage of disease severity (0.00%) in both sessions after 45 days, as described in Table (6). The check treatment resulted in the highest percentage of disease severity (38.16% and 37.33%), (38.99% and 48.00%, respectively).

Table (5): Effect of some fungicide compounds on powdery mildew of rose plants (*Rosa polyantha)* in greenhouse experiments during 2021 and 2022 growing seasons.

Fungicide	Disease severity (%)					
	Season 2021			Season 2022		
	After 15 days	After 30 days	After 45 days	After 15 days	After 30 days	After 45 days
Bellis 38%	5.66 a	3.66 b	0.00 b	5.66 ab	2.16 b	0.33 b
Collis 30%	0.00 c *	0.00 d	0.16 b	0.00 c	0.00 c	0.16 b
Dovex 50%	0.83 bc	0.00 d	0.00 b	2.66 bc	0.00 c	0.00 b *
Montoro 30%	0.00 c	0.00 d	0.00 b	3.33 bc	0.00 c	0.00 b
Tilt 25%	0.00 c	0.00 d	0.66 b	0.00 c	0.00 c	0.33 b
Topsin M 70%	0.00 c	1.33 c	0.83 b	0.00 c	2.33 b	0.50 b
Control	4.33 ab	24.49 a	38.16 a	8.00 a	24.16 a	37.33 a

*****Means followed by the same letters (s) in a column are not significantly different at ($p \leq 0.05$) according to Duncan's multiple range test.

Table (6): Effect of some fungicide compounds on powdery mildew of rose plants (*Rosa pinetorum*) in greenhouse experiments during 2021 and 2022 growing seasons.

Fungicide	Disease severity (%)					
	Season 2021			Season 2022		
	After 15 days	After 30 days	After 45 days	After 15 days	After 30 days	After 45 days
Bellis 38%	1.83 c	3.00 b	0.33 b	3.33 c	2.33 b	0.33 cd
Collis 30%	1.83 c	0.00 c	0.00 b	1.33 d	0.00 d	0.00 d
Dovex 50%	1.16 c	0.00 c	0.00 b	0.83 d	0.00 d	0.00 d
Montoro 30%	0.00 c	0.83 c	0.00 b	0.00 d	1.00 c	0.00 d
Tilt 25%	0.00 c	0.00 c	0.83 b	0.00 d	0.00 d	1.00 b
Topsin M 70%	5.16 b	2.50 b	0.66 b	10.00 a	2.66 b	0.50 c
Control	8.66 a	25.16 a	38.99 a	8.16 b	25.83 a	48.00 a

*Means followed by the same letters (s) in a column are not significantly different at ($p \leq 0.05$) according to Duncan's multiple range test.

3.4.1 Potency of biofungicides against powdery mildew on rose plants in greenhouse experiments during 2021 and 2022 growing seasons

The results in Tables (7 and 8) indicate significant differences between the bioagents against powdery mildew caused by *S. pannosa* var. *rosae*. Bio-Arc 6% and Bio-Zeid 2.5% were used in this study as fungicides. Data from the 2021 and 2022 growing seasons indicate that biofungicides can decrease the disease severity of rose powdery mildew on the cultivar (*R. polyantha*). After 45 days, Bio-Arc 6% and Bio-Zeid 2.5% had the lowest percentages of disease severity (0.66 and 0.83%) and (0.33 and 0.83%) during 2022 growing seasons as describe in Table (7), respectively. The check treatment resulted in the highest percentage of disease severity (48.66 and 44.66%, respectively). Both biofungicides showed the lowest percentage of disease severity in the cultivar (*R. pinetorum*) after 45 days during the 2021 and 2022 growing seasons. (1.16% and 1.16%) and (0.00% and 0.00%), respectively, as listed in Table (8). In contrast, the check treatment resulted in the highest percentage of disease severity (40.49 and 44.66%, respectively).

Table (7): Potency of some bio-fungicides on powdery mildew on rose plants (*Rosa polyantha)* in greenhouse experiments during the 2021 and 2022 growing seasons.

Biofungicide	Disease severity (%)					
	Season 2021			Season 2022		
	After 15 days	After 30 days	After 45 days	After 15 days	After 30 days	After 45 days
Bio-ARC 6%	0.00 b	1.83 b	0.66 b	0.00 b	1.00 b	0.33 b
Bio-Zeid 2.5%	0.83 b	1.66 b	0.83 b	0.83 b	1.66 b	0.83 b
Control	7.99 a	24.99 a	48.66 a	8.49 a*	27.99 a	44.66 a

*Means followed by the same letters (s) in a column are not significantly different at ($p \leq 0.05$) according to Duncan's multiple range test.

Table (8): Potency of some bio-fungicides on powdery mildew of rose plants (*R. pinetorum*) in greenhouse experiments during 2021 and 2022 growing seasons.

Biofungicide	Disease severity (%)					
	Season 2021			Season 2022		
	After 15 days	After 30 days	After 45 days	After 15 days	After 30 days	After 45 days
Bio-ARC 6%	0.00 c	2.33 b	1.16 b	0.00 c	2.33 b	1.16 b
Bio-Zeid 2.5%	2.16 b	0.00 b *	0.00 b	18.33 a	0.00 b	0.00 b
Control	11.66 a	29.66 a	40.49 a	11.66 b	31.49 a	44.66 a

*Means followed by the same letters (s) in a column are not significantly different at ($p \leq 0.05$) according to Duncan's multiple range test.

4. Discussion

Powdery mildew is one of the most important diseases affecting the rose. Powdery mildew caused by *Spaerotheca pannosa* is an economically important causal pathogen of rose and causes significant yield loss. Four cultivars were examined for their reaction to infection by the casual pathogen. These cultivars were Eiffel Tower (*R. hybrida*), Multiflora rose (*R. polyantha*), Pine rose (*R. pinetorum*), and Dwarf rose (*R. gymnocarpa*). Four isolates of the causal pathogen of rose powdery mildew were identified. The isolates were SP1, SP2, SP3, and SP4. These results are in line with those obtained by many workers (Leus *et al.*, 2002; Vakalounakis and Klironomou 1995) who reported that five commercial cultivars, which were infected by all isolates, and two species, from which *Rosa laevigata anemoides* was also susceptible for all isolates and *R. wichuraiana* showed only minor infections for two isolates. Only two races of *Sphaerotheca fusca* on cucurbits were found in 41 isolates from 30 locations in Crete. In the present study, we investigated six fungicides and two fungicides on powdery mildew disease in roses. Collis 30% SC and Dovex 50% SC fungicides when applied at the recommended concentrations resulted in the lowest percentage of disease severity (0.00%) on *R. polyantha* and *R. pinetorum* during the 2021 growing seasons. These results agree with those of Eliwa *et al.* (2018), who reported that the tested fungicide Bellis® 38% WG effectively reduced powdery mildew on sugar beet and delayed the spore germination of *Erysiphe betae*. Collis 30% SC, Dovex 50% SC, and Montoro

30% EC had the lowest percentage of disease severity (0.16 & 0.0 ٭%), (0.00% and 0.00%) and (0.00% and 0.00%) for *R. polyantha* and *R. pinetorum*, respectively, after 45 days during the 2022 growing season. These results are in agreement with those reported by other researchers (Akhileshwari *et al.,* 2012; Pramod and Dwivedi, 2007; Raju *et al.,* 2017; Singh, 2006). They reported that propiconazole, myclobutanil, triadimefon, and hexaconazole were the most effective in reducing the incidence of powdery mildew in many crops, and that fungicides are considered the shortest way to obtain efficient disease management results. The efficacy of penconazole against *Erysiphe cichoracearum* may be due to a reduction in ergosterol biosynthesis in the pathogen, which interferes with haustoria formation. Hence, these fungicides currently used for the control of powdery mildew on roses have an adverse effect on *Ampelomyces quisqualis*. Therefore, integrated pest management cannot be included. A commercial pelletized form of *A. quisqualis* (AQ10), when used in conjunction with myclobutanil at 10 µg/ml or triadimefon at 100µg/ml, no inhibition of *A. quisqualis* (McGrath *et al*, 2001). The interaction of *Ampelomyces* spp. and powdery mildew in natural infections presents an opportunity to control disease severity and develop biological control products (Viterbo *et al.*, 2007). The frequent application of mycoparasites in the field or greenhouse has reduced the severity of powdery mildew (Diego *et al.*, 2003). The present study implies that Bio-Arc 6% and Bio-Zeid 2.5% showed high effectiveness against powdery mildew in rose under field conditions. The findings of our study are in agreement with those of many researchers who reported that compounds produced by antagonistic fungi and bacteria have potential antifungal and antibacterial activities against plant pathogens (Alstrom, 2001; Koitabashi, 2005; Mercier and Manker, 2005; Wheatley, 2002; Zou *et al*., 2007). *Trichoderma harzianum* competes with *Podosphaera xanthii* for nutrients and space (Spadaro and Droby, 2016), whereas *B. subtilis* produces amphiphilic membrane-active peptide antibiotics, such as surfactin, fengycin, and iturin, which directly affect the hyphae and spores of powdery mildew fungus (Gilardi *et al*., 2008). Finally, the use of bio-fungicides is recommended to reduce the risk of fungicides to human health and the environment. Biofungicides can also be used as part of a curative spraying program in alternation with fungicides in the case of severe powdery mildew infection to reduce the residual effect of fungicides and avoid fungal resistance to fungicides as a result of recurrent spraying.

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