Scientific Papers. Series B, Horticulture. Vol. LXVIII, No. 2, 2024
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

BIOLOGICAL AND CONVENTIONAL CONTROL OF *SPHAEROTHECA FULIGINEA* PATHOGEN ON ZUCCHINI CROPS

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Abstract

Maintaining a good phytosanitary level of vegetable crops in greenhouses, it is conditioned by application of a complex of measures and means to prevent and control the attack of the pathogen and the pests present in the crops. The main objective of this experience was the control of the pathogen Sphaerotheca fuliginea on zucchini crops in organic and conventional systems, and a comparison was to be made between the efficacy of applied chemical products and the efficacy of biological products. The chemical products (Topas 100 EC 0.5/ L/ha, Amistar 1 L/ha, Cidely Top 1 L/ha, Dagonis 0.6 L/ha) had an efficacy between 73.44 and 96.33%, and the biological products (Fytosave 2 L/ha, Funres 3 L/ha, Mimoten 3 L/ha, Canelys 3 L/ha) between 20.74 and 56.90% for Diana, Perfect and Eskenderany varieties. In the zucchini crops in greenhouses, the chemical products applied in the conventional system had a much higher efficacy than the biological products.

Key words: *disease, zucchini, Sphaerotheca fuliginea, pathogen, greenhouse.*

INTRODUCTION

Powdery mildew, caused by *Sphaerotheca fuliginea* (Schlecht) Pollacci), is a major foliar disease worldwide, reducing crop quality and yield.

Powdery mildew (*Podosphaera xanthii*) is considered the most serious disease-causing yield losses, as it affects the leaves, stems and fruits of squash grown under different conditions (Hafez et al., 2018, Elsisi A., 2019).

The disease is generally controlled in commercial cucurbit crops via frequent applications of fungicides; however, heavy fungicide application has led to the development of resistant *Podosphaera xanthii* populations that can no longer be controlled by fungicides (McGrath et al., 1999). The need for new control strategies for the management of powdery mildews has led researchers and growers to explore suitable environmentally friendly alternatives or complementary to chemicals, biological control being the most investigated of these approaches (Bélanger and Labbé, 2002).

The organic management of crop diseases, such as powdery mildew in squash, is extremely important in order to ensure global food security, to reduce pesticide applications and GHG emissions, to maintain sustainable production practices, and to minimize the vulnerability of farmers to the negative impacts of climate change (El Chami D., 2020; El Chami et al., 2020; Frem et al., 2022).

Plant resistance inducers, also referred to as elicitors, are agents that confer improved protection to pathogen or pest attacks by inducing host defence mechanisms (Siah A. et al. (2018). COS-OGA, a novel oligosaccharidic elicitor, induced a large reduction in the severity of powdery mildew on cucumber crops (Van Aubel et al., 2014).

Sodium bicarbonate can be a safe and effective organic bio-agent for the control of powdery mildew in squash plants (Frem et al., 2022). The inhibitory effectiveness of phosphate and potassium salts makes them useful biocompatible fungicides and possibly ideal foliar fertilizers for disease control in the greenhouse (Reuveni et al., 1996). Foliar applications of potassium silicate reduce severity of powdery mildew on cucumber, muskmelon, and zucchini squash (Menzies et al., 1992).

MATERIALS AND METHODS

The main purpose of this experience was the control of pests in the zucchini squash crop in conventional and organic system, to make a

comparison between the effectiveness of chemical and biological products.
The biological material is represented by three cultivars: Diana, Perfect and Eskenderany, which were planted on August 8, 2023. To the crop in the conventional system, 3 treatments were applied, at intervals of 10 days, as follows: August 25 (T1), September 4 (T2) and September 14 (T3). To the crop in the biological system, during the vegetation period, 5 treatments were applied, at intervals of 5 days, as follows: August 25 (T1), August 30 (T2), September 5 (T3), September 11 (T4)) and September 15 (T5).
In the conventional system, a bifactorial experience was organized that includes 5 experimental variants, laid out according to the method of randomized blocks, as follows:
1. Topas 100 EC (penconazole 100 g/L, local systemic, translaminary) 0.5 L/ha;
2. Amistar (azoxystrobin 250 g/L, local systemic, translaminary) 1 L/ha;
3. Cidely Top (difenoconazole 125 g/L + cyflufenamid 15 g/L, local systemic, translaminary) 1 L/ha;
4. Dagonis (fluxapyroxad 75 g/L + difenoconazole 50 g/L, local systemic, translaminary) 0.6 L/ha;
5. Untreated control.
Products with a very short break time until harvesting (3 days) were chosen, because in protected areas harvesting is done much more often than in the field.
In the ecological system, the experience also includes 5 experimental variants, arranged according to the method of randomized blocks, as follows:
1. Fytosave (COZ-OGA) 2 L/ha;
2. Funres (Mimosa tenuifolia and citrus extract) 3 L/ha;
3. Mimoten (Mimosa tenuifolia 80% extract + 1.95% Zn + 0.05% Mo) 3 L/ha;
4. Canelys (cinnamon extract) 3 L/ha;
5. Untreated control.
Observations and determinations were made on the leaves (3 plants/variant) regarding the frequency and intensity of the *Sphaerotheca fuliginea* pathogen, based on which the degree of attack and the effectiveness of the products were calculated. Final observations were made on September 22, 2023.

Climate data monitoring in greenhouse was done with the help of thermohygrometer, which recorded air temperature and humidity at hourly intervals.
The high temperatures from July to September, associated with low atmospheric humidity (50.9-56.9%), have created very favorable conditions for the appearance and evolution of the powdery mildew attack on zucchini squash crops in greenhouse (Figure 1).

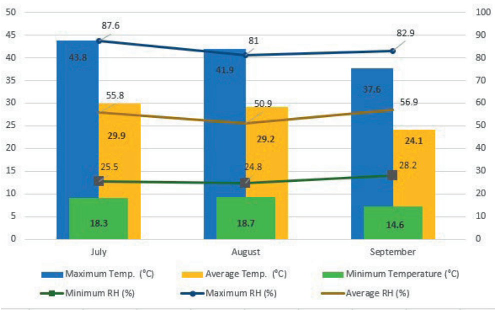

Figure 1. High plastic tunnel climate data for the period July - September 2023

RESULTS AND DISCUSSIONS

The Diana zucchini variety, the best results were obtained when applying the Dagonis product with an effectiveness of 96.33% on the upper part of the leaves and 83.67% on the lower part (Table 1, Figure 2). The untreated control showed a very strong powdery mildew attack with a frequency of 75%, intensity of 87.96% and an attack degree of 65.97% (Figure 3).

Figure 2. Squash plant, Diana variety treated with Dagonis product

Figure 3. Untreated control, Diana variety

Table 1. Efficacy of products to control the pathogen *Sphaerotheca fuliginea*, in the squash crop in the conventional system, Diana variety

Var.	The product	Dose / ha (L/ha)	Attack frequency (%)	The intensity of the attack (%)	The degree of attack (%)	Efficacy (%)
			The upper part of the leaf			
1	Topas 100EC	0.5	55.00c	27.90b	15.34b	76.74
2	Amistar	1.0	51.53cd	28.43b	14.64b	77.80
3	Cidely Top	1.0	53.63d	18.57c	9.95c	84.88
4	Dagonis	0.6	60.00b	4.04d	2.42d	96.33
5	Untreated control	-	75.00a	87.96a	65.97a	-
			The underside of the leaf			
1	Topas 100EC	0.5	47.59bc	18.69c	8.89b	83.37
2	Amistar	1.0	47.69bc	25.00b	11.92b	77.71
3	Cidely Top	1.0	50.60b	19.25c	9.74b	81.78
4	Dagonis	0.6	41.14c	21.25c	8.73b	83.67
5	Untreated control	-	69.44a	77.00a	53.47a	-

And in the varieties Perfect and Eskenderany, the best results were obtained when applying the Dagonis product with an effectiveness of 91.77% on the upper part of the leaves (Table 2, Figure 4) in the Perfect variety, respectively 91.84% in the Eskenderany variety (Table 3, Figure 6). The untreated control showed a very strong attack of powdery mildew, with a degree of attack of 58.74% (Figure 5) in the Perfect variety and 66.6% in the Eskenderany variety (Figure 7).

In the case of the crop in the conventional system, analyses were made on the squash fruits to determine the content of pesticide residues. In this sense, 10 samples were collected, one for each treated variant, which were sent to the National Phytosanitary Authority for analysis.

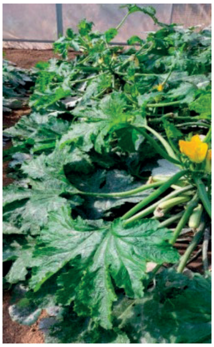

Figure 4. Squash plant, Perfect variety treated with Dagonis product

Figure 5. Untreated control, Perfect variety

Table 2. Efficacy of products to combat the pathogen *Sphaerotheca fuliginea*, in the squash crop in the conventional system, Perfect variety

Var.	The product	Dose / ha (L/ha)	Attack frequency (%)	The intensity of the attack (%)	The degree of attack (%)	Efficacy (%)
			The upper part of the leaf			
1	Topas 100EC	0.5	45.38c	24.41bc	11.07bc	81.15
2	Amistar	1.0	50.00b	31.25b	15.60b	73.44
3	Cidely Top	1.0	45.45c	18.30c	8.31bc	85.85
4	Dagonis	0.6	46.70c	10.35d	4.83c	91.77
5	Untreated control	-	65.00a	90.38a	58.74a	-
			The underside of the leaf			
1	Topas 100EC	0.5	31.53b	21.31b	6.71	79.34
2	Amistar	1.0	35.00b	18.72	6.55	79.50
3	Cidely Top	1.0	30.25b	15.95	4.82	85.16
4	Dagonis	0.6	31.90b	15.30	4.88	84.97
5	Untreated control	-	60.00a	54.16a	32.49	-

Table 3. Efficacy of products to combat the pathogen *Sphaerotheca fuliginea*, in the squash crop in the conventional system, Eskenderany variety

Var.	The product	Dose / ha (L/ha)	Attack frequency (%)	The intensity of the attack (%)	The degree of attack (%)	Efficacy (%)
The upper part of the leaf						
1	Topas 100EC	0.5	41.10c	35.35b	14.52bc	78.20
2	Amistar	1.0	48.27b	36.07b	17.41b	73.85
3	Cidely Top	1.0	36.66c	31.78b	11.65c	82.51
4	Dagonis	0.6	35.29c	15.41c	5.43d	91.84
5	Untreated control	-	70.37a	94.73a	66.60a	-
The underside of the leaf						
1	Topas 100EC	0.5	38.23bc	14.61b	5.58b	80.80
2	Amistar	1.0	44.82b	14.92b	6.67b	77.05
3	Cidely Top	1.0	61.90a	11.23b	6.95b	76.09
4	Dagonis	0.6	32.35c	12.73b	4.11b	85.86
5	Untreated control	-	66.67a	43.61a	29.07a	-

Figure 6. Squash plant, Eskenderany variety treated with Dagonis product

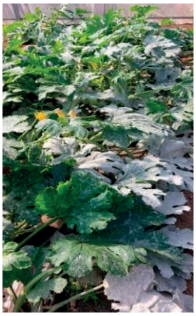

Figure 7. Untreated control, Eskenderany variety

The results of the analyzes showed that the samples comply with the provisions of Regulation (EC) 396/2005 with subsequent amendments and additions, regarding the analyzed pesticide residues.

In the squash crop, the 4 biological products: Fytosave, Funres, Mimoten and Canelys, showed lower biological effectiveness compared to the chemical products.

In the Diana variety, on the upper part of the leaves, the effectiveness of the products varied between 39.64% (Canelys) and 50.1% (Funres), in the conditions of a very strong degree of attack in the control 68.22% (Table 4). With the Perfect variety, the best results were obtained, with more than 56% effectiveness in the variants treated with Fytosave and Funres (Table 5).

In the Eskenderany variety, the lower results were obtained, with an effectiveness of over 30% in the case of the variants where the biological products Fytosave, Funres and Mimoten were applied (Table 6).

In the squash crops in greenhouses, the chemical products applied in the conventional system had a much higher effectiveness than the biological products (Figures 8, 9 and 10).

Table 4. Biological control of the *Sphaerotheca fuliginea* pathogen, in Diana variety squash crop

	Variant	Attack frequency (%)	The intensity of the attack (%)	The degree of attack (%)	Efficacy (%)
The upper part of the leaf					
1	Fytosave	68.00b	57.37c	38.94b	42.91
2	Funres	53.16c	64.09b	34.04b	50.10
3	Mimoten	56.00c	68.65b	38.33b	43.81
4	Canelys	66.66b	61.78bc	41.18b	39.64
5	Untreated control	81.55a	79.74a	68.22a	-
The underside of the leaf					
1	Fytosave	66.00b	26.51b	17.42b	37.89
2	Funres	50.63c	26.37b	13.35b	52.59
3	Mimoten	54.67c	28.90b	15.79b	43.92
4	Canelys	64.28b	18.61c	11.96b	57.52
5	Untreated control	85.55a	32.92a	28.16a	-

Table 5. Biological control of the *Sphaerotheca fuliginea* pathogen, in Perfect variety squash crop

	Variant	Attack frequency (%)	The intensity of the attack (%)	The degree of attack (%)	Efficacy (%)
		The upper part of the leaf			
1	Fytosave	63.33b	40.05c	25.36c	56.82
2	Funres	62.06b	40.83c	25.27c	56.90
3	Mimoten	70.37a	42.30c	29.76b	49.33
4	Canelys	64.51b	46.75b	30.15b	48.87
5	Untreated control	72.22a	81.34a	58.74a	-
		The underside of the leaf			
1	Fytosave	33.33bc	11.00c	3.66b	50.13
2	Funres	37.93b	14.54b	5.51b	24.93
3	Mimoten	31.85c	13.64b	4.34b	40.87
4	Canelys	42.38a	13.00b	5.51b	24.93
5	Untreated control	35.6b	20.62a	7.34a	-

Table 6. Biological control of the *Sphaerotheca fuliginea* pathogen, in Eskenderany variety squash crop

	Variant	Attack frequency (%)	The intensity of the attack (%)	The degree of attack (%)	Efficacy (%)
		The upper part of the leaf			
1	Fytosave	56.52b	73.07bc	41.29c	32.69
2	Funres	55.55b	68.66c	38.14c	37.82
3	Mimoten	57.89b	82.95b	48.01b	20.74
4	Canelys	48.38c	82.50b	39.91c	34.94
5	Untreated control	63.63a	96.42a	61.35a	-
		The underside of the leaf			
1	Fitosave	43.47b	14.50b	6.30b	49.27
2	Funres	37.03c	13.00b	4.84c	61.12
3	Mimoten	47.36a	15.27b	7.23b	41.78
4	Canelys	30.64d	14.73b	4.53c	63.52
5	Untreated control	42.42b	29.28a	12.42a	-

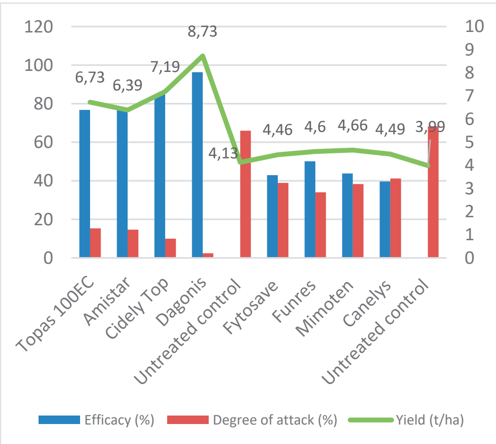

Figure 8. Efficacy of conventional and biological products and yield, Diana

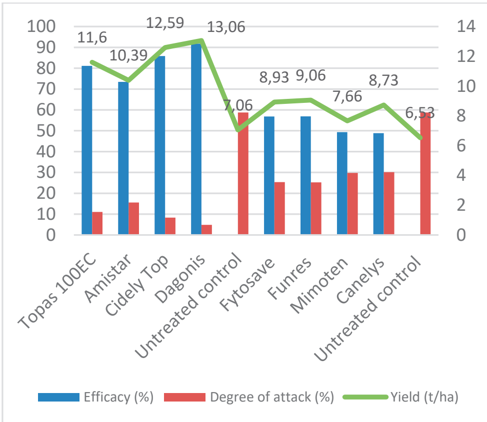

Figure 9. Efficacy of conventional and biological products and yield, Perfect

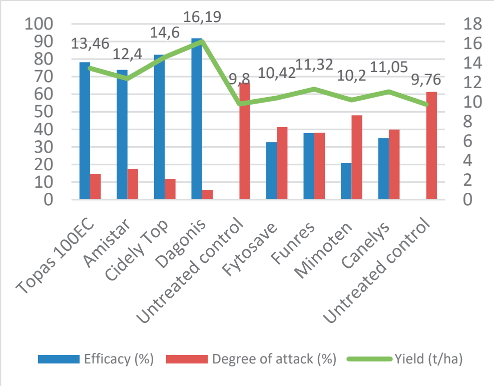

Figure 10. Efficacy of conventional and biological products on yield, Eskenderany

Between the degree of attack and yield there is a negative correlation, distinctly significant in the conventional system (-0.964, Perfect variety) and biological (-0.965, Diana variety). Significant negative correlation in conventional system (-0.932, Diana variety, -0.902, Eskenderany variety) and biological (-0.904 Perfect variety, -0.886, Eskenderany variety).

CONCLUSIONS

1. The biological products (Fytosave 2/ha, Funres 3 l/ha, Mimoten 3 l/ha, Canelys 3 l/ha), used to control the pathogen *S. fuliginea* had a much lower effectiveness compared to the chemical control products (Topas 100 EC 0.5/ l/ha, Amistar 1 l/ha, Cidely Top 1 l/ha, Dagonis 0.6, l/ha), used in conventional system;
2. In the conventional system, the best results were obtained when applying the Dagonis product (fluxapiroxad 75 g/l + difenoconazole 50 g/l) 0.6 l/ha, with an effectiveness of over 90% in Diana, Perfect varieties and Eskenderany;
3. The biological products had an average effectiveness between 48.27% in the case of the application of the Funres product (*Mimosa tenuifolia* extract 60% and citrus 20%) and 37.96% for Mimoten (*Mimosa tenuifolia* extract 80% + 1.95% Zn + 0.05% Mo).

ACKNOWLEDGEMENTS

This research work was carried out with the support of Ministry of Agriculture and Rural Development, financed from Project ADER 6.3.15/2023 - Integrated management for the control of pest agents in the main vegetable species grown in greenhouses in conventional and organic systems.

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