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BIOLOGICAL CONTROL OF MAIN DISEASES AND PESTS ON MELON CROPS IN THE FIELD

Gabriela ŞOVĂREL, Ion SCURTU, Simona HOGEA, Gicuța SBÎRCIOG

Research Development Institute for Vegetable and Flower Growing Vidra,
22 Calea București Street, Vidra, Ilfov County, Romania

Corresponding author email: gabriela_sovarel@yahoo.com

Abstract

The main foliar diseases of melons, Pseudoperonospora cubensis and Sphaerotheca fuliginea, have a negative impact on fruit yield and quality. Also, in warm and dry summer, the mites (Tetranychus urticae) caused significant damages on melons crop in the field. This experiment aimed to study the efficacy of biological plant protection products for the control of mites, powdery and downy mildew on melons crops in field. The experiment includes 2 fungicides for downy mildew based on aluminum fosetyl, Mimosa tenuiflora extract and citrus, 2 biological fungicides for powdery mildew, based on Bacillus amyloliquefaciens Bacillus pumilus and 4 biological products used to mites control, based on potassium salts, mixture of terpenoids, cinnamon extract and saponified oil extract from Neem tree. The biological products had efficacy between 56.25 and 88.25% in the control of the adult mite T. urticae, 47.02-66.48% on P. cubensis and 71.25-84.76% on S. fuliginea. It is concluded that it is possible to grow melon in an organic way using these biological products for controlling the main diseases and pest on melons crop in the field.

Key words: *pathogen, mite, downy mildew, powdery mildew, Tetranychus urticae.*

INTRODUCTION

The cultivation of melons occupies an important area in Romania, with 4250 ha and 62900 tons production. In 2020, in Europe, our country ranks 4th in terms of area after Italy, Spain and France and 6th in terms of yield after Spain, Italy, France, Portugal and Greece (FAO, 2020).

The main foliar diseases of melons, *Pseudoperonospora cubensis* (Berk. & M.A. Curtis) Rostovzev and *Sphaerotheca fuliginea* (Schlecht. Fr.) Pollacci, have a negative impact on fruit yield in Romania (Velichi, 2009; Sovarel et al., 2019), USA (Colucci and Holmes, 2010; Savory et al., 2011; Ojiambo et al., 2015), Europe and Asia. Also, in warm and dry summer, the mites (*Tetranychus urticae*) caused significant damages on melons crop in the field. The antagonists *Trichoderma viride*, *Gliocladium virens, Enterobacter cloacae*, saprofitic *Phytium olygandrum* can be used for seed treatment, soil introduction, pouring and sprays of plants for control of same important diseases on vegetable crops in protected facilities (Krasteva and Panayotov, 2009).

Serenade (*Bacillus subtilis* strain QST 713) are good efficacy (87%) on bacterial spot disease on greenhouse pepper (Sević et al., 2016).

Bacillus subtilis (B1) were effective against four major postharvest pathogens of muskmelon: *Alternaria alternata, Fusarium semitectum, Rhizopus stolonifer* and *Trichothecium roseum* (Yang et al., 2006).

Isolate T39 of *Trichoderma harzianum* is a biocontrol agent which controls the foliar pathogens, *Botrytis cinerea, Pseuperonospora cubensis, Sclerotinia sclerotiorum* and *Sphaerotheca fusca* (syn. *S. fuliginea*) in cucumber under commercial greenhouse conditions (Elad, 2000).

Trichoderma aggressivum f. *europaeum* TAET1 isolates inhibited *Botrytis cinerea, Sclerotinia sclerotiorum* and *Mycosphaerella melonis* growth by 100% in detached leaves assay and inhibited germination of *S. sclerotiorum* sclerotia (Sánchez-Montesinos et al., 2021).

Paecilomyces variotii is a potential biological control agent to be used against several aerial and soil diseases, thus it should be integrated into modern pest management strategies (Moreno-Gavira et al., 2021).

Powdery mildew incidence is reduced by soil surface applications with organic bio-fertilizer and organic materials such as wheat straw, and by foliar sprays with a fermented garlic preparation (Qin et al., 2011).

Tetranychus urticae Koch known as two-spotted spider mite is a polyphagous pest, has over than 200 host plant species (Kheradpir et al., 2007) and causes important economic loss all over the world (Abdallah, 2015). In Romania this pest attacks crops like eggplants, peppers, cucumbers, beans, tomatoes etc. (Călin et al., 2017). The mites are found on the underside of the leaf, where they feed by stinging and after the attack the leaves turn yellow and dry out (Camps et al., 2014).

Because it has a fast growth rate, a short life cycle and a high reproduction rate, it can very quickly reach a very high population density, leading to a qualitative depreciation of plants and a decrease in yields (Hanash et al., 2020).

There are many disadvantages to applying chemical acaricides, such as the development of resistance by the pest, damage to natural predators, phytotoxicity, environmental pollution and risks to human health (Gaber and Nasr, 2020). In order to reduce the populations of this pest and the need for pesticides, alternative control measures such as the application of biopesticides may be taken (Golec et al., 2020).

Biopesticides are control products with microbial, botanical, mineral or synthetic origin (Golec et al., 2020) with low mammalian toxicity, short persistence in the environment, safety for beneficial organisms, lack of harvest and re-entry restrictions and minimal risk for the development of resistance (Marcic et al., 2012).

MATERIALS AND METHODS

The experience was conducted in the field at the Research Development Institute for Vegetable and Flower Growing Vidra, in 2020. Planting was made on 2 June, using romanian melon (*Cucumis melo*) variety 'Festiv', sensitive to *Pseudoperonospora cubensis* and *Sphaerotheca fuliginea* pathogens. The experiment includes 2 fungicides for downy mildew based on aluminum fosetyl 800 g kg^{-1} (2 kg ha^{-1}), check treated with chemical product), *Mimosa tenuiflora* extract 60% and citrus extract 20% (3 L ha^{-1}), 2 biological fungicides for powdery mildew, based on *Bacillus amyloliquefaciens* strain FZB24 (0.37 kg ha^{-1}), *Bacillus pumilus* strain QST 2808 (10 L ha^{-1}) and 4 biological products used to mites control, based on potassium salts of C7-C20 fatty acids (16 Lha^{-1}), mixture of terpenoids QRD 460 (10 L ha^{-1}), cinnamon extract (3 L ha^{-1}) and saponified oil extract from Neem tree 40% (3 L ha^{-1}).

The experiment for pathogen control consists on 4 variants treated and check control.

1. Aluminum fosetyl 800 g kg^{-1}(2 kg ha^{-1}) + *B. amyloliquefaciens* strain FZB24 (0.37 kg ha^{-1})
2. Aluminum fosetyl 800 g kg^{-1} (2 kg ha^{-1}) + *B. pumilus* strain QST 2808 (10 L ha^{-1})
3. *M. tenuiflora* extract 60% and citrus extract 20% (3 L ha^{-1}) + *B. amyloliquefaciens* strain FZB24 (0.37 kg ha^{-1})
4. *M. tenuiflora* extract 60% and citrus extract 20% (3 L ha^{-1}) + *B. pumilus* strain QST 2808 (10 L ha^{-1})
5. Check control.

Six foliar treatments were applied at 7 days intervals, first application was made before natural infection.

Observations have been made on the appearance and evolution of pathogens attack *S. fuliginea* and *P. cubensis*. The assessment parameters are diseases incidence (DI) - % infected leaves and severity of attack (SA) - % area infected of leaves. There were calculated: degree of attack (DA %) = (DI x SA)/ 100 and efficacy (E %) with Abbott formula (E= (1- DA treated/DA check) x 100. Sample /plot 100 leaves, natural field infection. Data were analysed using analysis of variance (ANOVA) and the means were separated by using Duncan's multiple range tests at P = 0.05.

To control the two-spotted spider mite to a melon crop in field were applied treatments every 7 days, with products (biopesticides) based on potassium salts of fatty acids C7-C18 479.8 g L^{-1} (47.98%), mixture of terpenoids QRD 460 which is based on natural extract from *Chenopodium ambrosioides* 152.3 g L^{-1} (15.23%), cinnamon extract 70% and saponified oil extract from *Neem* tree 40%. The EPPO standard PP1/037(2) was applied to count the pest. The number of eggs, nymphs and adults was recorded separately on three pre-marked plants assess at least 50 cm^2 leaf surface infested areas (by cutting 25 discs 1.5 cm in diameter). Analysis of variance was calculate using ANOVA and the effectiveness of the products using Abbott`s formula.

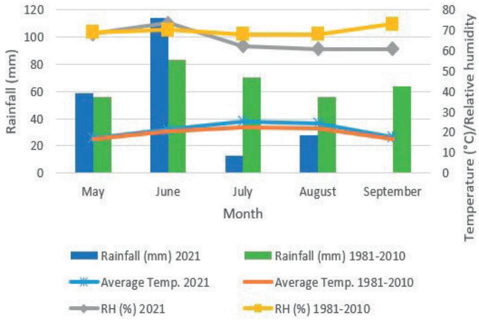

Figure 1. Average monthly temperature, relative humidity and rainfall between 1981 and 2010 and during 2021

Meteorological data during the growth season in 2021 and between 1981 and 2010 are presented in Figure 1. The average temperatures in 2021 were close to the multiannual average of 1981-2010. The rainfall deficit from July to September of 2021 (149 mm) determined a lower atmospheric humidity than the average from 1981-2010.

RESULTS AND DISCUSSIONS

The incidence of *P. cubensis* is lower on the variant treated with Aluminum fosetyl 800 g kg^{-1} (2 kg ha^{-1}) than *M. tenuiflora* extract 60% + citrus extract 20% (3 L ha^{-1}). All leaves studied on check control were attacked by this pathogen, with 100% incidence and 38.35% severity. The diseases incidence on treated variants varied between 57.76% (Aluminum fosetyl 800 g kg^{-1} (2 kg ha^{-1}) and 89.95% (*M. tenuiflora* extract 60% + citrus extract 20% (3 L ha^{-1}) (Table 1). The severity of attack on the treated variants varied between 19.97% (Aluminum fosetyl 800 g kg^{-1}) (2 kg ha^{-1}) and 22.58% (*M. tenuiflora* extract 60% + citrus extract 20%) (3 L ha^{-1}). Efficacy of product based on Aluminum fosetyl 800 g kg^{-1} (2 kg ha^{-1}) is higher than *M. tenuiflora* extract 60% + citrus extract 20% (3 L ha^{-1}).

The incidence and severity of *S. fuliginea* has the lowest value (16.68%, respectively 16.17%) on variants treated with *B. pumilus* strain QST 2808 (10 L ha^{-1}). The incidence of disease is high (53,0%) and severity attack (34.92%) on check control. Efficacy of products is better on variants treated with *B. pumilus* strain QST 2808 (10 L ha^{-1}) than *B. amyloliquefaciens* strain FZB24 (0.37 kg ha^{-1}).

At 14 days after the first spray all the treatments proved significantly superior over control (Table 2). Neem oil was the best treatment in reducing the eggs (5.75 eggs/50 cm^2 leaf surface) and the adults (3.75 adults/50 cm^2 leaf surface) of mites population. The best treatment in reducing nymphs of the pest was cinnamon extract (9.75 nymphs/50 cm^2 leaf surface) followed by neem oil (9.75 nymphs/50 cm^2 leaf surface).

The results of this test showed a good efficacy of neem oil in reducing eggs (90.34%) and controlling the two-spotted spider mite adults (from 68.27 to 88.28%, Table 3), as obtained Hanash et al. (2020) and Cenușă et al. (2016).

Table 1. Efficacy of some biological products for *S. fuliginea* and *P. cubensis* pathogens

	Pseudoperonospora cubensis				*Sphaerotheca fuliginea*			
Variant	DI	SA	DA	E	DI	SA	DA	E
1	57.76^{b}	22.25^{b}	12.85^{b}	66.48^{a}	18.22^{b}	23.98^{ab}	4.37^{bc}	76.38^{b}
2	73.38^{ab}	19.97^{b}	14.65^{b}	61.80^{ab}	17.44^{b}	16.17^{b}	2.82^{c}	84.76^{a}
3	89.95^{a}	22.58^{b}	20.31^{b}	47.02^{b}	22.44^{b}	23.71^{ab}	5.32^{b}	71.25^{b}
4	85.12^{ab}	20.81^{b}	17.71^{b}	53.82^{ab}	16.68^{b}	17.10^{b}	2.85^{c}	84.59^{a}
5	100.00^{a}	38.35^{a}	38.35^{a}	-	53.00^{a}	34.92^{a}	18.50^{a}	-

DI = disease incidence (%); SA = severity of disease attack (%); DA = degree of attack (%); E = Efficacy (%).
Means followed by the same letter in the same column indicates the absence of significant differences at P=0.05 by Duncan's multiple range tests.

Table 2. Average number of eggs, nymphs and adults at 3, 7 and 14 days after treatments (%)

No	Treatments	Average number of eggs, nymphs and adults after treatments (%)								
		3 days			7 days			14 days		
		eggs	nymphs	adults	eggs	nymphs	adults	eggs	nymphs	adults
1.	Potassium salts of fatty acids	27.00^{b}	19.50^{c}	9.75^{b}	24.5^{b}	14.25^{b}	10.5^{b}	16.25^{bc}	10.0^{b}	12.25^{b}
2.	Natural extract from *C. ambrosioides*	22.00^{b}	10.00^{b}	7.75^{b}	23.5^{b}	11.00^{bc}	9.25^{b}	28.00^{b}	12.5^{b}	14.00^{b}
3.	Cinnamon extract	11.00^{c}	9.75^{b}	7.50^{b}	12.25^{b}	6.75d	5.75^{bc}	14.00^{bc}	6.25^{b}	5.75^{c}
4.	Neem oil	21.00^{b}	8.50^{b}	8.25^{b}	17.5^{b}	9.00^{cd}	3.50^{c}	5.75^{c}	9.75^{b}	3.75^{c}
5.	Control	48.50^{a}	39.00^{a}	26.00^{a}	51.25^{a}	40.50^{a}	27.5^{a}	59.5^{a}	41.25^{a}	32.00^{a}

Means followed by the same letter within each column are not statistically different, LSD ($p<0.05$) according to Duncan`s multiple range test (DMRT).

Table 3. Effectiveness of biopesticides at 3, 7 and 14 days after treatments (%)

No	Treatments	Effectiveness of biopesticides after treatments (%)								
		3 days			7 days			14 days		
		eggs	nymphs	adults	eggs	nymphs	adults	eggs	nymphs	adults
1.	Potassium salts of fatty acids	44.33^{c}	50.00^{b}	65.38^{a}	52.20^{b}	64.81^{c}	61.82^{b}	72.69^{ab}	75.76^{ab}	61.72^{b}
2.	Natural extract from *Chenopodium ambrosioides*	54.64^{b}	74.36^{a}	70.19^{a}	54.15^{b}	72.84^{bc}	66.36^{b}	52.94^{b}	69.70^{b}	56.25^{b}
3.	Cinnamon extract	75.77^{a}	75.00^{a}	71.15^{a}	76.10^{a}	83.33^{a}	79.09^{c}	76.47^{ab}	84.85^{a}	82.03^{a}
4.	Neem oil	56.70^{b}	78.21^{a}	68.27^{a}	65.85^{ab}	77.78^{ab}	87.27^{a}	90.34^{a}	76.36^{ab}	88.28^{a}
5.	Control	-	-	-	-	-	-	-	-	-

Means followed by the same letter within each column are not statistically different, LSD ($p<0.05$) according to Duncan`s multiple range test (DMRT).

Table 4. Yield difference between treatments with different active ingredient for controlling *P. cubensis* and *S. fuligiena* on melons

No.	Active ingredient	Yield (t ha^{-1})
1.	Aluminum fosetyl 800 g kg^{-1} (2 kg ha^{-1}) + *B. amyloliquefaciens* strain FZB24 (0.37 kg ha^{-1})	28.32^{c}
2.	Aluminum fosetyl 800 g kg^{-1} (2 kg ha^{-1}) + *B. pumilus* strain QST 2808 (10 L ha^{-1})	28.86^{c}
3.	*M. tenuiflora* extract 60% and citrus extract 20% (3 L ha^{-1}) + *B. amyloliquefaciens* strain FZB24 (0.37 kg ha^{-1})	26.31^{b}
4.	*M. tenuiflora* extract 60% and citrus extract 20% (3 L ha^{-1}) + *B. pumilus* strain QST 2808 (10 L ha^{-1})	25.45^{b}
5.	Check control	21.36^{a}

Means followed by the same letter within each column are not statistically different, LSD ($p<0.05$) according to Duncan`s multiple range test (DMRT).

Table 5. Yield obtained (t ha^{-1}) at variants with products for *T. urticae*

No.	Active ingredient	Yield (t ha^{-1})
1.	Potassium salts of fatty acids	24.99^{bc}
2.	Natural extract from *Chenopodium ambrosioides*	23.97^{b}
3.	Cinnamon extract	26.10^{c}
4.	Neem oil	29.03^{d}
5.	Control	20.64^{a}

Means followed by the same letter within each column are not statistically different, LSD ($p<0.05$) according to Duncan`s multiple range test (DMRT).

Cinnamon extract had a efficacy of 82.03%, followed by variant with pottasium salts of fatty acids (61.72%). The lowest effectiveness in controlling the mite adults was registered at the variant with natural extract from *Chenopodium ambrosioides* (56.25%). The best efficacy in reducing nymphs was registered at variant with cinnamon extract (84.85%) followed by neem oil (76.36%).

The yield obtained had the highest values at variants with aluminum fosetyl + *B. pumilus* strain QST 2808 (28.86 ha^{-1}), followed by the Aluminum fosetyl (28.32 ha^{-1}) + *B. amyloliquefaciens* strain FZB24 (0.37 kg ha^{-1}) compared to check control (21.36 t ha^{-1}) (Table 4).

Regarding the yield obtained, at all 4 variants good values of yields were registered in comparison with the check control (Table 5). The biggest value of yield was at variant with neem oil (29.03 t ha^{-1}) compared to check control (20.64 t ha^{-1}).

CONCLUSIONS

The biological products based on *Mimosa tenuiflora* extract 60% + citrus extract 20% (3 L ha^{-1}), *Bacillus amyloliquefaciens* strain FZB24 (0.37 kg ha^{-1}) and *Bacillus pumilus* strain QST 2808 (10 L ha^{-1}) may be used with good results for control of *Pseudoperonospora cubensis* and *Sphaerotheca fuliginea* on melon crops in the field.

Neem oil had the best efficacy in controlling eggs (90.34%) and adults (88.28%) of *T. urticae* and variant with cinnamon extract registered a good efficacy (84.85%) in reducing nymphs of the pest. The variant with natural extract of *Chenopodium ambrosioides* had a low efficacy for all stages of the pest. Also, the highest yield was recorded on the variant with neem oil (29.03 t ha^{-1}) compared to check control (20.64 t ha^{-1}).

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