

## SYNERGISM BETWEEN SOIL AND LEAF PLANT PROTECTION PRODUCTS IN GREENHOUSE CUCUMBERS AND THEIR EFFECT ON YIELD AND PHYTOSANITARY STATUS

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### Abstract

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It was studied the effect of chemical and biological plant protection products (PPP) on root rot (*Fusarium* and *Verticillium* root rot) and powdery mildew in cucumber variety Mirey F1 grown in cultivation facilities in the Maritsa Vegetable Crops Research Institute, Plovdiv during the period 2008-2010. The presence and absence of synergism in their action and an influence on the plant productivity was also studied. It was established a high effectiveness against root rot caused by *Fusarium* spp. and *Pythium* spp., in treatment of plants with Previcur 607 SL + Topsin M 70 WP and Trichodermin NPA. The last product results in yield increase with 12.09%. A synergism in the action of studied soil and leaf PPP was established. The highest effectiveness against powdery mildew was recorded in soil treatment with Previcur 607 SL + Topsin M 70 WP and leaf PPP Collis, Quadris 25 SC, Timorex 66 EC and Timorex gold.

*Key words*: root rot, powdery mildew, effectiveness, yield

### Introduction

Great number of diseases, which sometimes could result in considerable damages, attacks cucumbers grown in cultivation facilities. The root rot (agents – fungus from genera *Pythium* and *Fusarium*) has the greatest significance among the diseases caused by microscopic fungi and those living parasitically on the aboveground parts of the plants – downy mildew (*Pseudoperonospora cubensis* (Berk & Curt.) Rostow) and powdery mildew (*Podosphaera xanthii* U. Braun & N. Shish. Comb. Nov. (syn. *Sphaerotheca fuliginea*)).

Fungi from genus *Pythium* (*P. aphanidermatum* and *P. ultimum*) are the main agents of root rot in cucumbers grown in cultivation facilities. A large-scale infestation could be caused for a short period provoking wilt and in stronger development – loss of plants (Roberts et al., 2005).

The economical importance of the fungi from genus *Fusarium* increases recently and especially of *Fusarium oxysporum* Schlechtend.: Fr. f. sp. *radicis-cucumerinum* D.J. Vakilounakis (FORC) being agents of root rot *Fusarium ox-*

*ysporum*. This disease causes serious damages. Moreno et al. (2001) report for losses reaching up to 75%. Vachev describes this disease for the first time in Bulgaria in 2007. The pathogen was isolated from 21 greenhouses in our country.

Powdery mildew caused by *Podosphaera xanthii*, is one of the serious diseases on the aboveground parts of the cucumbers which in epifitoty development causes significant losses reaching 20-30% and more (Velkov, 2003; Kiss, 2003). The control of the disease is conducted by multiple treatments with great numbers of chemical products for plant protection (PPP). This might be very dangerous for human health, for environmental contamination and for creation of resistance of the pathogen to these PPP. Recently a great attention was directed to development of alternative measures and methods for control – resistant varieties, plant oils and extracts, bio-agents and bio-products etc. (Simmonds et al., 1992; Copping and Menn, 2000; Belanger and Labbe 2002; Istvan, 2002; Kiss, 2003).

The appearance of these dangerous diseases coincides in time very often. In these conditions PPP are input in the soil

and another products are applied for treatment of above-ground parts of the plants.

**Purpose of the study:** To be established the effectiveness of biological and chemical PPP used for control of the agents of root rot and powdery mildew in cucumbers grown in cultivation facilities and to establish a presence or absence of synergism in their action.

## Material and Methods

The experiments were carried out in “Maritsa” Vegetable Crops Research Institute – Plovdiv during the period 2008 – 2010.

### Effectiveness of chemical and biological PPP against *Fusarium* and *Pythium* root rot in cucumbers

The experiment was conducted in 5 l containers in vegetative chamber. Long type greenhouse variety Mirey F1 was studied in all treatments.

The inoculum was cultivated on barley and it was input in the containers before planting.

Treatments:

1. Fusaclean – The product was applied twofold: 3 g/plant immediately before planting and 2 g/plant in 7-8 leaf phase.

2. Trichodermin NPA. The product was applied twofold: 3 g/plant directly before planting and 5 g/plant in 7-8 leaf phase.

3. Irrigation with mixture of Previcur 607 SL (propamocarb hydrochloride) + Topsin M 70 WP (thiofanate-methyl) 150 ml + 100 g/100 L water. Treatment was twofold – by 50 ml/plant immediately before planting and 200 ml/plant in 7-8 leaf phase.

4. Control – with infestation – untreated.

A comparative experiment was conducted in order to be established the effect of PPP on productivity of variety Mirey F1. Harvestings were performed three times a week. The yield was recorded by central stem (kg/da).

### Synergism between soil and leaf PPP. Effectiveness of biological and chemical PPP to powdery mildew in cucumber at different soil treatment

The experiment was performed in vegetative chamber. Cucumber variety Mirey F1 was used for conducting of the tests. Plants were grown in 5 l containers.

Variants:

1. Plant treatment with soil PPP
2. Fusaclean
3. Trichodermin NPA
4. Mixture of Previcur 607 SL + Topsin M 70 WP
5. Untreated control

• Treatment of the same plants with PPP for control to powdery mildew

1. Timorex 66 EC (66% oil from *Melaleuca alternifolia*) 0,5%;

2. Timorex Gold (extract from *Melaleuca alternifolia*) – 0, 75%;

3. Collis (boskalid 200 g/l + krezoxy-methyl 100 g/l) – 0,05%;

4. Quadris 25 SC (azoxystrobin 50 g/l) – 0,075%;

5. Control untreated

Three treatments were performed. The degree of attack by powdery mildew was read in 5-marks scale (0-4, interval of 25%) before each treatment and 5 days after the last one.

### Indexes

- Degree of attack by soil pathogens in %;
- Index of attack by powdery mildew;
- Effectiveness by Abbot formula;

The particular attempts were set by block scheme in four replications with ten plants for each experiment. Data were processed by one-way, two-way and three-way analysis of variance (Dimova and Marinkov, 1999). Duncan's multiple range test and Cluster analysis by programme product SPSS 12 for Windows were applied.

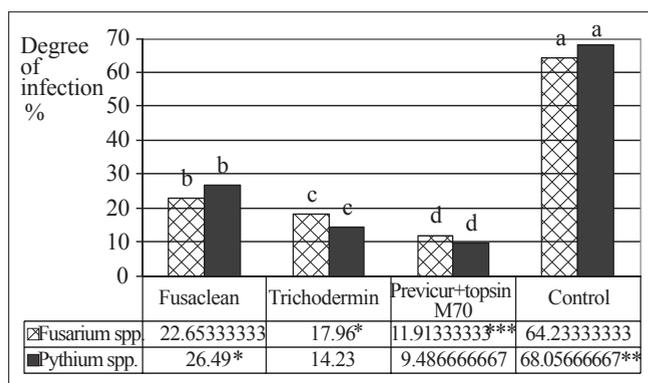
## Results and Discussion

### Effectiveness of chemical and biological PPP to *Fusarium* and *Pythium* root rot in cucumbers

Based on three-way analysis of variance was established that the factors Products (P), Pathogen (B) and their interaction (A x B) have a significant influence on the effectiveness of the studied PPP (Table 1). The effect of the factor Product ( $p < 0.001$ ) is proven very good as the power of the effect is 89.64%. The factor Pathogen has the smallest effect on the effectiveness (2.32%) but it was proven. The power of the influence of the interaction of the two factors (A x B) is 6.42% as it is proven good. These results demonstrate that there is a specific response and the effectiveness of PPP to the two pathogens depends on the applied product. The factor year (C) and interaction with the other two factors (AxC; BxC; AxBxC) have no significant influence on the effectiveness of the studied products. This demonstrates that the last ones manifest a similar effectiveness in the individual years of the study. Therefore, the result could be summarized averagely for two years period.

The degree of attack by *Fusarium* and *Pythium* root rot in cucumber variety Mirey F1 is expressed in Figure 1. The results show a considerable variation in the attack by the two pathogens. The treatment of the plants with Fusaclean has

stronger suppressing effect on the development of *Fusarium* spp. – 22.65%. The attack by *Pythium* spp. is proven stronger – 26.49 %. The application of Trichodermin and the combination Previcur 607 SL + Topsin M 70 WP cause suppression of the development of *Pythium* spp. (14.23 и 9.49%) in greater degree than with *Fusarium* spp. (17.94% and 11.91%).



**Fig. 1. Degree of attack of *Fusarium* and *Pythium* root rot in cucumber variety Mirey**  
a, b, c – Duncan’s multiple range test (p < 0,05)

A stronger attack is read after infestation with *Pythium* spp. in the control treatment.

A specific response for the individual PPP is established by the performed Duncan’s tests. The strongest effect on the two pathogens has the variant with the combination Previcur 607 SL + Topsin M 70 WP. The variant with plants treated with Trichodermin NPA has slower influence than the previous one but it is stronger towards that with Fusaclean. The control is attacked in the strongest degree by the two pathogens – 64.23% and 68.06%.

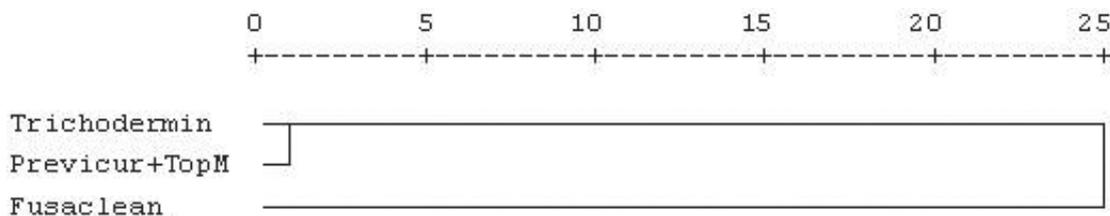
The cluster analysis made based on the effectiveness of PPP is given in the Figure 2. The dendrogram shows treatments arrangement in two basic groups of similarity. The most similar in their action are PPP Previcur 607 SL + Topsin M 70 WP and Trichodermin NPA. The product Fusaclean is grouped in specific cluster.

The results according to the performed analysis demonstrate that the effectiveness of PPP to *Fusarium* spp. и *Pythium* spp. is the highest in the products included in the first group. The obtained results correspond to those established by Hibar et al. (2006) and Rose and Punja (2004) in biocontrol of root rot in tomato and cucumbers grown in cultivation facilities (Figure 3).

**Table 1**  
**Three-way analysis of variance and influence of variation factors on the effectiveness of biological and chemical (conventional) products against *Fusarium* crown and *Pythium* root rot**

Source of variation	Degree of freedom (df)	Variance MS	Power of influence η %
Preparation (A)	2	***1323.85	89.64
Pathogen (B)	1	*68.50	2.32
Year (C)	1	9.57	0.32
A x B	2	**94.82	6.42
A x C	2	1.14	0.08
B x C	1	19.33	0.65
A x B x C	2	2.49	0.17
Within	4	2.92	0.39

- p<0.05; \*\* - p<0.01; \*\*\* - p<0.001



**Fig. 2. Hierarchical cluster analysis on the base of effectiveness of PPP. Dendrogram using Average Linkage (Between Groups)**

The yield is one of the most important indexes in conducting of comparative tests. The results from the two-way analysis of variance for the effect of the studied factors on the productivity of variety Mirey F1 are given in Table 2. The results demonstrate a significant effect of the factors product (92.74%) and year (3.00%). The interaction of the two factors is slight which shows that the specific PPP cause similar effect on the productivity of variety Mirey F1 in the two years.

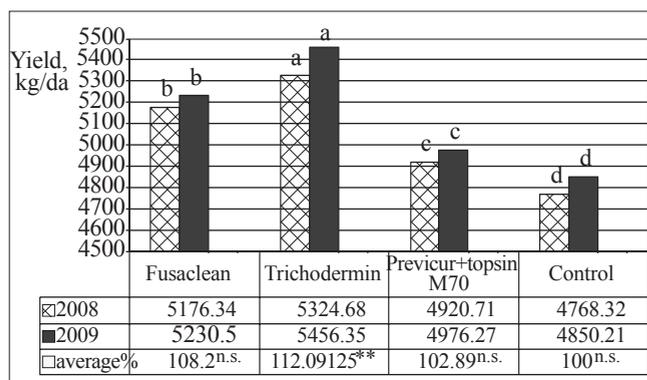


Fig. 3. Effect of soil PPP on the yield

a, b, c – Duncan's multiple range test ( $p < 0,05$ )

The results from the Duncan's test show that the highest yield is obtained in soil treated with Trichodermin, which is 112.09% towards the control. The yield is significantly lower in treatment with Fusaclean – 108.20% and the irrigation of plants with mixture of Previcur 607 SL + Topsin M 70 WP – 102.89 % has the slightest effect. The results reported confirm those announced by Altintas and Bal (2005).

The results compared by years demonstrate that only in treatment with Trichodermin NPA has proven differences. The yield is higher in 2009 towards the previous year. In 2008 it is 5324.68 kg/da and in 2009 – 5456.35 kg/da. The differences in the yields between the two years of study are insignificant in the remaining treatments.

### Synergism between soil and leaf PPP

The synergism is a phenomenon in the biology, which pre-determines supplementing of the effect from the combined action and/or interaction of two or more substances.

The establishment of synergism between soil and leaf PPP is one of the purposes in our study. It was established that the studied factors have a proven effect on the effectiveness of biological and chemical PPP against powdery mildew based on the performed three-way analysis of variance (Table 3). Strong effect exerts both the factor soil product (A) and leaf

Table 2

### Two-way analysis of variance and influence of variation factors on the yield of cv. Mirey F1

Source of variation	SS	df	MS	$\eta\%$
Products (A)	1615947	3	538648.8	***92.74
Year (B)	52254.98	1	52254.98	**3.00
A x B	7871.381	3	2623.794	0.45
Within	66315.55	24	2763.148	
Total	1742388	31		

\*\* -  $p < 0.01$ ; \*\*\* -  $p < 0.001$

Table 3

### Three-way analysis of variance and influence of variation factors on the effectiveness of biological and chemical products against powdery mildew

Source of variation	df	MS	$\eta\%$
Soil preparation (A)	3	***904.82	56.90
Foliar preparation (B)	3	***198.43	12.48
Year (C)	1	**1134.96	23.79
A x B	9	1.46	0.28
A x C	3	8.94	0.56
B x C	3	11.04	0.69
A x B x C	9	2.65	0.50
Within	27	8.47	4.79

\*\* -  $p < 0.01$ ; \*\*\* -  $p < 0.001$

product (B) and year (C). Therefore, in application of soil and leaf PPP will be observed expanding of the effect on development of powdery mildew but in individual years, the studied combinations of PPP will manifest greater or smaller effectiveness. The analysis clearly expressed that there is a synergism between the studied PPP.

The interaction between the individual factors is slight. This demonstrates that there is no specific response between the studied soil and leaf products during the specific years. Similar combinations of soil and leaf PPP will have higher effectiveness towards other combinations as it will have an effect in the two years.

The results from the tests with combined application of soil and leaf PPP is given in Table 4. The effectiveness in treatment of the plants with the soil product Fusaclean is the highest with application in combination with Collis (83.10% and 76.76%) in the two years of study.

The effectiveness is lower in 2009 in combination with Quadris compared with Collis but in 2010, the differences are not proven. The effectiveness is the lowest in combination Fusakean + Timorex 66 EC and Timorex gold in the two years of study. Averagely for the two years, the effectiveness of the combination Fusakean with Collis and Quadris 25 SC is proved the highest.

After treatment of plant with the soil product Trichodermin NPA the combinations with Timorex gold, Collis and Quadris 25 SC demonstrate the highest effectiveness. Proved lower effectiveness was established after treatment with Timorex 66 EC.

The treatment of the plants with Previcur 607 SL + Topsin M 70 WP causes increase of the effectiveness of leaf products as a whole but the effectiveness is proved the highest in PPP Collis (90.21%; 86.43%; 88.33%) and Quadris (89.07%; 85.02%; 87.05%). Timorex gold shows lower effectiveness (86.90%; 82.86%; 84.89%). The lowest effectiveness was read with Timorex 66 EC (85.53%; 79.74%; 82.64%).

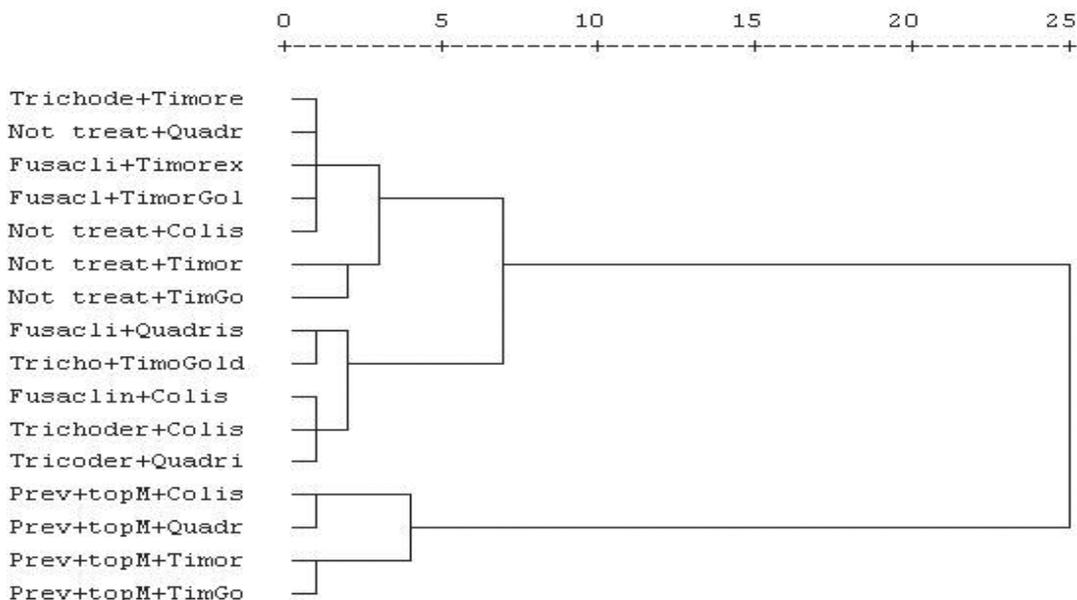
In the variants free of treatment with soil products in 2009, the highest effectiveness showed the products Collis and Quadris 25 SC and lower – Timorex 66 EC and Timorex gold. In 2010, the difference in effectiveness of the studied PPP is unproven. The highest effectiveness possess the products Collis (75.37%), Quadris 25 CK (74.60 %) and Ttimorex gold (72.48%) averagely for the two years.

A cluster analysis was made in order to be established the similarity in the action of the studied combinations of PPP (Figure 4). The dendograma classified the studied PPP combinations in three basic clusters. The first cluster includes the combinations Previcur 607 SL + Topsin M 70 WP with the leaf products Collis, Quadris 25 SC, Timorex 66 EC and Timorex gold. The second cluster contains combinations of PPP Trichodermin NPA with Quadris 25 SC, Collis, Timorex gold and Fusaclean with Collis and Quadris 25 SC. The third cluster combines all remaining combinations, which possess the greatest index of attack by powdery mildew. It contains the variants free of treatment with soil product and those with participation of the leaf PPP Timorex 66 EC and Timorex gold. The results show that the greatest synergism in their ac-

**Table 4**  
**Effectiveness of different biological and chemical PPP to powdery mildew**

Soil preparation	Foliar product	2009		2010		Average	
Fusaclean	Timorex	78.27	b	69.05	b	73.66	b
	Timorex gold	77.13	b	73.44	ab	75.29	b
	Collis	83.10	a	76.76	a	79.94	a
	Quadris	80.06	b	74.09	ab	77.08	ab
Trichodermin	Timorex	78.31	b	70.42	b	74.37	b
	Timorex gold	80.50	ab	73.24	ab	76.87	ab
	Collis	82.36	a	78.16	a	80.26	a
	Quadris	82.00	a	76.24	a	79.12	a
Previcur+topsin M 70 WP	Timorex	85.53	c	79.74	b	82.64	c
	Timorex gold	86.90	bc	82.86	ab	84.89	bc
	Collis	90.21	a	86.43	a	88.33	a
	Quadris	89.07	ab	85.02	a	87.05	ab
Untreated Soil	Timorex	74.32	c	66.37	n.s.	70.35	b
	Timorex gold	75.92	bc	69.05	n.s.	72.48	ab
	Collis	78.70	a	72.03	n.s.	75.37	a
	Quadris	77.50	ab	71.69	n.s.	74.60	a

a. b. c – Duncan’s multiple range test ( $p < 0.05$ ); n.s. – not significant



**Fig. 4. Hierarchical cluster analysis on the base of degree of infection. Dendrogram using Average Linkage (Between Groups)**

tion against powdery mildew possesses the combinations of PPP classified in the first cluster.

## Conclusion

The highest effectiveness against root rot in cucumbers caused by *Fusarium spp.* and *Pythium spp.* demonstrate the treatment of plants with mixture of Previcur 607 SL + Topsin M 70 WP followed by the treatment with Trichodermin NPA. Trichodermin NPA applied twofold in the soil proven increases the yield in cucumber variety Mirey F1.

It was established a synergism between the studied soil and leaf PPP.

The highest effectiveness against powdery mildew is achieved by the application of the soil products Previcur 607 SL + Topsin M 70 WP and leaf PPP Collis, Quadris 25 SC, Timorex 66 EC and Timorex gold.

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