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PATHOGENS WITH ECONOMIC IMPORTANCE FOR TOMATO CROPS GROWING IN THE FIELD AND THEIR CONTROL

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Abstract

During 2017, at the RDIFG Vidra, was organized a bifactorial experience, placed on the subdivision parcels method, with 12 variants and 4 repetitions, using Pontica 102 tomato variety. During the growing period on tomatoes have been identified following pathogens on foliage: Pseudomonas syringae pv. tomato, Xanthomonas campestris pv. vesicatoria, Alternaria porri f. sp. solani, Fulvia fulva and Phytophthora infestans. Their attack has influenced production in terms of quantity and quality. In order to reduce yield losses, different treatment variants were tested using the following fungicide-bactericids: copper hydroxide 50% (Copper Max 50 WP 0.25%), chlorothalonil 500 g/l (Bravo 500 SC 0.2%), azoxystrobin 200 g/l - difenoconazole 125 g/l (Ortiva Top 0.1%), iprovalicarb 8.4% + Cu of oxychloride 40% (Melody Compact 49 WG 0.2%), difenoconazole 250 g/l (Score 250 SC 0.05%), copper hydroxide with 50% metallic Cu (Champ 77 WG 0.25%), metiram 80% (Polygram DF 0.2%), dimethomorph 9% + mancozeb 60% (Acrobat MZ 69 WG 0.2%), mefenoxam 4% + macozeb 64% (Ridomil Gold MZ 68 WG 0.25%), mancozeb 80% (Dithane M 45 WP 0.2%). Foliar fertilizers have also been used Crop Max 0.3%, Agroleaf Power Total (20.20.20) 0.5% and Agroleaf Power HK (15.10.31) 0.5%.

Key words*: pathogens, Pseudomonas syringae* pv. *tomato, Xanthomonas campestris* pv. *Vesicatoria.*

INTRODUCTION

From the vegetable species, tomatoes (*Lycopersicon esculentum* Mill.) represent the largest area of culture.

Thus, in 2014, tomatoes occupied an area of 5 million hectares worldwide, with an average production of 33,988 t/ha (FAO, 2014).

Alternaria spp. colonizes different plant species with unfavorable effects on production, both quantitatively and qualitatively (Cristea, 2005).

An important incidence of *Alternaria* spp. was also reported on the seeds of certain species of crop plants (Cristea et al., 2008; Cristea (Manole) et al., 2015; Dudoiu et al., 2016; Gruia et al., 2016; Manole (Cristea) et al., 2015; Mardare et al., 2014; Pana et al., 2014). Research on the influence of abiotic factors on the biological parameters of fungi belonging to the genus *Alternaria* spp. (Mardare et al., 2015; Radu et al., 2011), was also carried out, the distribution of these fungi, depending on the level of the attack (Berca et al., 2015) and their influence on some seed indicators (Cristea et al., 2013).

A particular aspect of the attack of *Alternaria* spp. is the pathogenic-enzymatic interrelation between plant species (Cozea et al., 2011).

Pathogens responsible for the occurrence of tomatoes diseases and their description are presented by Docea et al. (2012) and Gheorghies et al. (2001).

For tomato attack (*Phytophthora infestans*) in field conditions, prognosis and warning measures are recommended (Gheorghies et al., 2001). Pathogens attacking tomato crops cause considerable economic damage, which can be direct (quantitative reduction of the harvest and damage to its quality) or indirect (social or economic effects - import from other countries; Severin et al., 2001).

In tomato field crops, the following pathogens are frequently attacked: *Xanthomonas campestris* pv. *vesicatoria* (staining the leaves and blistering the fruits), *Pseudomonas syringae* pv. *tomato* (pustular fruit stain), *Alternaria*

porri f. sp. *solani* (brown spotting of the leaves or alternarioza), *Fulvia fulva* (brown hair staining) and *Phytophthora infestans* (hand) (Mandru et al., 2017).

Alternaria porri f. sp. *solani* can cause signify-cant economic damage, the main symptoms being collar rot in the basal part of the seedlings, leaf and stem stains and rotting fruit (Walker, 1952).

The reported production losses can reach 79% and have been reported in Canada, India, USA, Nigeria (Basu., 1974; Datar et al., 1981; Sherf et al., 1986; Gwary et al., 1998).

"Collar" rot occurs at a frequency of 20-40% in seedlings after planting in the field (Sherf et al., 1986).

Fulvia fulva only attacks the plant foliage, but in favorable conditions it may cause premature defoliation (Babadoost, 2011).

Attack of bacteria *Xanthomonas campestris* pv. *vesicatoria* and *Pseudomonas syringae* pv. *tomato* is favored by high atmospheric humi-dity, and is manifested on leaves and fruits, on petiole, on stems, and can also cause plant defoliation and fruit degradation (Dafna Tamir-Ariel et al., 2007).

The most dangerous attack is caused by *Phytophthora infesters* which, under favorable conditions (moderate temperatures, maximum atmospheric humidity, the presence of drops of water on the foliage and fruits) may lead to crop failure if adequate control measures are not taken (Costache et al., 2007).

For the control of these pathogens, products with different active substances are frequently used: copper hydroxide 50% (Copper Max 50 WP 0.25%), chlorothalonil 500 g/l (Bravo 500 SC 0.2%), azoxystrobin 200g/l-difenoconazole 125g/l (Ortiva Top 0.1%), iprovalicarb 8.4% + Cu of oxychloride 40% (Melody Compact 49 WG 0.2%), difenoconazole 250 g/l (Score 250 SC 0.05%), copper hydroxide with 50% metallic Cu (Champ 77 WG 0.25%), metiram 80% **(**Polygram DF 0.2%), dimethomorph 9% + mancozeb 60% (Acrobat MZ 69 WG 0.2%), mefenoxam 4% + mancozeb 64% (Ridomil Gold MZ 68 WG 0.25%), mancozeb 80% (Dithane M 45 WP 0.2%).

The research undertaken at RDIVFG Vidra, in 2017, aimed to establish treatments for the simultaneous control of pathogens present in tomato field crops.

MATERIALS AND METHODS

During 2017, at the RDIFG Vidra, it was organized a bifactorial experience, placed on the subdivision parcels method, with 12 variants and 4 repetitions, using Pontica 102 tomato variety.

Treatment variants including foliar fertilizers are presented in Table 1.

Table 1. Experimental variants

V	Foliar fertilizers	Phytosanitary tratments	June	July	August
			Treatments 1, 2	Treatments 3, 4	Treatments 5, 6
1.	A1 Crop Max 0.3%	B1	1. Copper Max 50 WP 0.25% 2. Bravo 500 SC 0.2%	3. Ortiva Top 0.1% 4. Melody Compact 49 WG 0.2% + Score 250 SC 0.05%	5. Ortiva Top 0.1% 6. Melody Compact 49 WG 0.2%
2.		B2	1. Champ 77 WG 0.25% 2. Polyram DF 0.2%	3. Ortiva Top 0.1% 4. Acrobat MZ 69 WG 0.2%+ Score 250 SC 0.05%	5. Ortiva Top 0.1% 6. Acrobat MZ 69 WG 0.2%
3.		B3	1. Copper Max 50 WP 0.25% 2. Dithane M 45 WP 0.2%	3. Ortiva Top 0.1% 4. Ridomil Gold MZ 68 WG 0.25%+ Score 250 SC 0.05%	5. Ortiva Top 0.1% 6. Ridomil Gold MZ 68 WG 0.25%
4.		B4	Ut.	Ut.	Ut.
5.	A2 Agroleaf Power Total (20.20.20) 0.5% + Agroleaf Power HK (15.10.31) 0.5%	B1	1. Copper Max 50 WP 0.25% 2. Bravo 500 SC 0.2%	3. Ortiva Top 0.1% 4. Melody Compact 49 WG 0.2% + Score 250 SC 0.05%	5. Ortiva Top 0.1% 6. Melody Compact 49 WG 0.2%
6.		B2	1. Champ 77 WG 0.25% 2. Polyram DF 0.2%	3. Ortiva Top 0.1% 4. Acrobat MZ 69 WG 0.2%+ Score 250 SC 0.05%	5. Ortiva Top 0.1% 6. Acrobat MZ 69 WG 0.2%
7.		B3	1. Copper Max 50 WP 0.25% 2. Dithane M 45 WP 0.2%	3. Ortiva Top 0.1% 4. Ridomil Gold MZ 68 WG 0.25%+ Score 250 SC 0.05%	5. Ortiva Top 0.1% 6. Ridomil Gold MZ 68 WG 0.25%
8.		B4	Ut.	Ut.	Ut.
9.	A3 (Untreated control)	B1	1.Copper Max 50 WP 0.25% 2. Bravo 500 SC 0.2%)	3. Ortiva Top 0.1% 4. Melody Compact 49 WG 0.2% + Score 250 SC 0.05%	5. Ortiva Top 0.1% 6. Melody Compact 49 WG 0.2%
10.		B2	1. Champ 77 WG 0.25% 2. Polyram DF 0.2%	3. Ortiva Top 0.1% 4. Acrobat MZ 69 WG 0.2%+ Score 250 SC 0.05%	5. Ortiva Top 0.1% 6. Acrobat MZ 69 WG 0.2%
11.		B3	1. Copper Max 50 WP 0.25% 2. Dithane M 45 WP 0.2%	3. Ortiva Top 0.1% 4. Ridomil Gold MZ 68 WG 0.25%+ Score 250 SC 0.05%	5. Ortiva Top 0.1% 6. Ridomil Gold MZ 68 WG 0.25%
12.		B4	Ut.	Ut.	Ut.

To reduce the losses caused by the attack of pathogens, the following fungicides–bactericides alone or in combination: copper hydroxide 50% (Copper Max 50 WP 0.25%), chlorothalonil 500 g/l (Bravo 500 SC 0.2%), azoxystrobin 200 g/l + difenoconazole 125 g/l (Ortiva Top 0.1%), iprovalicarb 8.4 % + Cu of oxychloride 40 % (Melody Compact 49 WG 0.2%), difenoconazole 250 g/l (Score 250 SC 0.05%), copper hydroxide with 50% metallic Cu (Champ 77 WG 0.25%), metiram 80% (Polyram DF 0.2%), dimethomorph 9% + mancozeb 60% (Acrobat MZ 69 WG 0.2%), mefenoxam 4% + mancozeb 64% (Ridomil Gold MZ 68 WG 0.25%), mancozeb 80% (Dithane M 45 WP 0.2%).

These have been established according to the sequence of pathogens, and the interval between them in correlation with climatic factors.

There were applied 6 foliar treatments at intervals of 8-17 days.

Foliar fertilizers were used: Crop Max 0.3% (4 foliar treatments at 10 days intervals), Agroleaf Power Total (20.20.20) 0.5% (3 foliar treatments at 10 days intervals) and Agroleaf Power HK (15.10.31) 0.5% (one treatment after Agroleaf Power Total).

Dynamic observations have been made on the occurrence and evolution of pathogen attack (frequency and severity of the attack) in relation to climatic factors.

The best treatment variants have been established according to the average efficacy and the obtained production.

Qualitative determinations for total dry substance, soluble dry matter, carbohydrate content and vitamin C in tomato fruits from variants A1B4 (fertilized with Crop Max foliar 0.3%), A2B4 (fertilized with Agroleaf Power Foliar Total (20.20.20) 0.5% + Agroleaf Power HK (15.10.31) 0.5% and A3B4 (untreated control).

RESULTS AND DISCUSSIONS

During 2017, in the Vidra area, the fall - summer tomato crops, the Pontica variety 102, the following pathogen attack could be seen: *Pseudomonas syringae* pv. *tomato, Xanthomonas campestris* pv. *vesicatoria, Alternaria porri* f. sp. *solani, Fulvia fulva* and *Phytophthora infestans.*

The earliest attack of *Pseudomonas syringae* pv. *tomato* (29.05.) was followed by *Xanthomonas campestris* pv. *vesicatoria* (8.06.), *Alternaria porri* f. sp. *solani* (13.06.), *Fulvia fulva* (16.06.), and *Phytophthora infestans* (20.06.).

The rise and evolution of the attack was favored by rainfall in May (71.0 mm), June (43.5 mm) and July (99.0 mm) and maximum atmospheric humidity of over 70%, so at the end the third decade of August recorded values between 8.4% (*Fulvia fulva*) and 13.7% (*Phytophthora infestans* - Table 2).

Mandru et al. (2017) also carried out research on tomato culture, which identified the following pathogens on the foliage: *Pseudomonas syringae* pv. *tomato, Alternaria porri* f. sp. *solani, Fulvia fulva* and *Phytophthora infestans.*

Symptoms produced by the pathogens on the tomato plant foliage are shown in Figures 1, 2, 3, 4 and 5.

Figure 1. Attack by *Pseudomonas syringae pv. tomato* on the foliage

Figure 2. Attack by *Xanthomonas campestris* pv. *vesicatoria* on the foliage

Figure 3. Attack by *Alternaria porri* f. sp.*solani* on the foliage

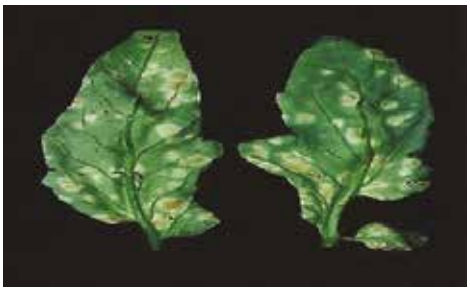

Figure 4. Attack by *Fulvia fulva* on the foliage

a) on foliage

b) on leaves

Figure 5. Attack by *Phytophthora infestans*

Table 2. Influence of climatic factors on the occurrence and evolution of pathogen attack to the tomato field crop (Vidra, 2017)

Pathogenic agents and climatic factors	Date of the attack	The degree of attack/month/decade											
		May			June			July			August		
		I	II	III	I	II	III	I	II	III	I	II	III
Pseudomonas syringae pv. *tomato*	29.05	0	0	0.2	0.5	3.3	5.2	5.8	6.4	7.9	8.5	10.1	12.2
Xanthomonas campestris pv. *vesicatoria*	8.06	0	0	0	0.3	2.7	4.6	5.2	5.8	6.7	7.0	7.9	9.5
Alternaria porri .f. sp. *solani*	13.06	0	0	0	0	0.7	4.9	5.5	7.3	8.1	10.0	11.3	12.7
Fulvia fulva	16.06	0	0	0	0	0.2	2.8	3.5	4.8	6.0	6.8	7.7	8.4
Phytophthora infestans	20.06	0	0	0	0	0.7	5.8	7.5	8.5	9.6	10.3	12.2	13.7
Temperature minimum (^{0}C)	-	10.9	10.5	12.4	15.0	14.0	16.3	15.9	15.9	17.5	21.1	18.3	15.1
Temperature average (^{0}C)	-	14.7	15.3	16.5	20.1	19.8	23.8	22.0	22.0	24.0	30.8	25.6	21.3
Temperature maximum (^{0}C)	-	19.4	20.9	21.4	27.0	26.0	31.9	28.4	28.9	31.0	36.6	31.8	28.7
Minimum relative humidity (%)	-	60.2	53.7	57.0	47.5	43.8	36.4	46.0	37.8	35.7	26.9	27.4	30.2
Average relative humidity (%)	-	70,3	63.1	66.9	59.5	56.8	56.4	57.9	47.6	46.8	36.7	38.7	41.7
Maximum relative humidity (%)	-	85.2	76.3	76.6	77.8	77.4	82.5	74.7	63.6	63.6	52.4	57.0	56.4
Precipitation (mm)	-	43.6	19.9	7.5	20.0	22.5	1.0	84.0	8.5	6.5	0	0	45.0

All variants of experiments have shown good results in controlling the pathogens *Pseudomonas syringae* pv. *tomato*, *Xanthomonas campestris* pv. *vesicatoria*, *Alternaria porri* f. sp. *solani, Fulvia fulva* and *Phytophthora infestans* (Table 3). Among them were A3B1 (E = 88.3%), A3B3 (E = 86.3%) followed by A1B1 (E = 87.4%), A1B3 (E = 85.3%), A2B1 (E = 86.3%) and A2B3 (E = 84.9%).

Table 3. Influence of phytosanitary treatments and foliar fertilizers on the attack of pathogens on field tomato culture (Vidra, 2017)

V	The degree of attack on the foil (%)						
	Pseudomonas syringae pv. *tomato*	*Xanthomonas campestris* pv. *vesicatoria*	*Alternaria porri* f. sp. *solani*	*Fulvia fulva*	*Phytophthora infestans*	Total	Effectiveness (%)
1.	1.3	1.2	1.1	1.8	1.7	7.1	87.4
2.	1.7	1.5	1.3	1.9	2.2	8.6	84.8
3.	1.5	1.4	1.4	1.5	2.5	8.3	85.3
4.	12.2	9.5	12.7	8.4	13.7	56.5	-
5.	1.5	1.4	1.4	2.0	2.4	8.7	86.3
6.	1.9	1.7	1.5	2.1	2.9	10.1	84.1
7.	1.8	1.6	1.7	1.7	2.8	9.6	84.9
8.	13.7	10.7	14.1	9.9	15.2	63.6	-
9.	1.0	0.9	0.8	1.5	1.9	6.1	88.3
10.	1.5	1.3	1.1	1.7	2.4	8.0	84.6
11.	1.2	1.1	1.2	1.3	2.3	7.1	86.3(2)
12.	11.6	8.7	11.5	8.0	12.2	52.0	-

Good results were observed at variant B1 variants with 6.13 kg/m^2 (134.1%) and B3 with 6.04 kg/m^2 (132.2%, Table 4) compared with B4 (the control untreated) at which production was 4.57 kg/m^2. Good results were also obtained in variant B^2 with 5.96 kg/m^2.

Regarding the differences in production obtained in addition to the untreated control variant, these are very significant in all three

Research on the control of pathogens *Alternaria porri* f. sp. *solani*, *Botrytis cinerea, Fulvia fulva* and *Phytophthora infestans* in tomato crops were also carried out by Costache et al. (2017), which established the efficacy and influence on the production of combinations of fungicides in simultaneous control thereof.

Table 4. Influence of phytosanitary treatments on production (Vidra, 2017)

Factor B	Production			
	kg/m^2	(%)	The difference from untreated varian	Signification
B1	6.13	134.1	+1.56	***
B2	5.96	130.4	+1.39	***
B3	6.04	132.2	+1.47	***
B4	4.57	100.0	-	-

DL 5%=0.021; DL 1%=0.029; DL 0.1%=0.039

The analysis of the data presented in Table 5 shows that treatments with foliar fertilizers (A1 fertilized with Crop Max 0.3%, A2 fertilized with Agroleaf Power Total (20.20.20) 0.5% and Agroleaf Power HK (15.10.31) 0.5% did not significantly influence the quantity of the obtained production, the values being very close: at A1 5.70 kg/m^2 was obtained, at A2 5.67 k/m^2 and at A3 (Mt) 5.65 kg/m^2.

Table 5. Influence of foliar fertilizer treatments on production (Vidra, 2017)

Factor A	Production			
	kg/m^2	(%)	The difference from untreated varian	Signification
A1	5.70	100.88	+ 0.05	-
A2	5.67	100.35	+ 0.02	-
A3 (Ut.)	5.65	100.00	-	-

DL 5%=0.070; DL 1%=0.100; DL 0.1%=0.172

Analyzing the data presented in Table 6, it was found that in all cases, in the variants treated (1, 2, 3, 5, 6, 7, 9, 10, 11), the differences in production obtained in addition by the untreated witness (4, 8, 12) are very significant.

Among the parameters analyzed for determining the influence of foliar treatments on Crop Max 0.3%, Agroleaf Power Total (20.20.20) 0.5% and Agroleaf Power HK (15.10.31) 0.5%, it was found that compared to the untreated control without foliar treatments,

fruit content in total dry substance (TDS), soluble dry matter (SDM), carbohydrate content and vitamin C content were clearly influenced (Table 7).

Thus, the total dry fruit content of the fruit was higher by 13.4-15.1%, the dry substance content soluble by 33.3-44.4%, the carbohydrate content by 37.8-44.4%, and the vitamin C content by 8.3-29.2%.

Table 6. Influence of phytosanitary treatments and foliar fertilizers on production (Vidra, 2017)

Variants	Foliar fertilizers	Phytosanitary tratments	Production			
			kg/m^2	%	The difference from untreated variant	Signification
1.	A1	B1	6.15	134.6	+1.58	***
2.		B2	6.02	131.7	+1.45	***
3.		B3	6.07	132.8	+1.50	***
4.		B4 (Ut.)	4.57	100.0	-	-
5.	A2	B1	6.12	132.5	+1.50	***
6.		B2	5.90	127.7	+1.28	***
7.		B3	6.05	130.9	+1.43	***
8.		B4 (Ut.)	4.62	100.0	-	-
9.	A3 (Ut.)	B1	6.13	135.6	+1.61	***
10.		B2	5.96	131.9	+1.44	***
11.		B3	6.01	132.9	+1.49	***
12.		B4 (Ut.)	4.52	100.0	-	-

DL 5%=0.065; DL 1%=0.087; DL 0,1%=0.110

Table 7. Influence of foliar fertilizers on the quality of tomato fruits

V.	Variation of fertilization	Water	(%)	TDS	(%)	SDM	(%)	Acidity (g citric acid at 100 g s.p).	(%)	Glucids	(%)	Vitamin C (mg/ 100g s.p)	(%)
1.	Crop Max 0.3%	93.56	99.2	6.44	113.4	3.9	144.5	0.77	100.0	3.25	144.4	27.28	129.2
2.	Agroleaf Power Total (20.20.20) 0.5% + Agroleaf Power HK (15.10.31) 0.5%	93.46	99.1	6.54	115.1	3.6	133.3	0.70	90.9	3.10	137.8	22.88	108.3
3.	Untreated control	94.32	100.0	5.68	100.0	2.7	100.0	0.77	100.0	2.25	100.0	21.12	100.0

CONCLUSIONS

In the field tomato crops, the pathogens *Pseudomonas syringae* pv. *tomato*, *Xanthomonas campestris* pv. *vesication*,, *Alternaria porri* f. sp. solani, *Fulvia fulva* and *Phytophthora infestans* diminish production in terms of quantity and qualitatively impair it. Among the variants of experienced treatments were B1 (T1: Copper Max 50 WP 0.25%; T2: Bravo 500 SC 0.2%; T3: Ortiva Top 0.1%; T4: Melody Compact 49 WG 0.2% + Score 250 SC 0.05%; T5: Ortiva Top 0.1%; T6: Melody Compact 49 WG 0.2%) with production of 6.13 kg/m^2 (134.1%; E medium = 87.3%) and B3 (T1: Copper Max 50 WP 0.25%; T2: Dithane M 45 WP 0.2%; T3: Ortiva Top 0.1%; T4: Ridomil Gold MZ 68 WG 0.25%+ Score 250 SC 0.05%; T5: Ortiva Top 0.1%; T6: Ridomil Gold MZ 68 WG 0.25%) with production of 6.04 kg/m^2 (132.2%; E medium = 85.5%).

Treatments with foliar fertilizers Crop Max 0.3%, Agroleaf Power Total (20.20.20) 0.5% and Agroleaf Power HK (15.10.31) 0.5% did not significantly influence production in terms of quantity but only qualitatively: the total dry substance (TSS) increase by 13.4-15.1%, the dry substance soluble (DSS) by 33.3-44.4%, the carbohydrate content by 37.8-44.4% and the vitamin C content with 8.3-29.2%.

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