Scientific Papers. Series B, Horticulture. Vol. LXI, 2017
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

THE REACTION OF TOMATO GENOTYPES TO FUNGAL PATHOGENS UNDER CONTROLLED CONDITIONS

Nadejda MIHNEA, Galina LUPAŞCU, Irina ZAMORZAEVA

Academy of Sciences of Moldova, Institute of Genetics, Physiology and Plant Protection, 20 Pădurii Street, MD-2002, Chisinau, Republic of Moldova

Corresponding author email: mihneanadea@yahoo.com

Abstract

The paper presents results of the reaction of new tomato varieties and perspective lines created in the Institute of Genetics, Physiology and Plant Protection to the seeds treatment with FC Fusarium oxysporum, F. solani, F. redolens, Alternaria alternata based on the estimation of seeds germination and length of embryonic radicles and stemlets. It should be mentioned that the reaction of some varieties to same isolates was quite different. Thus, in the case of seeds germination the capability of some approved varieties after treating them with FC of fungi, the highest resistance was found for varieties 'Exclusiv', 'Desteptarea', 'Milenium'. Variety 'Mihaela' has demonstrated the highest complex resistance to FC of 4 used fungi in the case of the reaction of radicles and stemlets, the phenomenon was manifested as insignificant reduction or stimulation. Using bifactorial analysis of variance we found that the most contribution to the variation of embryonic radicle and stemlet length had the species of fungus, being 41.07 and 58.58%, respectively. It should be mentioned that the genotype plays an important role too, its factorial pondering consists of the 32.49 and 22.00%, respectively, for the length of radicles and stemlets, and the interaction tomato genotype x fungus species was recorded as 25.03 and 17.73%, respectively, for both characters. The significant pondering of the influence of fungus species (Fusarium spp., A. alternata) and the interaction tomato genotype x species of fungus on the source of variation of plant growth organs reveals the necessity of constant monitoring of the composition of pathogen species and their virulence.

Key words: *tomato, resistance, fungal pathogens, Fusarium spp., A. alternata.*

INTRODUCTION

The resistance of agricultural crops to biotic and abiotic stressful factors is one of the basic requirements to contemporary varieties, including varieties of tomato. The problem of complex and sustainable resistance is real for many crops, but especially for tomato because their fruits are extensively used in ordinary food or dietary management of children and elderly people that is why the application of chemical plant protection has to be limited. In the Republic of Belarus fungal diseases may cause losses of 40-60% of tomato crops, in some years even of 80% (Polixenova, 2009).

Treatment with fungicides is quite difficult to optimize or make more efficient because as the capacity of plant infection as well as the efficiency of preparations may be manifested only in favorable climatic conditions that cannot often be forecasted.

The diseases are easily transmitted from one plant to another, spreading extensively on large surface. Tomatoes are susceptible to 200 fungal, bacterial, viral diseases and nematodes. The most common diseases are root rot, *Fusarium* wilt, *Verticillium* wilt, blight, various bacterial and viral infections, for which some sources of resistance are identified (Foolad, 2007; Scott Gardner, 2007).

Toxins of fungi *Alternaria* spp. and *Fusarium* spp. are often involved in the pathogenesis, accumulating in tomato fruits, especially of susceptible varieties, and making them quite toxic for human (Yamagishi et al., 2006).

Performing agricultural techniques, biological control, resistant varieties, chemical treatments are considered as basic factors of effective measures for the control of tomato diseases. Lifetime of the resistant varieties which are usually recommended for production is often limited by the emergence of new races of different pathogens exceeding the resistance of genes of cultivated varieties (Amini, Sidovich, 2010).

Chemical control of diseases is usually effective, but it has some unintended consequences as the reduction of amount of

many beneficial organisms, as well as toxic impacts on human health and environment (Manczinger, Antal, Kredics, 2002; Gavrilescu, Chisti, 2005).

From the point of economic view and ecological advantageous the use of varieties with long-term resistance for the control of tomato diseases produced by fungi is preferable.

The aim of our study was to test the level of resistance of new tomato varieties and lines to some fungal diseases (*Fusarium* spp., *A. alternata*) for the selection of forms with enhanced resistance.

MATERIALS AND METHODS

Six varieties and twelve perspective lines of tomato, created in the Institute of Genetics, Physiology and Plant Protection (IGPPP) and manifested the complex of valuable characters, were used as a material for research.

Seeds of tomato were treated with FC of the fungi for 18 hours. Seeds, which were contained in distilled water, were used as a control. The cultivation of seedlings was carried out in Petri dishes on the filter paper, moistened with distilled water, at room temperature 22-24ºC for 6 days. The important characters of growth and development of tomato at the early stages of ontogeny – germination, length of radicle and length of stemlet – were used as index-test of the reaction of plants.

In order to elucidate the features of the action of fungi *F. oxysporum, F. solani, F. redolens* and *A. alternata* on the ability of germination and growth of radicle and stemlet of tomato the analysis Box & Whisker Plot was made.

Cluster analyses were performed by creating dendrograms on the base of agglomerative-iterative algorithm using Ward method and the method *k*-means (Savary, 2010).

Bifactorial analysis of the variance ANOVA was applied to appreciate the role of the genotype, the species of fungus, and their interaction as a source of variation of quantitative traits.

RESULTS AND DISCUSSIONS

Analysis of the reaction of varieties and perspective lines of tomato to seeds treatment with the FC of fungi *F. oxysporum, F. solani, F. redolens* and *A. alternata* isolated from roots and leaves with symptoms of disease allowed to find that the reaction of plants to all four FC was different, specific for genotype, analyzed character, and species of fungus. Responses to infection were classified to the categories: inhibition, stimulation, lack of reaction (Table 1).

Table 1. The influence of culture filtrates of *Fusarium* spp. and *Alternaria alternata* on some characters of tomato growth and development

No.	Variant	Germination, %	% relative to control	Length of radicle, mm	% relative to control	Length of stemlet, mm	% relative to control
'Tomis'							
1.	H_2O (control)	100.0	100.0	37.7±1.8	100.0	20.8±1.0	100.0
2.	FC *F. oxysporum*	88.3	88.3	32.6±2.4	86.5	15.6±1.2*	75.0
3.	FC *F. solani*	48.3	48.3	27.9±3.9*	74.0	26.8±3.1	128.8
4.	FC *F. redolens*	81.7	81.7	29.6±3.1*	78.5	19.1±2.5	91.8
5.	FC *A. alternata*	78.3	78.3	16.2±1.6*	43.0	12.2±1.2*	58.6
'Exclusiv'							
1.	H_2O (control)	98.3	100.0	38.3±2.3	100.0	25.4±1.1	100.0
2.	FC *F. oxysporum*	91.5	93.1	15.5±1.3*	40.5	10.2±0.8*	40.2
3.	FC *F. solani*	71.2	72.4	13.6±1.6*	35.5	14.3±2.0*	56.3
4.	FC *F. redolens*	89.8	91.3	25.6±3.1*	66.8	15.8±1.9*	62.2
5.	FC *A. alternata*	100	101.7	31.3±2.6	81.7	18.6±1.5*	73.2
'Mihaela'							
1.	H_2O (control)	100.0	100.0	37.4±2.0	100.0	19.5±1.2	100.0
2.	FC *F. oxysporum*	90.0	90.0	35.8±3.1	95.7	18.5±1.6	94.9
3.	FC *F. solani*	55.0	55.0	33.3±4.2	89.0	23.3±1.2*	119.5
4.	FC *F. redolens*	88.3	88.3	44.2±3.4	118.2	23.6±1.6*	121.0
5.	FC *A. alternata*	90.0	90.0	31.8±2.3	85.0	16.7±1.3	85.6

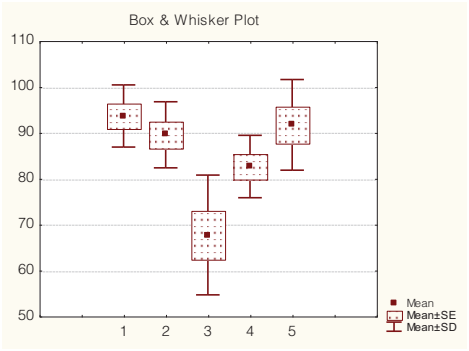
No.	Variant	Germi-nation, %	% relative to control	Length of radicle, mm	% relative to control	Length of stemlet, mm	% relative to control
'Mary Gratefully'							
1.	H_2O (control)	91.7	100.0	43.5±2.7	100.0	26.8±1.3	100.0
2.	FC *F. oxysporum*	92.7	101.1	46.6±92.7	107.2	23.3±1.4	86.9
3.	FC *F. solani*	78.2	85.3	42.0±4.2	96.5	23.3±1.8	86.9
4.	FC *F. redolens*	70.9	77.3	24.0±2.9*	55.2	9.5±1.6*	35.3
5.	FC *A. alternata*	81.8	89.2	11.0±0.8*	25.3	8.6±0.8*	32.1
'Desteptarea'							
1.	H_2O (control)	85	100.0	40.9±2.9	100.0	27.1±1.9	100.0
2.	FC *F. oxysporum*	76.5	90.0	13.6±1.5*	33.2	12.7±1.7*	46.9
3.	FC *F. solani*	80.4	94.6	21.6±3.0*	52.8	23.8±2.3	87.8
4.	FC *F. redolens*	80.4	94.6	56.3±3.3*	137.6	28.2±1.8	104.1
5.	FC *A. alternata*	100.0	117.6	53.6±3.9*	131.0	26.6±1.7	98.1
'Milenium'							
1.	H_2O (control)	86.7	100.0	36.9±2.8	100.0	22.9±1.4	100.0
2.	FC *F. oxysporum*	98.1	113.1	13.9±1.0*	37.7	8.9±0.8*	38.9
3.	FC *F. solani*	73.1	84.3	14.0±2.1*	37.9	13.8±3.7*	60.3
4.	FC *F. redolens*	84.6	97.6	27.3±2.7*	74.0	17.2±1.6*	75.1
5.	FC *A. alternata*	100.0	115.3	26.1±2.5*	70.7	15.7±1.5*	68.6

For example, estimating the capacity of seeds germination of approved varieties after treating them with FC of mentioned above fungi we found that varieties 'Exclusiv', 'Desteptarea', 'Milenium' manifested the highest resistance. This index has diminished under the action of these pathogens to 6.9-27.6%; 5.4-10.0%; 2.4-15.7%, respectively, but sometimes significant stimulation was recorded.

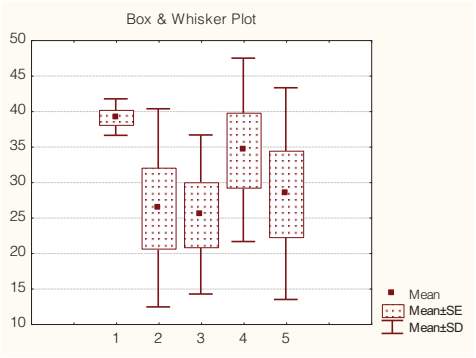
Thus, the variety 'Milenium' under the influence of FC *F. oxysporum* demonstrated increasing 13.1%, 'Desteptarea' and 'Milenium' under the influence of FC *A. alternata* – 17.6 and 15.3%, respectively.

The highest complex resistance was recorded at the 'Mihaela' variety by the evaluation of the reaction of radicles and stemlets to the action of FC of four fungi used in research, the phenomenon was manifested as insignificant diminishing or stimulation: -15.0 ... + 18.2% and -14, 4 ... + 21.0%, respectively, for radicles and stemlets.

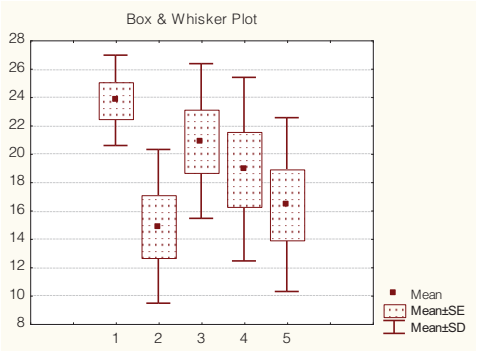
In order to elucidate the peculiarities of action of fungi *F. oxysporum, F. solani, F. redolens* and *A. alternata* on the capacity of germination, growth of radicle and stemlet in tomato the analysis Box & Whisker Plot was proceeded, 6 varieties were used as cases (Figure 1).



Germination, %



Length of radicle, mm



Length of stemlet, mm

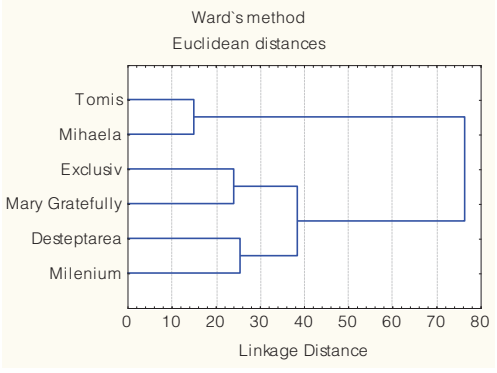
Figure 1. The influence of culture filtrates of causative agents of root rot in tomato to the growth and development of seedlings at the early stages:
1 – control (H_2O), 2 – FC *F. oxysporum*, 3 – FC *F. solani*, 4 – FC *F. redolens*, 5 – FC *A. alternata*

The data obtained showed that in the case of germination the strongest repression (with statistical support, $p \leq 0.05$) was recorded under the influence of fungus *F. solani* (-27.7%) and *F. redolens* (-11.7%), in the case of radicle growth – *F. solani* (-35.1%), and in the case of stemlet growth – *F. oxysporum* (37.4%) and *A. alternata* (-31.0%). The results demonstrated the specificity of action of these pathogenic fungi on growth and development of tomato seedlings at the early stages of ontogeny. From such reason we can conclude that the complex test of perspective tomato forms is necessary in the process of creation of varieties which are capable to develop normal growth organs in the presence of mentioned fungi in the soil.

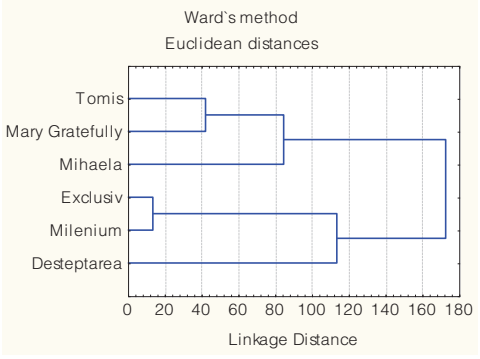
By cluster analysis some similarities and differences between studied varieties were found when the reaction of germination and growth of seedlings to the influence of fungi *Fusarium* spp. and *A. alternata* was registered (Figure 2).

Thus, similarity of varieties 'Tomis' and 'Mihaela' was shown by analysis of germination, they have diminished indices; 'Exclusiv' and 'Mary Gratefully' – intermediate level; 'Desteptarea' and 'Milenium' – the highest germination and sometimes attested stimulation.

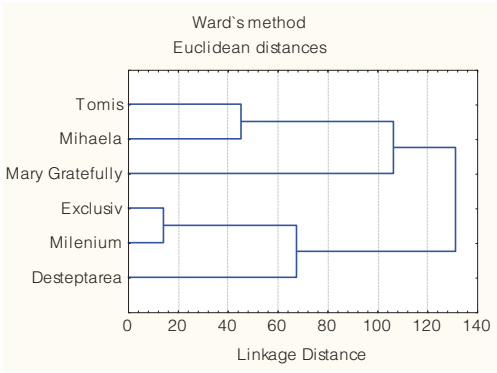
Analyzing growth of radicle and stemlet we found that following variety 'Tomis', 'Mihaela' and 'Mary Gratefully' has demonstrated similarity of these indexes as high. This tells about their fitness for production, provides additional conditions for sowing seeds or seedlings to avoid the danger of reducing their germination capacity in the case of strong soil infestation with causal agents of root rot.



Germination, %



Length of radicle, mm



Length of stemlet, mm

Figure 2. The dendrogram distribution of approved tomato varieties on the basis of similarity of responses to pathogens *Fusarium* spp. and *Alternaria alternata*

By bifactorial analysis of variance it was found that the greatest contribution in the variation of length of radicle embryonic and stemlet had a species of fungus, its contribution was 41.07 and 58.58%, respectively (Table 2).

Table 2. Factorial analysis of the *tomato genotype x fungal pathogen* relationships in tomato

Source of variation	Degree of freedom	Mean sum of squares	Contribution in the source of variation, %
Length of radicle			
Tomato genotype	5	8100*	32.49
Species of fungus	4	10241*	41.07
Tomato genotype x species of fungus	20	6242*	25.03
Random effects	1424	351	1.41
Length of stemlet			
Tomato genotype	5	1210.2*	22.00
Species of fungus	4	3222.3*	58.58
Tomato genotype x species of fungus	20	975.1*	17.73
Random effects	1103	93.5	1.70

*-p≤0,05

It was established that the genotype played an important role too; its factorial pondering consisted of 32.49% and 22.00% for the length of radicle and stemlet, respectively; the interaction *tomato genotype x species of fungus* was recorded as 25.03% and 17.73%, respectively, for both characters. The significant pondering of the contribution of fungus species (*Fusarium* spp., *A. alternata*) and interaction *tomato genotype x species of fungus* in the variation of growth plant organs reveals the necessity of constant monitoring of the composition of species of pathogen agents and their virulence.

The 12 lines obtained by intra-species crosses were studied in order to identify tomato lines with increased resistance to pathogens *Fusarium* spp. on the base of reaction to filtrates of fungi cultures, varieties 'Elvira' and 'Trapeza' were used as the control.

In the control variants the ***germination*** of seeds ranged within 88.3 - 95.0% in most lines excepting two lines L 202 and L 309: 61.7; 65.0% (Table 3).

The results demonstrated that FC of studied fungi influenced different on seeds germination.

For example, inhibition was -5.7 ... -24.2% under the influence of *F. oxysporum* FC. Strong repression was found for 'Trapeza' (-17.0%), L 207 (-22.8%), L 315 (-24.2%), lack of reaction – f or L 202, L 204, L 204, L 206, stimulation: L 208 (+ 9.8%), L 313 (+ 5.3%), L 314 (+ 8.0%), insignificant cases: 'Elvira', L 203, L 308 (-5.7 ... - 9.2%).

In the case of FC *F. solani* inhibition was more pronounced and varied in 1.9 ... 30.5%. Significant inhibition was registered in 'Trapeza' (-30.1%), L 203 (-30.5%), L 308 (23.7%), L 314 (-24.0%), L 315 (-15.5 %), L 207 (-14.0%), lack of reaction in the line L 309, stimulation – L 204 (+ 5.3%), insignificant reaction: L 202 (-2.8%), L 204 (5.3%), L 204 (+ 7.3%), L 206 (-3.3%), L 208 (7.9%), 'Elvira' (-1.9%), L 313 (7, 1%).

FC *F. redolens* produced inhibition at 12 forms from 14, it varied within the ranges -1.9 ... -27.3%, two forms – L 202, L 309 – had no response to the treatment. It should be mentioned that repression was up to 10% in 8 genotypes.

Table 3. The influence of culture filtrates of root rot causative agents to the seeds germination

Line	Origin	Control H_2O	*F. oxysporum*	% relative to control	*F. solani*	% relative to control	*F. redolens*	% relative to control
	Trapeza, control	88.3	73.3	-17.0	61.7	-30.1	75.0	-15.1
202	F_7 Maestro x Irişca	61.7	61.7	0	60.0	-2.8	61.7	0
203	F_6 (Maestro x Irişca) x Maestro	98.3	91.7	-6.7	68.3	-30.5	76.7	-22.0
204	F_6 (Maestro x Irişca) x Irişca	93.3	93.3	0	98.3	+5.3	86.7	-7.1
204a	F_6 (Maestro x Irişca) x Irişca	91.7	91.7	0	85.0	-7.3	85.0	-7.3
206	F_6 (Maestro x D.M.M.) x D.M.M.	100.0	100.0	0	96.7	-3.3	90.0	-10.0
207	F_7 'Mihaela' x Irişca	95.0	73.3	-22.8	81.7	-14.0	83.3	-12.3
208	F_7 'Mihaela' x D.M.M.	85.0	93.3	+9.8	78.3	-7.9	83.3	-2.0
	Elvira, martor	88.3	83.3	-5.7	86.6	-1.9	83.3	-5.7
308	F_{13} Nistru x L 325	91.7	83.3	-9.2	70.0	-23.7	66.7	-27.3
309	F_{11} Nota x Kecskemeti	65.0	55.0	-15.1	65.0	0	65.0	0
313	F_{13} Novicioc x Iuliana	95.0	100.0	+5.3	88.3	-7.1	88.3	-7.1
314	F_{12} Uspeh x L 325	83,3	90.0	+8.0	63.3	-24.0	81.7	-1.9
315	F_{10} Nistru x Saladette	96.7	73.3	-24.2	81.7	-15.5	88.3	-8.7

Radicle embryonic. It was found that genotypes demonstrated very different susceptibility to FC, mean values with the relation to the control varied within the limits -0.4 ...-75.5% for *F. oxysporum* isolate, - 9.6 ... -76.4% – *F . solan*i, and -12.4 ... -42.5% – *F. redolens* (Table 4). It should be mentioned that *F. oxysporum* in 9 cases from 14 had stimulating influence (+3.4 ... + 169.0%), L207 manifested a strong sensitivity (-75.0%). Evaluated lines were most strongly influenced by *F. solani.*

Eleven from 14 genotypes exhibited a suppression which was within the limits -9.6....-76.4%. Stimulation was found in 'Trapeza' (+ 8.4%), L 206 (+ 19.0%) and L 315 (+ 4.5%). In the variant with FC *F. redolens* 7 from 14 genotypes showed inhibition, but 6 lines demonstrated the stimulation of radicle growth. So the lines were strongly different in this analyzed character that reveals the opportunity to identify resistant genotype.

Table 4. The influence of culture filtrates of root rot causative agents to the embryonic radicle length

Line	Origin	Control H_2O	*F. oxysporum*	% relative to control	*F. solani*	% relative to control	*F. redolens*	% relative to control
	Trapeza	40.6±1.88	42.0±1.96	+3.4	44.0±3.58	+8.4	41.0±2.32	+1.0
202	F_7 Maestro x Irişca	27.8±1.91	27.7±2.03	-0.4	9.5±1.18	-65.8	38.2±1.92	+37.4
203	F_5 (Maestro x Irişca) x Maestro	30.3±1.39	35.9±2.00	+18.5	17.3±3.07	-42.9	18.6±1.52	-38.6
204	F_5 (Maestro x Irişca) x Irişca	27.7±1.26	36.8±2.31	+32.8	22.4±2.39	-18.2	32.0±1.97	+15.5
204a	F_5 (Maestro x Irişca) x Irişca	13.6±1.03	36.7±2.38	+169.8	12.3±1.10	-9.6	28.7±1.75	+111.0
206	F_5 (Maestro x D.M.M.) x D.M.M.	40.7±1.88	52.5±1.77	+29.6	48.2±2.15	+19.0	42.6±2.02	+5.2
207	F_7 'Mihaela' x Irişca	37.2±2.05	9.1±0.75	-75.5	15.9±2.45	-57.0	40.82±2.42	+9.7
208	F_7 'Mihaela' x D.M.M.	48.4±2.49	47.2±2.12	-2.5	30.0±3.81	-38.0	30.5±2.14	-37.0
	Elvira	36.0±2.48	47.6±2.42	+32.2	16.5±2.10	-54.2	20.7±2.01	-42.5
308	F_{13} Nistru x L 325	45.1±2.54	54.0±2.14	+19.7	11.8±1.91	-73.8	37.7±2.32	-16.4
309	F_{11} Nota x Kecskemeti	23.8±4.56	23.0±2.24	-3.4	12.9±1.94	-45.8	24.4±3.35	+2.5
313	F_{13} Novicioc x Iuliana	45.9±2.00	48.1±1.95	+4.8	30.7±2.82	-33.1	40.2±2.07	-12.4
314	F_{12} Uspeh x L-325	38.1±1.75	43.1±2.64	+13.1	9.0±0.83	-76.4	22.5±2.04	-41.0
315	F_{10} Nistru x Saladette	35.7±1.71	30.8±2.09	-13.7	37.3±1.83	+4.5	29.7±1.33	-16.8

Stemlet. Its repression varied within the limits -0.5...-74.3% for *F. oxysporum*, -16.7… -74.5% – *F. solani*, -5.2...-56.6% – *F. redolens* (Table 5). Strong sensitivity to *F. oxysporum* was recorded in lines L 207 (-74.3%), L 208 (33.3%), L 202 (-19.2%), L 315 (-26.8%), stimulation was registered in 5 lines: L 203 (+ 5.8%), L 204 (+ 11.1%), L 204a (+ 58.5%), L 308 (+ 23.8%), L 314 (+ 1.6%) (Table 5). Filtrate of culture of *F. solani* in 10 cases from 14 inhibited stemlets growth. High sensitivity was found in lines: L 202 (-74.5%), L 206 (26.1), L 308 (-64.9%), L 309 (-50.0%), L 314 (- 42.8), stimulation in the variety 'Trapeza' (+ 1.4%); L 203 (+ 5.8%), L 204 (+ 47.7%), L 204a (+ 3.8%).

Thus, the lines L 203, L 208 and variety 'Elvira' were the most sensitive to *F. redolens,* repression consisted of 46.8; 56.6 and 40.2%, respectively. Strong stimulation was found in L 309 (52.5%).

Table 5. The influence of culture filtrates of root rot causative agents to the tomato stemlet length

Line	Origin	Control H_2O	*F. oxyspo-rum*	% relative to control	*F. solani*	% relative to control	*F. redolens*	% relative to control
	Trapeza	21.2±1.03	20.2±1.27	-4.7	21.8±1.57	+1.4	25.0±1.72	+17.9
202	F_7 Maestro x Irişca	18.8±1.30	15.2±1.33	-19.2	4.8±1.21	-74.5	20.6±1.32	+9.6
203	F_6 (Maestro x Irişca) x Maestro	18.8±1.06	19.9±1.31	+5.8	19.9±3.51	+5.8	10.0±0.90	-46.8
204	F_6 (Maestro x Irişca) x Irişca	15.3±0.70	17.0±0.95	+11.1	22.6±1.64	+47.7	17.2±1.43	+12.4
204a	F_6 (Maestro x Irişca) x Irişca	13.0±1.17	20.6±1.52	+58.5	13.5±2.94	+3.8	14.0±0.85	+7.7
206	F_6 (Maestro x D.M.M.) x D.M.M.	31.4±1.07	26.6±0.85	-15.5	23.2±1.05	-26.1	23.6±1.39	-24.9

Line	Origin	Control H_2O	*F. oxyspo-rum*	% relative to control	*F. solani*	% relative to control	*F. redolens*	% relative to control
207	F_7 'Mihaela' x Irişca	27.2±1.26	7.3±1.31	-74.3	21.8±3.24	-19.9	25.8±1.56	-5.2
208	F_7('Mihaela' x D.M.M.)	28.8±1.88	19.2±1.01	-33.3	23.3±1.57	-19.1	12.5±1.31	-56.6
	Elvira	20.4±1.38	20.5±1.25	-0.5	17.0±1.83	-16.7	12.2±1.26	-40.2
308	F_{13} Nistru x L 325	26.5±1.25	32.8±1.41	+23.8	9.2±2.78	-64.9	18.8±1.58	-29.1
309	F_{11} Nota x Kecskemeti	11.8±3.16	11.7±1.37	-0.9	5.9±1.45	-50.0	18.0±2.74	+52.5
313	F_{13} Novicioc x Iuliana	28.4±1.04	27.5±1.53	-3.2	22.9±1.61	-19.4	21.2±1.47	-25.4
314	F_{12} Uspeh x L 325	18.7±1.13	19.0±1.34	+1.6	10.7±3.12	-42.8	12.1±1.05	-35.3
315	F_{10} Nistru x Saladette	27.2±0.94	19.9±1.45	-26.8	21.0±0.97	-22.8	20.5±1.25	-24.6

Cluster analysis (*Ward method*) allowed finding similar particularities in created varieties and lines with respect to studied characters: germination, length of radicle and stemlet (Figure 3).

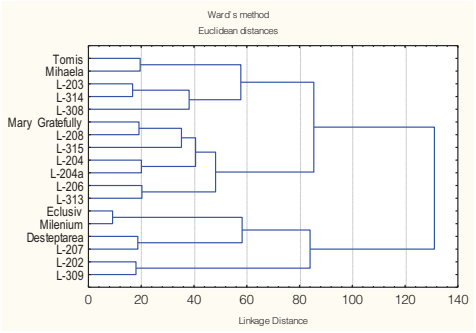


Figure 3. The degree of similarity of tomato varieties and lines on the base of the reaction to pathogens *Fusarium* spp.
(***Cases***: germination, length of radicle, length of stemlet)

Clusters of genotypes with similar response to pathogens *Fusarium* spp. were identified. It was found that the lines L 203, L 208, L 314 were high similar with the varieties 'Tomis' and 'Milenium', and L 202, L 207, L 209 – with varieties 'Exclusiv', 'Milenium' and 'Desteptarea'.
Cluster analysis of *k-means* (*method centroid*) demonstrated that groups of varieties and lines were separated into three clusters on the base of different reaction to FC *Fusarium* spp. (Figure 4).

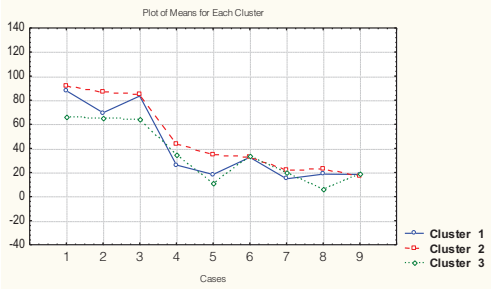


Figure 4. Cluster analysis (*k*-means) of distribution of genotypes on the base of response to culture filtrates of *Fusarium* spp.
Horizontal: *germination* (% to the control) under the FC influence : 1 – *F. oxysporum, 2 – F. solani, 3 – F. redolens; length of radicle*: 4 – *F. oxysporum*, 5 – *F. solani*, 6 – *F. redolens*; *length of stemlet*: 7 – *F. oxysporum*, 8 – *F. solani*, 9 – *F. redolens*.
Vertical: 1, 2, 3 – clusters of genotypes

As members of the *cluster 1* were: 'Tomis', 'Exclusiv', 'Mihaela', 'Desteptarea', 'Milenium', L 203, L 204a, L 207, L 314; *cluster 2:* 'Mary Gratefully', L 204, L 206, L 208, L 313, L 315; *cluster* 3: L 202, L 308, L 309. The varieties of clusters 1 and 2 showed higher resistance compared with the cluster.

CONCLUSIONS

It has been found that the pathogens *Fusarium* spp. and *A. alternata* significantly influenced on the early ontogeny of tomato genotypes by the suppression of seeds germination, growth of radicle and stemlet (sometimes - by their stimulation). Cluster analysis using *k-means* method allowed to find that fungal species *F. solani* and *F. redolens* showed a higher discriminating capacity on varieties / lines of tomato in comparison with *F. oxysporum*. This reveals more pronounced specificity of interaction with these pathogens.

The varieties 'Exclusiv', 'Desteptarea', 'Milenium' manifested the highest resistance in seeds germination capacity, as well as the variety 'Mihaela' demonstrated the highest complex resistance in respect with the reaction of radicle and stemlet to all 4 culture filtrates.

Using factorial analysis it was found that the species of fungus (*Fusarium* spp., *A. alternata*) included the greatest contribution to the source of variation of radicles and stemlets length, its contribution consisted of 41.07 and 58.58%, respectively.

The significant pondering of the influence of fungus species (*Fusarium* spp., *A. alternata*) and the interaction tomato genotype x species of fungus on the source of variation of plant growth organs reveals the necessity of constant monitoring of the composition and virulence of fungal species causing root rot in tomato.

REFERENCES

Amini J., Sidovich D.F., 2010. The Effects of Fungicides on Fusarium oxysporum f. sp. lycopersici Associated with Fusarium Wilt of Tomato. In: J. of Plant Protect. Research, vol. 50, nr. 2, 172-178.

Foolad M.R., 2007. Genome mapping and molecular breeding of tomato. In: International J. of Plant Genomics, 52.

Gavrilescu M., Chisti Y., 2005. Biotechnology – a sustainable alternative for chemical industry. In: Biotechnol. Adv., vol. 23, 471-499.

Manczinger L., Antal Z., Kredics L., 2002. Ecophysiology and breeding of mycoparasitic Trichoderma strains. In: Acta Microbiologica et Immunologica Hungarica, vol. 49, 1-14.

Polixenova V.D., 2009. Induced resistance of plants to pathogens and abiotic stress factors (in the example of tomato). Annals of BSU, Ser. 2, N 1, 48-60.

Savary S. et al., 2010. Use of Categorical Information and Correspondence Analysis in Plant Disease Epidemiology. In: Adv. in Bot. Research, vol. 54, 190-198.

Scott J.W., Gardner R.G., 2007. Breeding for Resistance to Fungal Pathogen. In: Genetic Improvement of Solanaceous Crops. Vol. 2. Tomato. Ed. Razdan M.K., Mattoo A.K., USA, Sci. Publishers, 421-456.

Yamagishi D. et al., 2006. Pathological evaluation of host-specific AAL-toxins and fumonisin mycotoxins produced by *Alternaria* and *Fusarium* species. In: J. of General Plant Pathol., Vol. 72, Issue 5, 323-327.


EX·TERRA·AVRVM