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Morphometric and Anatomical-Histometric Characteristics of two Varieties of the Species *Solanum lycopersicum* L. Infected by Cucumber Mosaic Virus

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Abstract

Viruses induce different external and internal symptoms on plants. Our investigations showed that the occurrence and the appearance of symptoms is a result of interaction of a specific virus and its host plant within concrete conditions of the environment. There are many literature data on the impact of viruses on the cell and its organelles and changes in tissue and organs, their structure and function, but very little data on the quantification of most of these changes. Therefore, in this study we determined some morphometric parameters (internode length, stem height, leaf area and weight) and some anatomical-histometric parameters (leaf thickness, upper and lower epidermis thickness, palisade tissue thickness, spongy tissue thickness, mesophyll thickness, area of upper and lower epidermis cells, area of palisade and spongy parenchyma cells, main nerve height and width and vascular bundle height, width and area of the main nerve) of two varieties of tomato plants (var. Saint Pierre and var. Novosadski jabučar) infected by 746-07 isolate of cucumber mosaic virus (746-07-CMV). The results show that the virus exerted influence on all investigated parameters, with some differences depending on the combination of virus/tomato variety. As a consequence of reduction of internodes length and stem height for both varieties, stagnation in growth occurred in higher percentage for the variety of Novosadski jabučar. Area and thickness of leaves were abortive in growth; they had thinner palisade tissue and its cell surface. From this, one may conclude that the productive ability of plants was reduced.

Key wards: variety, *Solanum lycopersicum* L., cucumber mosaic virus, morphometric characteristics, anatomical - histometric characteristics.

Introduction

Symptoms of virus diseases caused by viruses are induced by changes which they create in plant's cells; the infected cells are changed physiologically, which may be seen in the histological and the morphological substance of plants (Kurstak, 1981; Matthews, 1993; Juretić, 2002). Viruses bring about the *external* symptoms, visible to the naked eye, as well as the *internal* symptoms, visible in cells, at the level of plant tissue and organs. Symptoms of virus diseases are diverse and may be classified according to different criteria. They are most commonly grouped into three basic categories: the first arise according to changes in colour, the second are a consequence of histopathological changes, and the third arise from patho-morphological changes (Juretić, 2002). The generally accepted opinion among virologists and phytopathologists is that majority of symptoms may be specific for the given virus and its plant host, that is, their occurrence and appearance are a result of interaction of the specific virus/ specific host, in specific conditions of the environment.

The literature is fairly rich with data about impact of viruses on cell structure and function as well as about modifications in tissue and organs of plants as a result of the following: disruptions in division of cells (histogen changes), in growth and configuration of cells (histotrophical changes), in appearance of new tissue (neoplasmatic changes), in conversion of one tissue into another (metaplasmatic changes), in appearance of specific pathological bunches (structural changes) and death of cells (necrogen changes). On the other hand, there are few data of quantification of these changes, that is, morphometric and anatomical-histometric parameters concerning these changes (see Matthews, 1993; Hata and Francki, 2004; Bald, 2009). This is the reason why, in this investigation, we tried to designate some morphometric and anatomical-histometric parameters for two varieties of tomato infected with 746-07-CMV, and to deduce whether these parameters might be connected with a specific relationship between a virus and its host.

Materials and methods

In our investigation we used two varieties of the species *Solanum lycopersicum* L. (var. Saint Pierre and var. Novosadski jabučar) and 746-07-CMV, obtained by Branka Krstić, the Faculty of Agriculture, Belgrade, which was proved to belong to IA subgroups of the strains of cucumber mosaic virus (Krstić and Vico, 2004).

The soil for the growth of plants was sterilised in the autoclave at the temperature of 120^0C during four hours. Then the soil rested for 8 days, mixing temporarily, and then it was placed into an intergrowth casket, and the seed was added. Fifteen days later, the tomato plants were replanted into jars with sterile soil. The plants were infected by the infective juice which was extracted from the leaves of systematically infected plants of *Niciotiana glutinosa* L. with an additive of 0.2 M of the phosphate buffer pH 7.2 in the rate of m1/g of the leaves mass. For this purpose, the standard method of mechanical inoculation was used (Krstić and Tošić, 1994). The

inoculation was performed when the plants developed 4-5 leaves (21-day old tomato plants). The experimental infected plants, as well as the healthy plants were grown and sustained in the controlled laboratorial conditions (22-25 ^{0}C, 14 h photoperiod).

Systematically infected plants of both varieties, 40-day old, as well as healthy plants of the same seniority were taken for analysis. For morphmetrical measurement, fresh plant material was used, whereas for anatomical-histological measurement, material conserved in 50% alcohol ethanol was used.

The presence of a virus in the inoculated plants was determined on the basis of visible symptoms.

Out of morphometric parameters, the internode length, the stem height and the leaf area and weight were determined. The leaf area was determined by the method of contour of leaf on the paper (Petrović i Štrbac, 1996). The method is based on proportionality between the known mass and the area of paper, and mass and area of paper which is obtained by cutting the contour of lamina: $M_h : M_j = P_h : P_i$, where M_h is the mass of paper, M_j - the mass of paper clip, P_h - the area of paper and P_i-the area of lamina (leaf area). Solving this proportion by P_i, we calculated the leaf area.

To perform anatomical-histological analyses of leaf, the main nerve included, we used leaves from the medial part of the plant by the same insertion. Leaves of diseased plants exhibited symptoms of a systematic infection. All analysed parameters were determined in the same histological sections. We analysed 30 cross cuts of leaves taken from five different plants. Permanent histological preparations were made by the paraffin technique (see Blaženčić, 1994) which included: handling the material in fixative, cutting the material by the microtome so that the thickness was 20 micrometers, and, finally, double colouring by safranin and alcian blue. The following parameters were measured: the leaf thickness, the upper and lower epidermis thickness, the palisade tissue thickness, the spongy tissue thickness, the mesophyll thickness, the area of the upper and lower epidermis cells, the area of the palisade and spongy parenchyma cells, the main nerve height and width and the vascular bundle height, width and area of the main nerve. The cuts of leaves were done by using OLIMPUS VANOX AH 2 microscope, with 10x40 magnification, using the OLYMPUS IMAGE ANALISER software package. Computer image processing has enabled precise measurement of the length of straight and curved lines, surfaces, volume and diameter. The obtained results were statistically treated by Maple 10 statistical package. For all investigated parameters, the following elements were calculated: the arithmetical means and the standard deviations of samples, the difference between arithmetical means of infected and healthy plants. Significance of the difference between arithmetical means was investigated by t-test with the level of significance of 95%. The zero hypothesis about equality of arithmetical means was tested. The supposed level of significance gave the critical p value of $p=0.05$. In the case of $p<0.05$, there was a statistically significant difference between observed parameters, and then the zero hypothesis was rejected, while in the case $p>0.05$, there were no significant differences, and the zero hypothesis was accepted.

Results and discussion

There are different methods to check the presence of a virus (see Abad et al., 2000; Juretić, 2002). In this paper, the presence of 746-07-CMV in the inoculated plants was detected by visual examinations of characteristics symptoms that the virus produces in leaves of *Solanum lycopersicum* L. (see Kaper and Waterwopt, 1981; Palukaitis et al., 1992). Minor deviations in the appearance and the intensity of symptoms were observed between plants of Saint Pierre and Novosadski jabučar. This may be connected with a specific virus/host relationship, which is in accordance with numerous investigations regarding variations of symptoms that a virus produces in different hosts (see Walkey, 2005).

Morphological characteristics

The results of the conducted investigations show that there exist differences in the internode length and the stem height between infected and healthy plants of both varieties (Tab. 1), which means that the virus generates stagnation in the growth of plants. The stagnation expressed in percentage is greater for the var. Novosadski jabučar (Tab. 4) and is statistically significant Tab. 1). From Table 1, one may conclude that the value of standard deviation for the height of a stem is greater for infected plants of both varieties comparing with the healthy control plants.

There is an evident difference in the leaves area and weight between diseased and healthy plants of both varieties and these differences are statistically significant. The percentage of decrease in leaf area is higher for var. Saint Pierre, comparing to Novosadski jabucar, while weight values are reverse (Tab. 4).

In the available literature, there are no exact numerical indicators about the impact of CMV on the mentioned parameters, but indirectly, from description of symptoms referring to depression in growth of plants and impact of infection on different degrees of shrinkage of leaves up to its thread appearance (Šutić, 1987; Erić and Grbelja, 1990; Palukaitis et al., 1992; Juretić, 2002; Palukaitis and Garcia-Arenal, 2003; Erić et al. 2007), one may conclude that these parameters tend to decrease.

Anatomical-histometrical characteristics

Leaves are vegetative organs which are very sensitive and apparently react to the impact of many viruses expressing different outside and inside symptoms (Šutić et al., 1999; Bald, 2009). The intensity, that is, the expressiveness of symptoms in the same environmental conditions, depends on relations of the given virus and its host plant, which has also been proved in our investigations. The results of measurements of anatomical-histological parameters of a leaf and its statistical analysis show that there are differences in values of these parameters for investigated varieties of tomato (Tab. 2 and 3).

It is shown, in the Table 2, for the var. Saint Pierre that there are statistically significant differences in 8 out of 15 parameters, comparing infected and healthy

plants. The trend of decreasing was detected for: the leaf thickness, the mesophyll thickness, the spongy tissue thickness, the main nerve width, and the increasing trend was detected for: the thickness of both epidermis, the main nerve height, and the area of its vascular bundle. The remaining parameters showed no statistically significant differences.

Tab. 1. Statistical values of some morphometric characteristics of diseased (b) and healthy (z) plants
Statističke vrijednosti nekih morfometrijskih karakteristika oboljelih (b) i zdravih (z) biljaka

			$\bar{x}$	Sx	Sxy	Cs	Cp	Ci	ns*
Solanum lycopersicum L. var. Saint Pierre	stem height in cm *dužina stabljike u cm*	b	57.98	6.8174	3.48	0.8858	0.4026	12.6055	ns
		z	61.46	5.5397				-5.6455	
	internode length in cm *dužina internodije u cm*	b	4.84	4.8359	0.28	0.4427	0.6697	-1.1784	ns
		z	5.12	5.1538				1.7384	
	leaf area in cm^2 *površina lista u* cm^2	b	59.68	18.2282	19.2	3.4296	0.0013	30.7346	*
		z	78.89	21.5690				8.0062	
	leaf weight in g *težina lista u g*	b	0.97	0.0404	0.15	16.1389	1.389×10^{-18}	.1685	*
		z	1.13	0.2286				-1310	
Solanum lycopersicum L. var. Novosadski jabučar	stem height in cm *dužina stabljike u cm*	b	55.74	5.1665	14.9	4.4945	0.0020	22.5458	*
		z	70.64	5.3158				7.2542	
	internode length in cm *dužina internodije u cm*	b	4.75	4.7466	1.31	2.0713	0.0721	-.1484	ns
		z	6.06	6.0552				2.7684	
	leaf area in cm^2 *površina lista u* cm^2	b	72.02	15.0589	18.3	3.4497	0.0013	29.2064	*
		z	90.16	22.0608				8.0062	
	leaf weight in g *težina lista u g*	b	0.96	0.0985	0.20	8.2718	1.389×10^{-10}	.2548	*
		z	1.16	0.0751				.1550	

Meaning: $\bar{x}$: arithmetical mean; Sx: standard deviation; Sxy: difference of arithmetical means; Cs: computed statistics; Cp: p-value; Ci: interval of significance for level 95%; ns: there are no statistical differences; *: there are statistically significant differences.

Tab. 2. Statistical values for the anatomical-histological parameters of leaves of diseased (b) and healthy (z) plants of the species *Solanum lycopersicum* L. var. Saint Pierre
Statističke vrijednosti anatomsko-histoloških parametara lista oboljelih (b) i zdravih (z) biljaka vrste Solanum lycopersicum L. *var. Saint Pierre*

		$\bar{x}$	Sx	Sxy	Cs	Cp	Ci	ns *
leaf thickness *debljina lista*	b z	76.9637 84.7710	7.1489 8.3388	7.8073	3.8346	0.0003	3.7291 11.8856	*
upper epidermis thickness *debljina gornjeg epidermisa*	b z	6.8633 6.1187	0.6146 0.8821	-0.7447	-3.7938	0.0004	-3.5074 -1.1386	*
lower epidermis thickness *debljina donjeg epidermisa*	b z	4.7647 4.1853	0.7461 0.6574	-0.5793	-3.1902	0.0023	-0.2157 -0.9430	*
palisade tissue thickness *debljina palisadnog tkiva*	b z	20.7667 20.8283	3.7004 2.8522	0.0617	0.0723	0.9426	1.7715 -1.6481	ns
spongy tissue thickness *debljina sunđerastog tkiva*	b z	44.5690 53.4603	7.4576 8.3271	8.8913	4.3566	5.5350 x 10^{-5}	12.9777 4.8050	*
mesophyll thickness *debljina mezofila*	b z	64.6333 74.1163	8.5041 7.7038	9.4830	4.5265	3.0683 x 10^{-5}	13.6774 5.2886	*
area of upper epidermis cells *površina ćelija gornjeg epidermisa*	b z	52.8273 54.4333	5.3611 6.8013	1.6060	1.0157	0.3142	4.7747 -1.5627	ns
area of lower epidermis cells *površina ćelija donjeg epidermisa*	b z	37.6180 38.0960	5.6653 5.5982	0.4780	0.3287	0.7435	3.3888 -2.4328	ns
area of palisade tissue cells *površina ćelija palisadnog tkiva*	b z	94.8297 100.845	13.5347 9.7574	6.0153	1.9746	0.0535	12.1261 -.9547	ns
area of spongy tissue cells *površina ćelija sunđerastog tkiva*	b z	84.0913 88.3460	9.5959 10.0425	4.2547	1.6777	0.0988	9.3312 -.8218	ns
main nerve height *visina glavnog nerva*	b z	481.321 440.427	36.1868 42.1267	-40.8937	-4.0332	0.0002	-20.5879 -61.1995	*
main nerve width *širina glavnog nerva*	b z	425.584 475.360	71.6866 50.7566	49.7767	3.1039	0.0031	81.9531 17.6003	*
vasc. bundle height of m.n. *visina vaskularnih snopića*	b z	155.372 151.445	13.2630 6.5385	-3.92667	-1.4545	0.1532	1.5205 -9.3738	ns
vasc. bundle width of m.n. *širina vaskularnih snopića*	b z	250.363 247.537	30.1808 29.1717	-2.8260	-0.3688	0.7137	12.5145 -18.1665	ns
vasc. bundle area of m.n. *površina vaskularnih snopića*	b z	38152.4 35407.2	5926.64 4461.44	-2745.19	-2.0269	0.0476	-29.6997 -5460.676	*

Remark: thickness, height and width are given in µm, and area in μm^2

Tab. 3. Statistical values for the anatomical-histological parameters of leaves of diseased (b) and healthy (z) plants of the species *Solanum lycopersicum* L. var. Novosadski jabučar

Statističke vrijednosti anatomsko-histoloških parametara lista oboljelih (b) i zdravih (z) biljaka vrste Solanum lycopersicum L. *var. Novosadski jabučar*

		$\bar{x}$	Sx	Sxy	Cs	Cp	Ci	ns *
leaf thickness *debljina lista*	b z	70.9970 71.1990	9.9284 8.3565	0.2020	0.0853	0.9324	4.9476 -4.5436	ns
upper epidermis thickness *debljina gornjeg epidermisa*	b z	5.8270 5.3987	0.9965 0.7915	-0.4283	-1.8435	0.0706	$.3726x10^{-1}$ - .8939	ns
lower epidermis thickness *debljina donjeg epidermisa*	b z	4.5316 3.9943	0.6795 0.6568	-0.5373	-3.1143	0.0029	- .1919 - .8827	*
palisade tissue thickness *debljina palisadnog tkiva*	b z	14.8077 16.9167	3.0226 1.7549	2.1090	3.3051	0.0018	3.3930 .8250	*
spongy tissue thickness *debljina sunđerastog tkiva*	b z	45.8313 44.8893	6.8556 7.7993	-0.9420	-0.4969	0.6212	2.8543 - 4.7383	ns
mesophyll thickness *debljina mezofila*	b z	60.6383 61.7277	9.2093 7.9939	1.0893	0.4893	0.6265	5.5479 -3.3693	ns
area of upper epidermis cells *površina ćelija gornjeg epidermisa*	b z	37.4760 40.4803	3.5426 4.2424	3.0043	2.9772	0.0043	5.0256 .9830	*
area of lower epidermis cells *površina ćelija donjeg epidermisa*	b z	34.0480 30.1930	5.2995 3.6799	-3.8550	-3.2727	0.0019	-1.4910 -6.2190	*
area of palisade tissue cells *površina ćelija palisadnog tkiva*	b z	62.9647 67.1650	10.6561 13.6704	4.2003	1.3273	0.1899	10.5429 -2.1422	ns
area of spongy tissue cells *površina ćelija sunđerastog tkiva*	b z	58.6180 58.6420	8.3273 8.3974	0.0240	0.0111	0.9912	4.3461 -4.2981	ns
main nerve height *visina glavnog nerva*	b z	389.254 368.296	38.8702 38.4474	- 20.9587	-2.0997	0.0401	-.9779 -40.9395	*
main nerve width *širina glavnog nerva*	b z	430.690 415.763	57.7382 42.5104	-14.9277	-1.1403	0.2592	11.3251 -41.1804	ns
vasc. bundle height of m.n. *visina vaskularnih snopića*	b z	132.027 124.743	14.4360 10.2233	-7.2837	-2.2553	0.0283	-.8037 -13.7637	*
vasc. bundle width of m.n. *širina vaskularnih snopića*	b z	260.408 246.381	35.1545 32.3227	-14.0263	-1.6088	0.1131	3.4291 -31.4819	ns
vasc. bundle area of m.n. *površina vaskularnih snopića*	b z	34503.0 27117.3	7323.02 5361.08	-7385.68	-4.4573	4.3195×10^{-5}	-4062.413 -10708.95	*

Data in Table 3 show that in the infected plants of var. Novosadski jabučar, the leaves were slightly less thick (71.00 μm), comparing with healthy plants (71.20 μm). Also, the mesophyll thickness was 60.64 μm for the infected plants and 61.73 μm for healthy ones. However, inside the mesophyll, there was decrease in the thickness of the palisade parenchyma which was statistically significant. Furthermore, the result of the statistical analysis showed that the infected plants had decreasing area of upper epidermis cells which was statistically significant, as well as the increase in the area and thickness of lower epidermis cells, the main nerve height, the vascular bundle height and area, which were also statistically significant. Differences among other parameters were not statistically significant.

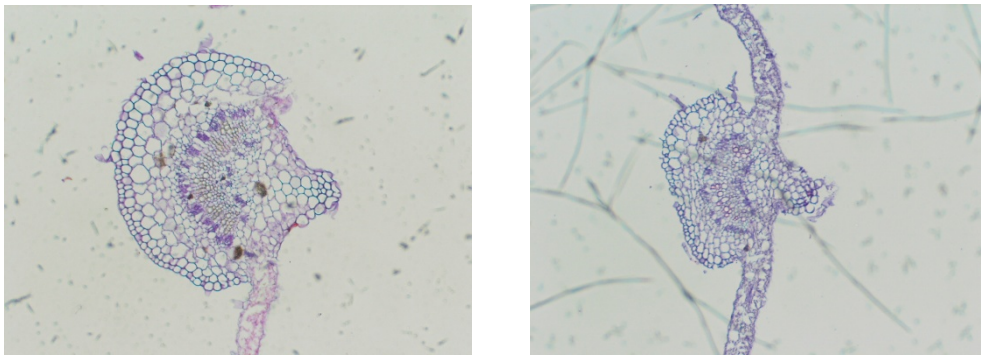
Tab. 4. Comparable values of some morphometric and anatomical-histological parameters of diseased (b) and healthy (z) plants
Uporedne vrijednosti nekih morfometrijskih i anatomsko-histoloških parametara oboljelih (b) i zdravih (z) biljaka

	Solanum lycopersicum L. var. Saint Pierre		*Solanum lycopersicum* L. var. Nov. jabučar	
Measured parameters	b	z	b	z
average of stem height	57.98	61.46	55.74	70.64
% decreasing of stem height	5.6622		21.0929	
average of leaf area	59.6834	78.8865	72.0216	90.3300
% decreasing of leaf area	24.3427		20.2683	
average of leaf weight	0.9695	1.1289	0.9555	1.1604
% s decreasing of leaf weight	14.1199		17.6577	
average of leaf thickness	76.9637	84.7710	70.9970	71.1990
% decreasing of leaf thickness	9.2099		0.2837	
mesophyll thickness	64.6333	74.1163	60.6383	61.7277
% decreasing of mesophyll thickness	12.7543		1.7648	
palisade tissue thickness	20.7667	20.8283	14.8077	16.9167
% decreasing of palisade tissue thickness	0.2958		12.4669	
spongy tissues thickness	84.0913	88.3460	58.6189	58.6420
% decreasing of spongy tissue thickness	4.8160		0.0410	
area of palisade parenchyma cells	94.8294	100.845	62.9647	67.1650
% decreasing of area of palisade parenchyma cells	5.9649		6.2537	
vascular bundle area	38152.4	35407.2	34503.0	27117.3
% increasing of vascular bundle area	7.1954		21.4060	

The anatomical-histological analysis showed that the leaf thickness, the palisade parenchyma thickness and the areas of palisade parenchyma cells decreased under the impact of 746-07-CMV (Tab. 2 and 3), but decreased values of these parameters were not the same in percentage for both varieties.

The leaf thickness, the palisade tissue thickness and the area of palisade parenchyma cells exhibited the productive power of leaf (Barden, 1978; Nešković et al., 2003; Đurić, 2009). Its increasing values indicate a greater content of chlorophylls in a leaf, which increases total photosynthesis, that is, increases productivity. According to the fact that the photosyntetical tissue of infected plants is less developed, there is a smaller quantity of chlorophylls in its leaves. The result is a reduction in photosynthesis because the total photophosphorylation by which the light energy, using chlorophyll, converts into the chemical energy conjunct in molecules of ATP is reduced. In other words, less chlorophyll – less photophosphorylation, and, as a consequence, reduced photosynthesis, that is, reduced synthesis of organic substances (see Nešković et al., 2003). Besides, the impact of viruses on decrease in photosynthesis because of the decrease of quantity of chlorophylls in a leaf (see Šutić, 1987), they directly affect the process of photophosphorylation, that is, the process of producing energy by reducing the transport of electrons in chloroplasts (cit. Song et al., 2009).

In a number of recent investigations (van. Kooten et al., 1990; Rahoutei et al., 2000; Scharte et al., 2005), it has been shown that in virus infected plants the photosynthesis is reduced, and the reduction depends both on a virus and a host. Song et al. (2009) proved that tomato and cucumber plants infected by CMV virus had the reduced photosynthesis.



b z

Fig. 1. *Solanum lycopersicum* L. var. Novosadski jabučar – cross-section of main nerve with vascular bundles of infected (b) and healthy (z) plants

Solanum lycopersicum L. var. Novosadski jabučar – poprečni presjek glavnog nerva sa vaskularnim snopovima zaraženih (b) i zdravih (z) biljaka

For both investigated varieties of tomato, the increasing of vascular bundle area of the main nerve was statistically significant comparing to the same parameter for healthy plants (Tab. 2 and 3). As it is visible, on cross-sections, that the number of

vascular elements in bundle of infected plants increased (Fig.1), we suppose that the infection implies a loss of the function of existing vascular elements, so that the plant creates new vascular elements to obtain the conduction of assimilate and water, which implies increasing the vascular tissue area. Something similar happens with water stress for some plants (cit. Hoekstra et. al., 2001).

Conclusion

The investigation of the morphometric and the anatomical-histometric characteristics of two varieties of tomato infected with 746-07-CMV showed the following:

- The virus made impact on all examined parameters, with some differences depending on the combination of virus/tomato variety.
- Both varieties showed stagnation in growth, which was greater in percentage for var. Novosadski jabučar.
- Leaf area and thickness fell behind in development. They had thicker palisade parenchyma and smaller area of its cells, so that one may conclude that productive ability decreased.

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Morfometrijske i anatomsko-histometrijske karakteristike dvije sorte vrste *Solanum lycopersicum* L. zaražene virusom mozaika krastavca

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Sažetak

Virusi uzrokuju različite spoljašnje i unutrašnje simptome biljaka. Istraživanja su pokazala da je pojava i izgled većine simptoma rezultat interakcije određenog virusa i njegovog biljnog domaćina, u konkretnim uslovima sredine. U literaturi postoji veliki broj podataka o uticaju virusa na ćeliju i njene organele i na promjene u tkivima i organima, na njihovu strukturu i funkciju, ali vrlo malo podataka o kvantificiranju većine tih promjena. Zbog toga smo u ovom istraživanju određivali neke morfometrijske parametre (dužinu internodija i visinu stabljike, te površinu i težinu lisne plojke) i anatomsko-histometrijske parametre (debljinu liske, debljinu epidermisa lica i naličja, debljinu palisadnog tkiva, debljinu sunđerastog tkiva, debljinu mezofila, površinu ćelija epidermisa lica i naličja, površinu ćelija palisadnog i sunđerastog tkiva, visinu i širinu glavnog nerva i visinu, širinu i površinu provodnog snopića glavnog nerva) kod biljaka dviju sorti vrste *Solanum lycopersicum* L. (Saint Pierre i Novosadski jabučar), zaraženih izolatom 746-07 virusa mozaika krastavca. Rezultati pokazuju da je virus ispoljio uticaj na sve praćene parametara, uz određene razlike zavisno od kombinacije virus/sorta paradajza. Zbog skraćivanja internodija i stabljike, kod obe sorte ispoljen je zastoj u rastu ali je on procentualno veći kod sorte Novosadski jabučar. Listovi u razvoju zaostaju površinom i debljinom, imaju tanje palisadno tkivo i manju površinu njegovih ćelija, te se na osnovu toga može zaključiti da im je smanjena produktivna sposobnost.

Ključne riječi: varijetet, *Solanum lycopersicum* L., virus mozaika krastavca, morfometrijske karakteristike, anatomsko - histometrijske karakteristike.

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