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Evaluation of pepper breeding lines (*Capsicum annuum* L.) to important diseases in organic agricultural system

Оценка на селекционни линии пипер (*Capsicum annuum* L.) към важни заболявания в органична селскостопанска система

Katya VASILEVA (✉), Velichka TODOROVA

Agricultural Academy, Maritsa Vegetable Crops Research Institute, 4003, Plovdiv, Bulgaria

✉ Corresponding author: kkvasileva@abv.bg

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ABSTRACT

The reaction of pepper breeding lines under organic production conditions to *Verticillium* wilt, viruses and phytoplasma was observed at Maritsa Vegetable Crop Research Institute, Plovdiv, Bulgaria during two successive years. The diseases severity was recorded, when symptoms of *Verticillium dahliae*, viruses and *Phytoplasma* diseases were deeply expressed. The *Verticillium dahliae* attack index for early production breeding lines varied widely from 15.04% for line O58/14 to 43.83% for O26/16. For kapia type materials, the attack rate of Verticillium wilt ranged from 39.27% (O17/15) to 46.68% (O79/16). The highest index of attack by the disease was established for the powder breeding line (OP69/16) – 49.85%. The viruses which were monitored belong to groups of tobamoviruses, cucumoviruses and tospoviruses and were only 5.00% in breeding lines for early production. The *Phytoplasma* development was from 10.51% (O12/15) to 32.92% (O38/14). It was established that among studied diseases *Verticillium* wilt (42.41%) was more dangerous for studied pepper breeding lines in organic conditions followed by *Phytoplasma* disease (20.67%) and viruses (0.59%).

Keywords: *Capsicum*, infestation, *Verticillium* wilt, viruses, *phytoplasma*

РЕЗЮМЕ

Проучена е реакцията на селекционни линии пипера при условия на органично производство към вертицилийно увяхване, вируси и фитоплазма в в продължение на две последователни години в Институт по зеленчуковите култури Марица, Пловдив, България. Отчита се степента на заразяване, когато симптомите на заболяванията са силно изразени. Индексът на нападение на *Verticillium dahliae* за ранни производствени линии варира в широки граници от 15,04% за линия O58/14 до 43,83% за O26/16. За материали от тип капия степента на нападение на вертицилийно увяхване варира от 39,27% (O17/15) до 46,68% (O79/16). Най-висок индекс на нападение от болестта е установен при линията за мелене (OP69/16) – 49,85%. Вирусите, които са наблюдавани, принадлежат към групи тобамовируси, кукумовируси и тосповируси и са до 5,00% само при линии за ранно производство. Развитието на фитоплазмата е от 10,51% (O12/15) до 32,92% (O38/14). Установено е, че сред изследваните болести вертицилйиното увяхване (42,41%) е по-опасно за изследваните линии за отглеждане на пипер в органични условия, следвано от фитоплазмата (20,67%) и вирусите (0,59%).

Ключови думи: *Capsicum*, нападение, вертицилийно увяхване, вируси, фитоплазма

INTRODUCTION

Global warming poses a great threat to crop production all around the world. The increase in atmospheric temperature in response to global climate change might have serious reactions for crop production and be dangerous for food security (Lobell et al., 2011). Furthermore, continuously increasing populations in the world put pressure on agriculture to produce more crops. The effects of climate change on crop production, cropping system, and soil fertility are expected to be huge but uncertain (Gomiero et al., 2011).

Organic farming is both a philosophy and a system of agriculture, which avoids or largely excludes the use of synthetically produced fertilizers, pesticides and to the maximum extent possible relies upon crop rotations, crop residues, animal manures, legumes, green manures, off farm organic wastes, mineral bearing rocks and bio-fertilizers to maintain soil productivity and to supply plant nutrients and biological means to control insects, weeds and other pests (Stockdale et al., 2001).

Different approaches are used to prevent or control plant diseases by farmers around the world. Beyond good agronomic and horticultural practices, growers often rely heavily on chemical control methods of plant diseases which in return cause dangerous effects to the environment and human and animal health. Various efforts have been made to find less risky options for controlling plant diseases in sustainable agriculture and among which the biological control using effective microorganisms has been demonstrated to be a feasible mechanism (Zucchi et al., 2008).

Indiscriminate use of chemical fertilizers is a common practice which is high risk both for soil health and environment. It has been more than three decades that global agriculture has been depicted towards organic agriculture owing to sustainability and reduced environmental effects (Adhikari et al., 2016).

Cultivation of crops and other plants was crucial and always at risk due to the attack by phytopathogens. Among pathogens, fungi were the predominant pathogens responsible for a range of diseases in plants and a drastic decrease in crop yields. Currently, there was an increasing public concern on the continuous use of agrochemicals to control the pathogens and pests causing diseases in plants (Daulagala, 2021).

The effectiveness of organic amendments is also theorized to change along with climate variation (Lotter et al., 2003). Application of organic manure increases organic elements' availability in soil, thereby improving the nutrient use efficiency of crops and alleviating the harmful impact of climate change on crop production (Lotter et al., 2018).

Microorganisms living in the soil are important for decomposing, mineralizing, and recycling organic matter (Nguyen et al., 2016). Microbial populations intensively induce the production of phytohormones such as gibberellins and auxin in plant roots grown in fertile soil with rich organic manures which stimulate plant growth (Nguyen et al., 2000).

Increased interest in organic farming in recent years has encouraged numerous studies that compare different aspects of organic and conventional food manufacture (Worthington, 2011). Most of these studies indicate certain advantages of organically agricultural outgrowth, primarily in terms of the impact of the fabrication process on the environment, as well as regarding quality properties of products (Szafirowska, 2008, 2009). Some studies, while acknowledging the positive organic yield impact on the environment, suggest that there is no significant difference between the organic and the conventional production system in terms of qualitative properties, yield, and morphological agricultural products characteristics of agricultural products (Hallmann and Rembiałkowska, 2012; Knap et al., 2014a, 2014b).

Todorova and Filyova (2014) reported that variety Stryama realized its yield potential in organic production systems that confirmed its good adaptability. The exceeding towards the control variant of growing was up to 45.32% in system with Lumbrical fertilization and bio pesticides application. Breeding line 1186/06,

kapia type, also demonstrated higher total yield in most organic system but it was with worse fruit characters than in conventional conditions of growing. In the last years our efforts have been directed to development and establishment of genotypes which combine good results for productivity and fruit morphology (Filyova et al., 2022, Filyova and Todorova, 2022). An important part in the process of creating and researching materials suitable for organic production is the evaluation of their response to abiotic and biotic stress factors.

The aim of this study was to compare the reaction of pepper breeding lines developing and grown in organic conditions to different important diseases.

MATERIAL AND METHODS

Pant material

The study was conducted at Maritsa Vegetable Crop Research Institute, Plovdiv, Bulgaria during two successive years on an area in which all requirements for organic agriculture are observed almost ten years (2008). Eight pepper breeding lines developed in these conditions were evaluated for infestation of some important phytopathogenic diseases – verticillium wilt, virus diseases and *Phytoplasma* disease. Three lines of them (O58/14, O38/14, O26/16) were for early (green conical fruits) production and consumption, four (O79/16, O11/15, O12/15, O17/15) were for red kapia fruits production and consumption while pepper line OP69/16 was directed for grinding and powder.

The plants were transplanted in the middle of May in this open field area in an organic producing system by scheme 100+60/15 cm with 30 plants per line. The plants were grown from May to September. The agrotechnical practices including irrigation, fertilization etc. were conducted in the term of organic production.

Disease severity rating

The diseases severity was recorded, when symptoms of *Verticillium dahliae*, viruses (tobamoviruses, cucumoviruses and tospoviruses) and *Phytoplasma* disease were expressly manifested. An infestation index of McKiney (in %) was used and the rate of pathogens attack was reported on scale (0 to 5). The severity was measured on a scale of 0 to 5, where 0 = no vascular discoloration observed, 1 = 1 to 25% of the vascular tissue discolored, 2 = 26 to 50% of the vascular tissue discolored, 3 = 51 to 75% of the vascular tissue discolored, 4 = 76 to 100% of the vascular tissue discolored, and 5 = 100% of the vascular tissue discolored, with foliar wilting also observed (Bhat et al., 1999).

Data analysis

MS Excel 2020 Descriptive Statistics analysis tool was used to generate reports of univariate statistics for the data, providing information about the central tendency and variability of our data. Duncan's multiple range test (Duncan, 1955) was applied to compare the means of studied breeding lines at the significant level $P<0.05$. Standard deviations (SD) were calculated to show the extent of variability in relation to the mean of the population. The results for each individual type of pepper were summarized and processed.

RESULTS AND DISCUSSION

The reaction of pepper breeding lines under organic production conditions to Verticillium wilt, viruses and phytoplasma was observed.

The initial symptoms of the Verticillium disease appeared on the lowest leaves, which lose their turgor, turn slightly yellow and finally curl and dry. Subsequently, the disease also covers the leaves from the upper floors. The roots of diseased plants are fresh, healthy in appearance. In a cross-section of the root neck and the stem, browning of the conducting bundles was observed.

The leaves on infected with viruses' plants were mosaic-colored with pale green or yellowish spots, with dark green stripes remaining only along the main nerves. Fruits were also mosaic gray, sometimes with small necrotic spots.

The observed phytoplasma symptoms were: The upper leaves were curled, snapping, hard when squeezed in the initial phase and yellowish in color. On the underside, the

ribbing was violet colored. Later, chlorosis also covers the lower leaves. Root rot was also observed, starting from the tops, and continuing to the base of the stem.

The *Verticillium dahliae* attack index for early production breeding lines varied widely from 15.04% for line O58/14 to 42.16% for O38/14 and 43.83% for O26/16 (Fig. 1). For kapia type materials, the attack rate of *Verticillium* wilt ranged from 39.27% (O17/15) to 46.68% (O79/16). The highest index of attack by the disease was established in the breeding line for powder (OP69/16) – 49.85%.

During the observation period, the development of viruses in all materials was the weakest in comparison with the other two diseases. The viruses which were monitored belong to groups of tobamoviruses, cucumoviruses and tospoviruses. They were recorded only in all breeding lines for early production, but the average values were very low - 0.13% for O58/14, 0.20% for O26/16 and 5.00% for O38/14. The range of phytoplasma development for early green fruit production genotypes was as follows: O26/16 – 18.18%; O58/14 – 19.23%; O38/14 – 32.92%. Kapia type lines was an index of attack by the disease in the range of 10.51% (O12/15) - 25.00% (O79/16). The attack percentage for genotype OP69/16 was 18.99% (Figure 1).

The lowest statistically proven attack by *Verticillium* wilt observed among lines was found in line 058/14. The data showed that in virus diseases, significant differences were demonstrated between 038/14 and the other lines. Statistically proven groups also formed in the survey for phytoplasmas, with the weakest proven attack in 012/15 (Table 1).

In organic production conditions the reaction to *Verticillium dahliae* of the examined pepper breeding lines was in high values: for early green fruits production - 33.67%, kapia - 43.71% and for powder 49.85%. The minimum reported value was 0%, and the maximum was 73.08%. The coefficient of variation was within wide limits for the three directions (Table 2).

From studied groups of pepper materials, only the lines for early production (green fruits) were affected by viruses but in very low rate (1.77%). The average attack by *Phytoplasma* disease for the three groups of accessions was the lowest for powder– 18.99%, the highest for early production 23.44% and the average for the type kapia 19.59%. The standard deviation was in the range 22.38 – 27.31 (Table 2).

Table 1. Significant differences in diseases severity between breeding lines

Breeding lines	*Verticillium dahliae*, %		Virus diseases, %		*Phytoplasma* disease, %	
For early (green conical fruit) production						
O58/14	15.04	c	0.13	b	19.23	bc
038/14	42.16	a	5.00	a	32.92	a
O26/16	43.83	a	0.20	b	18.18	bc
For Kapia (red fruit production)						
O79/16	46.68	a	0.00	b	25.00	ab
O11/15	42.87	a	0.00	b	24.50	ab
O12/15	46.02	a	0.00	b	10.51	c
O17/15	39.27	ab	0.00	b	18.35	bc
For powder						
OP69/16	49.85	a	0.00	b	18.99	bc

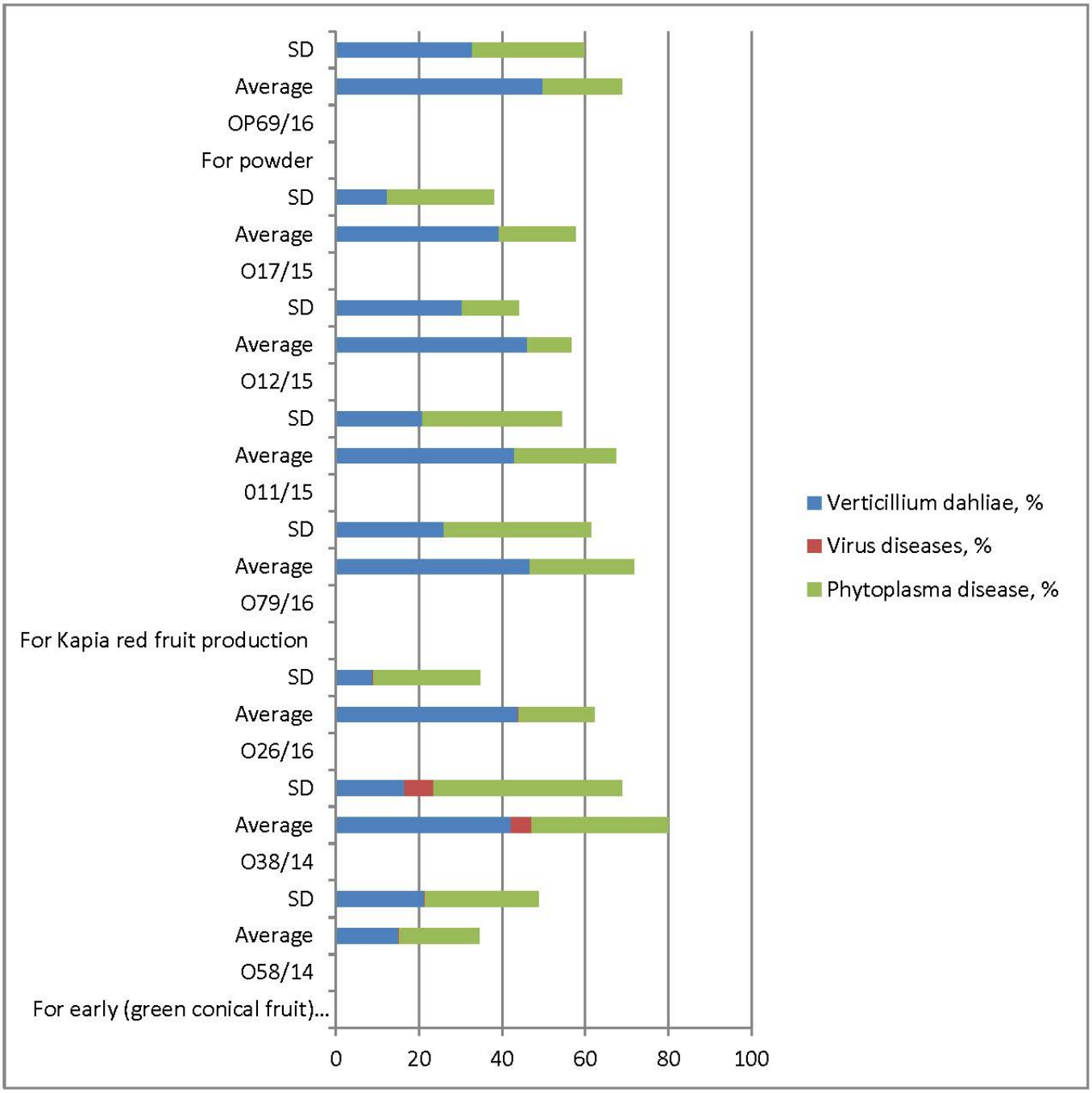

Figure 1. Reaction of pepper breeding lines to diseases in organic conditions

Our results also confirmed the established by Daulagala (2021) that fungal pathogen was predominant among studied diseases. In this connection our last efforts are aimed at the creation and identification of resistant or tolerant accessions to *Verticillium* wilt (Vasileva et al., 2019; Vasileva and Todorova, 2020, 2022). Sweet peppers differ from common hot peppers in size and shape of the fruits, capsaicin content and usage. The fruits were non-pungent and had been widely used in immature or green stages as vegetables for stuffing or for salads. Considered as a high cash crop, it occupied an important rank in world agriculture due to its high profit and nutritional value for human health. Sweet pepper fruits are a rich source of vitamin C, polyphenols, chlorophylls, carotenoids, sugars (Flores et al., 2009), magnesium, calcium, potassium, phosphorus, and iron (Jadczak et al., 2010).

Table 2. Disease severity of phytopathogenic factors, descriptive statistics (DS)

DS	*Verticillium dahlia* %	Virus diseases %	*Phytoplasma* disease %
For early (green conical fruit) production			
Min	0.00	0.00	0.00
Max	53.75	10.00	65.00
Average	33.67	1.77	23.44
SD	19.19	4.03	27.31
For Kapia red fruit production			
Min	24.60	0.00	0.00
Max	67.43	0.00	50.00
Average	43.71	0.00	19.59
SD	17.89	0.00	22.38
For powder			
Min	26.61	0.00	0.00
Max	73.08	0.00	37.98
Average	49.85	0.00	18.99
SD	32.86	0.00	26.86
Total average	42.41	0.59	20.67

The application of commercially available organic fertilizers was seen to be a poor choice. The practice of other organic manures and chemical fertilizers were similar concerning the growth and yield of sweet pepper. The use of high cost-chemical fertilizers could be readily substituted by farm-produced organic sources of plant nutrients and thus aid in sustainable and efficient resource use. However, it was important to note the better results of vermicompost as the source of organic manure in sweet pepper (Adhikari et. al., 2016).

CONCLUSIONS

As a result of the research, it is established that among studied diseases *Verticillium* wilt (42.41%) is more dangerous for studied pepper breeding lines followed by *Phytoplasma* disease (20.67%).

The fungal pathogen attacks to the highest degree the line for powder (49.85%), followed by kapia type lines (43.71%).

The phytoplasma infests the materials from three groups comparatively similar as the degree is from 18.99% in the line for grinding to 23.44% in the lines for early (green fruits) production.

Among all breeding lines only O58/14, for early production, combines a relatively weak infestation from studied pathogens and in this sense it could be recommended as the most suitable for growing in the conditions of organic production.

REFERENCES

Adhikari, P., Khanal, A., Subedi, R. (2016) Effect of Different Sources of Organic Manure on Growth and Yield of Sweet Pepper. Advances in Plants & Agriculture Research, 3 (5), 00111. DOI: https://doi.org/10.15406/apar.2016.03.00111

Albiach, R., Canet, R., Pomares, F., Ingelmo, F. (2002) Microbial biomass content andenzymatic activities after the application of organic amendments to a horticultural soil. Bioresource technology, 75 (1), 43-48. DOI: https://doi.org/10.1016/S0960-8524(00)00030-4

Bhat, R.G., Subbarao, K.V. (1999) Host range specificity in *Verticillium dahliae*. Phytopathology, 89,1218-1225.

Daulagala, W.H., (2021) Chitinolytic Endophytic Bacteria as Biocontrol Agents for Phytopathogenic Fungi and Nematode Pests: A Review. Asian Journal of Research in Botany, 5 (3), 14-24.

Duncan, D. (1955): Multiple range and multiple F-test. Biometrics, 11, 1-42. DOI: https://doi.org/10.2307/3001478

Filyova, P., Todorova, V., Tringovska, I. (2022). Assessment of Productivity in Pepper Varieties and Breeding Lines (*Capsicum Annuum* L.) in Different Systems of Organic Production. Journal of Mountain Agriculture on the Balkans, 25 (2), 301–315.

Filyova, P., Todorova, V. (2022). Breeding Assessment of Fruit Morphological Characters in Pepper Varieties and Breeding Lines (*Capsicum annuum* L.) in Conditions of Organic Production. Journal of Mountain Agriculture on the Balkans, 25 (4), 304–319.

Flores, P., Hellin, P., Fenoll, J. (2009) Effect of manure and mineral fertilization on pepper nutritional quality. Journal of Science, Food and Agriculture, 89 (9), 1581-1586. DOI: https://doi.org/10.1002/jsfa.3627

Gomiero, T., Pimentel, D., Paoletti, M.G. (2011) Environmental impact of different agricultural management practices: conventional vs. organic agriculture. Critical reviews in plant sciences, 30 (1-2), 95–124. DOI: https://doi.org/10.1080/07352689.2011.554355

Hallmann, E., Rembiałkowska, E. (2012) Characterisation of antioxidant compounds in sweet bell pepper (*Capsicum annuum* L.) under organic and conventional growing systems. Journal of the Science of Food and Agriculture, 92 (12), 2409-2415. DOI: https://doi.org/10.1002/jsfa.5624

Jadczak, D., Grzeszczuk, M., Kosecka, D. (2010) Quality characteristics and content of mineral compounds in fruit of some cultivars of sweet pepper (*Capsicum annuum* L.). Journal of Elementology, 15 (3), 509-515.

Knap, M., Kump, P., Nečemer, M., Potočnik, K., Vidrih, R. (2014a) The content of minerals in Slovenian organic and conventional produced fruits, herbs and vegetables. Acta agriculturae Slovenica, 103 (2), 271-279. DOI: http://dx.doi.org/10.14720/aas.2014.103.2.11

Knap, M., Ogrinc, N., Potočnik, K., Vidrih, R. (2014b) Antioxidant activity in selected Slovenian organic and conventional crops. Acta Agriculturae Slovenica, 103 (2), 281- 289. DOI: http://dx.doi.org/10.14720/aas.2014.103.2.12

Liang, S., Li, Y., Zhang, X., Sun, Z., Sun, N., Duan, Y., Xu, M., Wu, L. (2018) Response of crop yield and nitrogen use efficiency for wheat-maize cropping system to future climate change in northern China. Agricultural and Forest Meteorology, 262, 310-321. DOI: https://doi.org/10.1016/j.agrformet.2018.07.019

Lobell, D.B., Schlenker, W., Costa-Roberts, J. (2011) Climate trends and global crop production since 1980. Science, 333 (6042), 616-620. DOI: https://doi.org/10.1126/science.1204531

Lotter, D.W., Seidel, R., Liebhardt, W. (2003) The performance of organic and conventional cropping systems in an extreme climate year. American Journal of Alternative Agriculture, 18 (3), 146-154. DOI: https://doi.org/10.1079/AJAA200345

Nguyen, N.L., Kim, Y.J., Hoang, V.A., Subramaniyam, S., Kang, J.P., Kang, C.H., Yang, D.C. (2016) Bacterial diversity and community structure in Korean ginseng field soil are shifted by cultivation time. PloS one, 11 (5), e0155055. DOI: https://doi.org/10.1371/journal.pone.0155055

Stockdale, E.A., Lampkin, N.H., Hovi, M., Keatinge, R., Lennartsson, E.K.M., Macdonald, D.W., Padel, S., Tattersall, F.H., Wolfe, M.S., Watson, C.A., (2001) Agronomic and environmental implications of organic farming systems. Advances in Agronomy, 70, 260-306. DOI: https://doi.org/10.1016/S0065-2113(01)70007-7

Szafirowska, A., Elkner, K. (2008) Yielding and fruit quality of three sweet pepper cultivars from organic and conventional cultivation. Vegetable Crops Research Bulletin, 69, 135-143. DOI: https://doi.org/10.2478/v10032-008-0028-x

Szafirowska, A., Elkner, K. (2009) The comparison of yielding and nutritive value of organic and conventional pepper fruits. Vegetable Crops Research Bulletin, 71, 111- 121. DOI: https://doi.org/10.2478/v10032-009-0032-9

Todorova, V., Filyova P. (2014) Evaluation of pepper genotypes in different organic production systems. Türk Tarım ve Doğa Bilimleri Dergisi, 1 (Özel Sayı-1), 629-635.

Vasileva K., Todorova V., Masheva S. (2019) Evaluation of collection of pepper (Capsicum spp.) resources for resistance to *Verticillium dahliae* Kleb. Bulgarian Journal of Agricultural Science, 25 (5), 1030–1038.

Vasileva K., Todorova V. (2020) Evaluation of pepper (*Capsicum annuum* L.) varieties to several methods of inoculation with *Verticillium dahliae* Kleb in different conditions. Bulgarian Journal of Agricultural Science, 26 (2), 423–430.

Vasileva K., Todorova V. (2022) Assessment of pepper genetic resources for *Verticillium* wilt resistance. Genetika, Serbia, 54 (2), 829-840. DOI: https://doi.org/10.2298/GENSR2202829V

Worthington, V. (2011) Nutritional quality of organic versus conventional fruits, vegetables, and grains. The Journal of Alternative and Complementary Medicine, 7 (2), 161–173. DOI: https://doi.org/10.1089/107555301750164244

Zucchi, T.D., De Moraes, L.A.B., De Melo, I.S. (2008) Streptomyces sp. ASBV-1 reduces aflatoxin accumulation by *Aspergillus parasiticus* in peanut grains. Journal of Applied Microbiology, 105 (6), 2153-2160. DOI: https://doi.org/10.1111/j.1365-2672.2008.03940.x