DOI: 10.22620/agrisci.2016.20.012

ВЛИЯНИЕ НА БИОЛОГИЧНОТО ТОРЕНЕ ВЪРХУ КАЧЕСТВОТО НА ПЛОДОВЕТЕ ОТ ОРАНЖЕРИЙНИ ДОМАТИ
INFLUENCE OF BIOLOGICAL FERTILIZATION ON THE FRUIT QUALITY OF GREENHOUSE TOMATOES

Костадин Костадинов[1]*, Галина Певичарова[2], Стоян Филипов[1], Красимир Михов[1]
Kostadin Kostadinov[1]*, Galina Pevicharova[2], Stoyan Filipov[1], Krasimir Mihov[1]

[1]Аграрен университет – Пловдив
[2]Институт по зеленчукови култури "Марица" – Пловдив
[1]Agricultural University – Plovdiv
[2]Maritsa Vegetable Crops Research Institute – Plovdiv

***E-mail: kostadinov8@yahoo.com**

Abstract

The experiment was carried out in steel-glass greenhouses at the experimental field of the Agricultural University - Plovdiv with Fado F1 tomato variety. Several variants were tested: 1. N_{44}: P_8: K_{52} + WuksalMacromix; 2. Agrobiosol + Osmo Bio garden + Biofa; 3. Lumbrikompost + Osmo Bio garden + Alga 600 PO 2; 4. Orgamax + Hemozim bio 5 N5P3K6 + Biofa; 5. Evrobio + Lumbrikompost + Hydrolysed proteins + Softgard; 6. Orgamax + Lumbrikompost + Hydrolysed proteins + Softgard; 7. Agrobiosol + Lumbrikompost + Hydrolysed proteins + Softgard; 8. Naturale + Lumbrikompost + Hydrolysed proteins + Softgard. The following planting scheme was applied: 40 + 85 + 70 + 85 + 40 X 42.5 cm in 28,000 plants / ha and food area per plant – 3.400 cm^2. The plants were formed with one stem, the tops were pruned 50 days prior to the last picking. The studied organic fertilizers and their combined application influenced the biochemical content of the fruit to a different extent and in a different way. In phenophase mass fruitingthe highest lycopene content of the tomato fruits the variant fertilization with Evrobio + Lumbrikompost + Hydrolysed proteins + Softgard - 5.71 mg %, and the weight of the fruit at the variant fertilization with Agrobiosol + Osmo Bio garden + Biofa - 173.03 g, the excess over the conventional version N_{44}: P_8: K_{52} + Wuksal Macromix was 14.42%. The variants with the best indicators were the variants with organic fertilization by Orgamax + Lumbrikompost + Hydrolysed proteins + Softgard; Agrobiosol + Lumbrikompost + Hydrolysed proteins + Softgard and Naturale + Lumbrikompost + Hydrolysed proteins + Softgard, which significantly exceeded the control.

Key words: biological production, vegetative behavior, tomatoes, greenhouses, quality.

INTRODUCTION

Organically grown vegetables are an opportunity for effective production and a variant for healthy nutrition. Except the organic production that is obtained in this way, a lot of authors indicate high quality as well. In a number of which form the quality of the organically and conventionally grown vegetables in the open are compared. (Vlahova, 2012; Akimasa, 2003). More in this direction have been conducted in greenhouse conditions with tomato as main vegetable (Montero et al., 2008; Reinaldo et al., 2008; Rosales et al.2011; Sima et al., 2010, Pevicharova and others, 2013). The products received ambiguous and are significantly affected by the soil and climatic conditions, the terms for the production and the sort.

In order to clarify the influence of organic fertilizers on tomatoes grown under greenhouse conditions in Bulgaria, a study was conducted which defined some biochemic indicators of the quality as compared with the conventional production.

MATERIALS AND METHODS

For the period 2012-2014 a soil experiment with 8 variants was set to study some elements of a technology for organic tomato production. The influence of the fertilization with organic fertilizers on the biologic performance, the productivity, and the quality of greenhouse tomatoes grown under the late production technology was studied.

The experimental work was taken out to the steel glasshouses of the experimental field of the Agricultural University – Plovdiv, with indeterminate tomatoes – *Fado F_1* variety. The plants were grown by soil planting and watered by a drip irrigation system. Organic agents were applied as plant protection. In order to establish the effect of the used organic fertilizers, 15 variants were tested on the tomato plants:

The organic fertilizers for basic fertilization were applied with the pre-plant soil cultivation in the following norms: *Agrobiosol* - 120 kg/da; *Orgamax* - 150 kg/da; *Eurobio* - 50 kg/da; *Naturale NPK 8-8-6* - 100 kg/da, *Lumbricompost* – 400 l/da.

In the control variant with mineral fertilization, the phosphorus and potassium were applied with the pre-plant tillage in the form of triple superphosphate and potassium sulphate. The nitrogen was applied in equal doses through four-time feeding from the *beginning of fruit formation* phenophase at an interval of 15 days.

Osmo Bio garden was introduced at the rate of 100 kg/da in four-time feeding from the *beginning of fruit formation* phenophase at an interval of 15 days.

A four-time feeding by means of fertigation was applied with *Hemozim* and hydrolysed plant protein from the *beginning of fruit formation* phenophase at an interval of 15 days in a dose of 80 l/ha.

The foliar spray was performed at temperatures up to 26°C by means of a knapsack sprayer, twice at an interval of 10 days, the first treatment performed 3 weeks after planting. The *Alga 600* treatment dose was 50 g/da; the Biofa treatment dose was 0.5 %; the Softgard treatment dose was 125 ml/da.

The seedlings were grown in a heated steel-glasshouse, the period for sowing being the first ten days of January, and planting – the middle of March. The field experiment was set in 4 replications with 14 plants in each. The following planting scheme was applied: 40+85+70+85+40 X 42.5 cm with 28,000 plants/ha and nutritional area per plant of 3,400 cm^2. The plants were formed with one stem, the tops were pruned 50 days prior to the last picking.

Indicators of the study:

1. Biochemical analyses of tomatoes – in botanical ripeness, with average samples of 20 fruits for each variant, the following indicators were defined: the content of dry matter by refractometer, the ascorbic acid after *Tillman's* reaction method (Genadiev A., et al.1969), the titratable organic acids through direct titration of the juice with 0.1 NaOH, common colors and lycopene after Manuelyan (1991). The analyses were performed during the initial and mass fruit-bearing, and at the end of vegetation.

2. Morphological characteristics of the fruit – at the beginning and mass fruit-bearing the following indicators were defined: fruit mass in grams; number of locules; thickness of the pericarp in mm; fruit hardness in kg/cm^2; diameter in mm; height in mm; the I = h /d index.

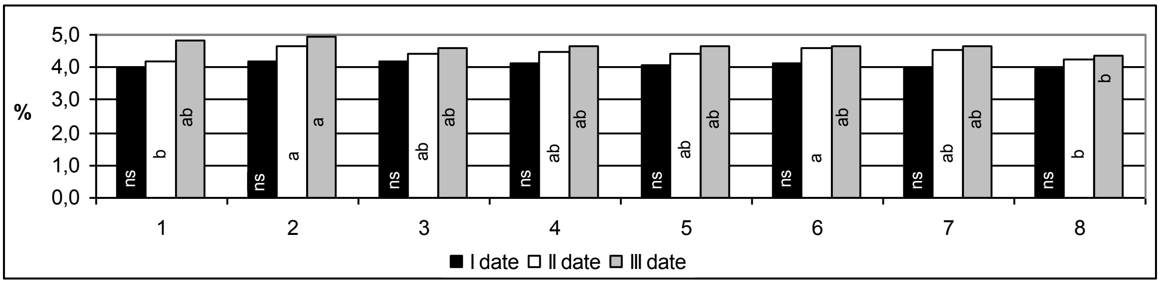
RESULTS AND DISCUSSION

The soluble solids are a basic indicator of the biochemical components that have influence on the quality of the fruits. It is a characteristic feature of the sort, but to a certain extent it is influenced by the technology and the climatic conditions. This indicator was rather influenced by the applied fertilization with organic fertilizers and a combination between them. Most of the variants with organic fertilizers demonstrated higher values than the control one with mineral fertilization. In 2012 it varied from 3.8 % at the control, measured at the beginning of fruit-bearing, to 5.7 % at the end of vegetation (Figure 1). A tendency for an increase of the soluble solids with increased t^0 C was noticed as well as of the illumination in all the variants with organic fertilizers and the control one. The highest values were measured at the end of the picking period. Under the conditions of suitable microclimate the fertilization with organic fertilizers led to the formation of fruits with higher va-lues compared to the control one. It was an ambiguous influence. At the beginning of the picking period the maximum was with variants 3, 6 and 7 – 4.0 %, and during the weight picking period, the maximum result was with variant 5, respectively, 4.8 %.

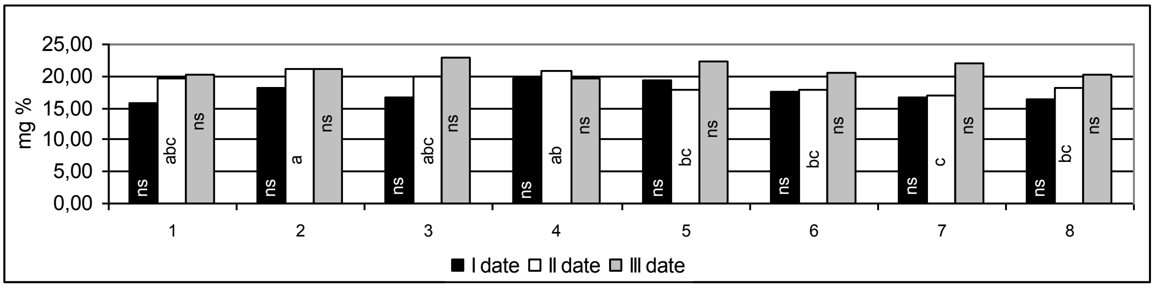
In 2013 the noted tendencies about soluble solids from the first year were preserved. A slight variation was noted between the minimum and maximum values and the higher initial levels, measured at the beginning of the picking period (Figure 1). During that year, most of the variants with organic ferlilization had higher or equal values compared with the control one.

Similar results and preserved tendency from the previous two years were measured also in 2014 – the soluble solids varied from 4.0 % at the beginning of the picking period with the control variant to 5.0 % at the end of the picking period with variant 2 (Figure 1). Most of the studied variants with organic fertilizers formed fruit with soluble solids, equal to or higher than the control one.

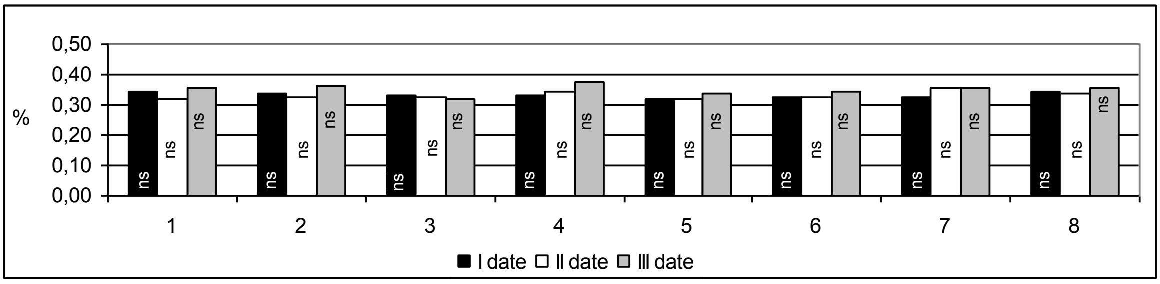
As a whole, it can be noted that with organic production, the fertilization with some types of organic fertilizers increases the contents of soluble solids as a result of the influence of the applied fertilizers, the combination between them, and the climatic conditions during the period of picking.



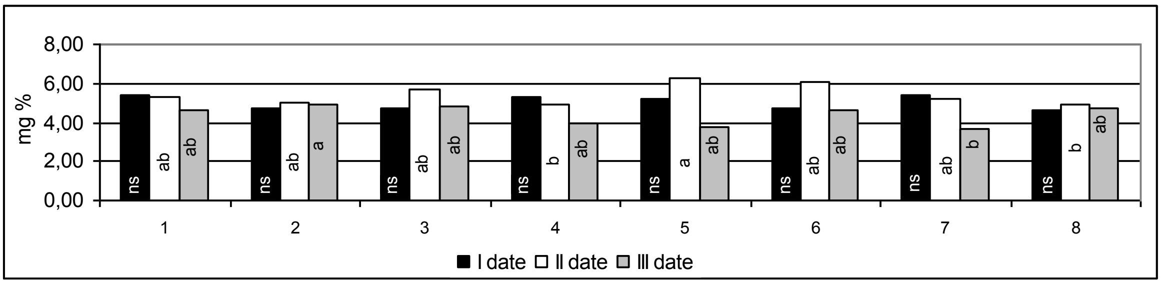
a) Soluble solids



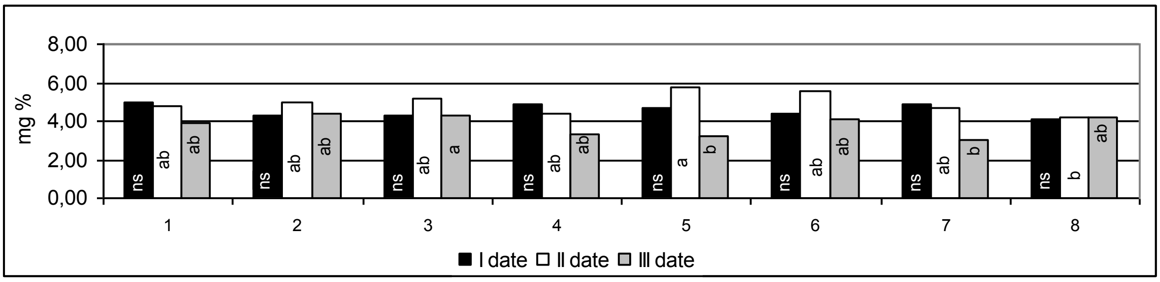
b) Ascorbic acid



c) Titratable organic asids



d) Total pigments



e) Lycopene

Fig. 1. *Basic chemical components of the investigated tomatoes*
(The results are statistically processed by Duncan)

One of the components forming the higher biological value of the tomato fruit is the content of ascorbic acid.

In 2012 the values of this indicator varied between 10.58 and 13.34 mg % for the beginning of the picking period (Figure 1).

During the weight fruit-ripening and the end of the picking period, with improved climatic conditions, the values of ascorbic acid increased, varying from 14.7 to 18.4 mg %, for the second recording, and increase from 10.7 to 20.7 mg % for the third recording. An increase of the values of the ascorbic acid was noted at the 2nd and 3rd recording of the control and the studied variants with organic fertilizers.

In most variants, the fertilization with organic fertilizers led to the formation of fruits with a higher content of vitamin C.

During the second year of the experiment (2013) similar tendencies were noted as compared to the previous one. The values from the initial to the weight picking period increased, and the higher varia-tion between the variants during the weight picking period at the end of harvesting. (Figure 1).

The last year of the study confirmed the conclusions from the first two. A slightly stronger varying between the separate variants was observed, respectively from 19.1 to 30.5 mg % at the beginning of the picking; from 19.1 to 27.2 for weight picking and at the end of the picking season it was between 20.0 and 31.0 mg %.

Organic fertilization has shown great influence with this indicator as well but it is not unidirectional. There are variants which show maximal or values close to them - 30.1 mg %, with variant 3 in 2014, but there are also low values - variant 1 and variant 7, with 19.1 mg % in 2012. Those results showed that the indicator was strongly influenced by the climatic conditions.

The level of the titratable organic acids and their ratio to the overall sugars was of great importance.

Organic acids are a biochemical component, which is relatively more stable and characteristic for the separate sorts. However, varying was observed under the influence of the studied factors.

During the first and second year of the experiment the varying at the initial and the weight fruit-bearing is similar. For 2013 the levels were 0.32–0.37 % at the beginning of fruit-bearing and 0.33–0.37 % in the weight fruit-bearing (Figure 1). The values were similar in 2012 as well, respectively 0.33–0.37 % and 0.32–0.37 % at the initial and the weight fruit-bearing.

Slightly lower levels were indicated in the last year of the experiment (2014), and there was almost no difference in the separate periods of picking: 0.28–0.34 % first reporting, 0.29–0.36 % with weight picking and 0.27–0.35 % at the end of the picking.

The common colours and lycopene, in particular, are essential for the formation of organic value of the tomato fruits. The even and intensive coloring of the fruit is a major factor when assessing the production.

The common colours are positively influenced by the applied organic fertilization and in most of the studied variants they are with increased content. In 2012, at the beginning of fruit-bearing, values between 4.78 and 5.96 mg % were measu-red, and they slightly changed during the period of weight fruit-bearing, respectively, 4.42 to 7.41 mg %, the maximum value reached only in variant 5 (Figure 1). A significant decrease was measured at the end of the fruit-bearing period, when levels of 3.49 to 5.34 mg % were observed.

The second year did not show any significant differences of this indicator, as the values measured in all three dates of the performed analyses were similar and varied as follows: 1st recording – from 4.06 to 6.14 mg %, 2nd recording – from 4.97 to 6.65 mg %, and 3rd recording – from 4.72 to 6.12 mg %.

The third year of the experiment preserved the tendencies of the previous one, but with lower minimum and maximum levels. At the beginning of the picking period they varied from 3.47 to 5.35 mg %. They were the same during the period of weight fruit-bearing with levels from 3.62 to 5.92 mg % and there was a significant decrease at the end of the fruit-bearing – from 2.57 and 5.30 mg %. The lower values can be explained with the cooler, more rainy and cloudy year of 2014.

In some of the variants (5, 6) the values were higher, while in others – 1, 4, 5, they were lower.

The same tendencies were observed also for lycopene, which is a main component of the common colours. Average for the period a greater number of embodiments had higher values than the control during all phenophases.

The quality of greenhouse tomato fruits was defined by means of their morphological characteristics. The morphological indicators of the fruits are characteristic of the sort, but they are influenced also by the growing conditions and the applied agricultural technique, which defines their significance for the correct regulation of the nutritional regimen (Table 1).

Table 1. Morphological characteristics of fruit from tomatoes, 2012-2014

Phenophase	Variant №	Diameter				Height				Index				Number of locules			
		2012	2013	2014	Average	2012	2013	2014	Average	2012	2013	2014	Average	2012	2013	2014	Average
		mm				mm				I = h /d				бр.			
Beginning of fruiting	1	72.18	65.90	69.50	69.19	58.14	57.1	52.4	55.88	0.81	0.87	0.75	0.81	3.80	3.40	3.40	3.53
	2	70.83	70.40	71.30	70.84	56.53	57.2	57.2	56.98	0.80	0.81	0.80	0.80	3.20	3.80	3.80	3.60
	3	70.60	74.20	74.10	72.97	55.5	60.3	55.8	57.20	0.79	0.81	0.75	0.78	3.60	4.20	4.40	4.07
	4	72.15	73.00	72.10	72.42	59.92	59.2	55.9	58.34	0.83	0.81	0.78	0.81	3.40	3.00	4.20	3.53
	5	71.80	71.00	71.40	71.40	59.55	57.9	53.8	57.08	0.83	0.82	0.75	0.80	4.00	3.40	3.80	3.73
	6	72.90	73.00	70.50	72.13	56.53	57.6	55.9	56.68	0.78	0.79	0.79	0.79	3.60	3.40	4.40	3.80
	7	71.60	72.50	72.80	72.30	58.64	58.1	55.5	57.41	0.82	0.80	0.76	0.79	2.80	3.20	3.60	3.20
	8	71.60	73.40	72.20	72.40	56.2	59.7	55.4	57.10	0.78	0.81	0.77	0.79	3.00	3.60	4.20	3.60
Mass fruiting	1	68.00	71.40	68.50	69.30	58.8	59.2	55	57.67	0.86	0.83	0.80	0.83	3.20	3.80	2.60	3.20
	2	69.60	74.20	71.30	71.70	61.4	59.6	57.1	59.37	0.88	0.80	0.80	0.83	3.40	3.80	3.00	3.40
	3	70.00	72.40	66.10	69.50	59.9	58.6	54.6	57.70	0.86	0.81	0.83	0.83	3.40	2.80	3.20	3.13
	4	68.20	72.20	65.30	68.57	59.7	59.6	53.6	57.63	0.88	0.83	0.82	0.84	3.40	3.20	2.80	3.13
	5	67.10	72.40	68.30	69.27	58.4	59.4	54.7	57.50	0.87	0.82	0.80	0.83	3.60	3.40	3.20	3.40
	6	69.00	74.80	68.20	70.67	57.3	61.2	55.1	57.87	0.83	0.82	0.81	0.82	3.00	3.80	3.00	3.27
	7	68.00	73.80	69.80	70.53	57.4	61.2	55.6	58.07	0.84	0.83	0.80	0.82	3.60	3.00	3.20	3.27
	8	68.60	72.60	69.70	70.30	57.6	62	55.9	58.50	0.84	0.85	0.80	0.83	3.80	3.00	3.00	3.27

Table 1. (Contunied)

Phenophase	Variant №	Mass								Thickness of the pericarp				Hardness of the fruit			
		2012		2013		2014		Average		2012	2013	2014	Average	2012	2013	2014	Average
		g	%	g	%	g	%	g	%	mm				kg			
Beginning of fruiting	1	166,20	100,00	148,40	100,00	147,30	100,00	153,97	100,00	9.44	10.00	7.80	9.08	3.63	5.30	7.38	5.44
	2	158,90	95,61	159,30	107.35	156,90	106,52	158,37	102,86	10.64	11.10	9.40	10.38	4.39	6.09	8.84	6.44
	3	158,60	95,43	170,30	114.76	166,80	11324,00	165,23	107,32	10.44	11.40	8.80	10.21	4.03	5.74	8.34	6.04
	4	173,60	104,45	156,80	105.66	166,70	113,17	165,70	107,62	10.56	10.90	8.80	10.09	4.19	5.78	7.72	5.90
	5	164,60	99,04	162,10	109.23	135,90	92,26	154,20	100,15	10.92	10.90	8.80	10.21	4.64	5.83	10.10	6.86
	6	165,70	99,70	169,30	109.23	155,90	105,84	163,63	106,28	11.00	11.40	7.60	10.00	2.41	5.68	8.24	5.44
	7	161,60	97,23	167,20	112.67	163,20	110,79	164,00	106,52	10.00	11.60	8.20	9.93	3.72	5.59	9.22	6.18
	8	158,30	95,25	173,90	117.18	160,90	109,23	164,37	106,75	10.68	11.60	7.60	9.96	3.63	5.26	8.66	5.85
Mass fruiting	1	143,50	100,00	149,70	100,00	160,50	100,00	151,23	100,00	9.56	9.80	8.00	9.12	4.03	4.82	5.42	4.76
	2	163,40	113,87	175,20	117,03	180,50	112,46	173,03	114,42	10.04	10.10	7.40	9.18	4.87	4.36	5.86	5.03
	3	162,60	113,31	169,50	113,23	146,30	91,15	159,47	105,45	10.00	10.20	6.60	8.93	5.40	4.82	5.56	5.26
	4	158,00	110,10	166,70	111,36	139,50	86,92	154,73	102,32	9.76	9.70	7.00	8.82	4.57	4.77	4.88	4.74
	5	162,30	113,10	165,80	110,75	155,40	96,82	161,17	106,57	9.64	10.20	7.20	9.01	5.05	5.44	5.00	5.16
	6	160,60	111,92	175,60	117,30	153,40	95,58	163,20	107,92	9.96	10.10	7.00	9.02	4.84	4.49	4.46	4.60
	7	162,60	113,31	179,50	119,91	162,30	101,12	168,13	111,18	10.60	10.80	7.60	9.67	4.76	4.44	4.82	4.67
	8	165,00	114,98	177,20	118,37	163,30	101,74	168,50	111,42	9.92	11.10	7.80	9.61	4.34	5.01	5.10	4.82

The weight of the fruit (Table 1) is of great economic significance for the production of tomatoes in steel glass-houses with spring planting. Concerning this indicator, the tested variants were higher or lower than the control in accordance with the applied scheme of organic fertilization.

During the phenophase *beginning of fruit-bearing* all the studied variants had big fruits and weight of over 100 g, outweighing the control variant. Variants 4, 3, 8, 7 and 6 had very big fruits of between 164 and 166 g and they outweighed the control by 6.28 % to 7.62 %.

During the *mass fruit-bearing* period all stu-died variants had higher fruit weight compared with that of the control, the out weight being 2.32 in Orgamax + Hemozim bio 5 $N_5P_3K_6$ + Biofa up to 14.42 % in Agrobiosol + Osmo Bio garden + Biofa.

The linear measures (h and d) were slightly influenced by the organic fertilization. Part of variants 2, 6, 7 and 8 exceeded the control to a different degree during the *beginning* and *mass fruit-bearing* periods. The results were influenced by the specific climatic conditions of the respective year. A stronger stimulating effect was reported at the *beginning of fruit-bearing*, fading away during *mass fruit-bearing.*

No significant differences are observed in the number of locules between the control and the tested variants. Variant 3 had a lot of locules (4.07), and the other variants had a few (3.13-3.60).

The pericarp thickness was positively influenced by the organic fertilization. Almost all variants showed better values of that indicator as compared with the control at the *beginning of fruit-bearing*. During the *mass fruit-bearing* period the effect weakened, the climatic conditions of the year being a strong factor for the expression of the above indicator.

An important market indicator is the hardness of the fruit. This indicator was higher than the control one in half of the studied variants (2, 3, 5, 8), the difference being from 0.06 to 0.50 kg.

CONCLUSIONS

The application of organic fertilization to greenhouse production of tomatoes improved the fruit quality of most variants, expressed by the analysed biochemical indicators.

The studied organic fertilizers and their combined application influenced the biochemical content of the fruits to a different extent and in a different way. In phenophase *mass fruiting* the highest lycopene content of the tomato fruits the variant fertilization with Evrobio + Lumbrikompost + Hydrolysed proteins + Softgard - 5.71 mg %, and the weight of the fruit at the variant fertilization with Agrobiosol + Osmo Bio garden + Biofa.

The morphological characteristics of the fruits from plants grown organically are similar to those grown by conventional fruit production. In *mass fruiting* the weight of fruits other is the high variant at fertilization Agro Biosol + Osmo Bio garden + Biofa-173.03 g, the excess over the conventional version N_{44}: P_8: K_{52} + Wuksal Macromix being 14.42 %.

The variants with the best indicators were the variants with organic fertilization by Orgamax + Lumbrikompost + Hydrolysed proteins + Softgard; Agrobiosol + Lumbrikompost + Hydrolysed proteins + Softgard and Naturale + Lumbrikompost + Hydrolysed proteins + Softgard, which significantly exceed the control one.

ACKNOWLEDGEMENT

The Research team expresses their sincere gratitude to the Agricultural University – Plovdiv, which finance was made possible by the implementation of the project.

REFERENCES

Vlahova, V., 2012. Prouchvane kachestvoto na plodovete ot piper (Capsicum annuum L.) pri prilagane v usloviyata na biologichno zemedelie. Ekologia i badeshte, XI, № 4, 39–45.

Genadiev, A., D. Kalcheva., N. Nenchev., N. Tevekeliev, N. Chavdarova, 1969. Analiz na hranitelnite produkti. Tehnika, Sofia, s. 695.

Pevicharova, G., K. Kostadinov, S. Filipov, 2013. Vliyanie na substrata varhu kachestvoto na oranzheriyni domati. Nauchni trudove tom IX “Hranitelna nauka, tehnika i tehnologii – 2013“ 18-19 oktomvri 2013, Plovdiv. Tehnologia na hranite, Nauchno napravlenie „Himichen i mikrobiologichen analiz i kontrol na hranite”, str. 674–678.

Nakano, Akimasa, 2003. Effect of organic and inorganic fertigation on yields, values of tomato (Lycopersicon esculentum Mill. cv. Saturn). Plant & Soil; Aug, Vol. 255 Issue 1, 343–349.

Manuelyan, H., 1991. Express methods for assessing the carotenoid composition of tomato fruits (in G.Kallo. Genetic improvement of tomato) Spring –Velag, 193–195.

Montero, L., Duarte, C., León, M., Cun, R., Rodríguez, B., 2008. Ecological fertigation for tomato cropping under greenhouses conditions. Revista Ciencias Técnicas Agropecuarias; 2008, Vol. 17 Issue 3, p 18–21, 4p, 9 Charts.

Rosales, M. A.; Cervilla, L. M.; Sánchez-Rodríguez, E.; Rubio-Wilhelmi, M. del M.; Blasco, B.; Ríos, J. J.; Soriano, T.; Castilla, N.; Romero, L.; Ruiz, J. M., 2011. The effect of environmental conditions on nutritional quality of cherry tomato fruits: evaluation of two experimental Mediterranean greenhouses. Journal of the Science of Food and Agriculture 91 (1) Chichester: John Wiley & Sons, 2011, 152–162.

Sima, Rodica M.1 , Măniuţiu, D. Nicolae1, Cenariu, Diana1, Lazăr, Vasile1, Sima, Nicuşor F.1, 2010. The impact of culture system and fertilization type on yield and fruit quality of greenhouse tomatoes. Advances in Agriculture & Botanics; 2010, Vol. 2 Issue 1, 49–54.

Dimitrov, Y., N. Palagacheva, 2012. Risky periods of pesticide (insecticide and fungicide) pollution of vegetables grown in greenhouses. Agroznanje, vol. 13, br. 1, Stručni rad. Professional paper. UDK: 632.95.028. DOI: 10.7251/AGREN1201153D. University of Banjaluka, Fculty of agriculture, Agro Knowledge Journal, 153–158.