J. Elementol. 2008, 13(4): 491-499

EVALUATION OF CHERRY TOMATO YIELDING AND FRUIT MINERAL COMPOSITION AFTER USING OF BIO-ALGEEN S-90 PREPARATION

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Abstract

The aim of the experiments carried out in a high, polyethylene in the years 2004--2006 was to examine the influence of the algae preparation Bio-algeen S-90 on yield, mineral composition of fruits, content of assimilatory pigments, intensity of assimilation and transpiration and photosynthetic water use efficiency index of the cherry tomato cv. Conchita F_1. The results on tomato yields proved significant differences in total and marketable yield under the influence of Bio-algeen. The biggest total and marketable yields were obtained when plants were treated three times with Bio-algeen. Bio-algeen also caused increase in content of mineral components in cherry tomato fruits. Three- and fourfold sprays increased the content of total nitrogen, phosphorus, potassium, calcium, zinc, iron and nitrates. Treating tomato plants with the preparation increased the content of assimilatory pigments of tomato. Increase in a number of Bio-algeen sprays led to higher contents of total, a and b chlorophyll and carotenoids in leaves. Intensity of assimilation and transpiration of the plants and water use efficiency index depended on number of plants spraying with Bio-algeen. Plants sprayed two and three times with Bio-algeen were characterized by greater transpiration and assimilation intensity, but also by smaller efficiency of water use index.

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Key words: vegetables, seaweeds, content of bioelements, water use efficiency index.

OCENA PLONOWANIA I SKŁADU MINERALNEGO OWOCÓW POMIDORA DROBNOOWOCOWEGO PO ZASTOSOWANIU PREPARATU BIO-ALGEEN S-90

Abstrakt

Celem badań prowadzonych w wysokim tunelu foliowym, w latach 2004-2006, było określenie wpływu stosowania preparatu z alg morskich Bio-algeen S-90 na plon, skład mineralny owoców, zawartość barwników asymilacyjnych, intensywność asymilacji i transpiracji oraz wskaźnik efektywności wykorzystania wody w procesie fotosyntezy roślin pomidora drobnoowocowego odmiany Conchita F_1. Wykazano istotne różnice w plonie ogółem i handlowym pod wpływem traktowania roślin preparatem Bio-algeen S-90. Największy plon ogółem i handlowy owoców uzyskano w przypadku 3-krotnego oprysku preparatem. Preparat Bio-algeen wpłynął również na zwiększenie zawartości składników mineralnych w owocach pomidora drobnoowocowego. Opryskiwanie 3- i 4-krotne roślin zwiększyło poziom azotu ogólnego, fosforu, potasu, wapnia, cynku, żelaza oraz azotanów. Traktowanie roślin preparatem zwiększyło zawartość barwników asymilacyjnych u pomidora. Zwiększanie liczby oprysków preparatem Bio-algeen wpłynęło na wyższą zawartość chlorofilu a, b i całkowitego oraz karotenoidów w liściach. Intensywność asymilacji i transpiracji roślin oraz wskaźnik efektywności wykorzystania wody zależał od liczby oprysków preparatem Bio-algeen. U roślin, które opryskiwano 2- i 3-krotnie, stwierdzono większą intensywność transpiracji i asymilacji, ale mniejszy wskaźnik efektywności wykorzystania wody.

Słowa kluczowe: warzywa, algi morskie, zawartość biopierwiastków, wskaźnik wykorzystania wody.

INTRODUCTION

Bio-algeen is a natural extract from sea thallophytic algae containing a brown pigment. It contains over seventy active components: macro and microelements (Czeczko and Mikos-Bielak 2000). It is a source of the following chemical elements: nitrogen (0.02%), potassium (0.096%), phosphorus (0.006%), magnesium (0.21%), calcium (0.31%), iron (6.3 $mg \cdot kg^{-1}$), boron (16 $mg \cdot kg^{-1}$), molybdenum, cobalt and selenium (Patier et al. 1993).

The aim of using extracts from sea algae in tomato cultivation is to form a strong, well developed root system (Pertuit 1995). Om addition, biostimulators enhance plants' tolerance to uncomfortable growth conditions (water deficiency, temperature changes, diseases attack). Another important role of biostimulators is to increase assimilation rate and availability of nutrients. They also improve plants' growth, flowering and fruit setting as well as increase yield and quality of fruits (Becket and Van Standen 1989, Wysocka-Owczarek 2001).

Using extracts from sea algae in plants cultivation enhances the chlorophyll content in leaves. Chlorophyll level depends on betanine level in seaweed extract (Blunden et al. 1996).

MATERIAL AND METHODS

In 2004-2006 experiments were carried out at the Department of Vegetable Crops of the University of Agriculture in Szczecin to examine the influence of the sea algae preparation Bio-algeen S-90 on yield, chemical composition of fruits, content of assimilatory pigments and intensity of plant assimilation and transpiration in the cherry tomato cv. Conchita F_1. Tomatoes were cultivated in a high, unheated polyethylene tunnel.

Tomato seeds were sown in a greenhouse on 20th March and seedlings were planted on 20th May 2004 and on 17th May 2005 and 2006 in an unheated foil tunnel in rows, using row spacing 1.4 x 0.25 m. The surface area of every plot was 3.5 m^2 (10 plants on the plot of ground).

Bio-algeen S-90 preparation was used in concentration 0.3% in the form of spraying conducted one, two, three and four times. A dose of 1 ml of Bio-algeen was applied to each plot every time. The first spraying was carried out at the stage of 2-3 proper leaves, second – before planting, third – at the beginning of flowering, fourth – at the initial stage of plants yielding.

Plants were headed in the first decade of July behind the sixth cluster. During the plant vegetation period the biometrical measurements were carried out (height of plant, diameter of stem, number of leaves, number of flowers and fruits).

Harvest of fruits was conducted from the third decade of July to the first decade of September. After the harvest total and marketable yield were evaluated.

Content of carotenoids and chlorophyll a and b were estimated in leaves. After the harvest, chemical analyses of macro- and microelements content were carried out. Total nitrogen was estimated according to the method recommended by Kjeldahl, phosphorus – according to the colorimetric method, potassium, magnesium, calcium; iron and zinc were estimated in a plasma spectrometer. Nitrate nitrogen (N-NO_3) content was estimated according to the potentiometric method. Chlorophyll content was estimated according to the method recommended by ARNON et al. (1956) in LICHTENTHALER and WELLBURN modification (1983). The measurements of gas exchange were carried out by the means of a gas analyser IRGA LCA-4 working in an open system.

The experiment was conducted in a randomized blocks design, in four replications. Results were statistically verified by Tukey's test at the significance level α = 0.05.

RESULTS AND DISCUSSION

Results regarding tomato yielding proved significant differences in total and marketable yield under the influence of Bio-algeen. The greatest total and marketable tomato fruit yield was obtained in the years 2004-2006 when plants were sprayed three times with the preparation (Figure 1). Synthesis of the experimental results proved that the total yield in this case amounted to 6.64 kg·m^{-2} and was on average 1.2 kg·m^{-2} greater than the yield of a control combination and of the combination where Bio-algeen was used once. The marketable yield, obtained from the control plants and from those plants which were treated only once with Bio-algeen was significantly smaller, by an average 1.27 kg·m^{-2}.

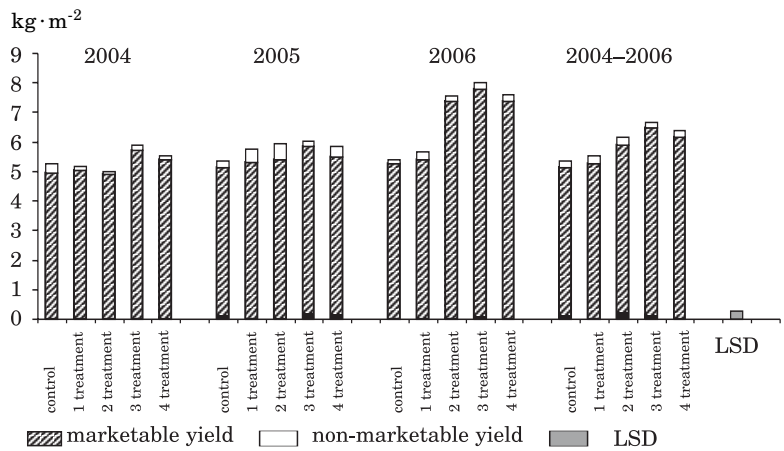

Fig. 1. The influece of Bio-algeen treatment on the yield of small-sized tomato in the years 2004-2006

Tomato is an important source of mineral salts, especially of potassium. Nurzyński and Michałojć (1998) determined 0.29-0.35% P, 3.84-3.95% K, 0.10--0.11% Ca and 0.17-0.18% Mg in tomato fruit dry matter. Kobryń (2002) noticed the mineral composition of tomato fruits is highly variable between cultivars. In the years 2002-2003 Dobromilska and Kujath (2004) estimated the levels of macroelements (g·kg^{-2}) as N 22.6, P 5.43, K 31.2, Ca 1.63, Mg 1.4 and microelements (mg·kg^{-1} d.m.) as Fe 80 and Zn 24.13 in fruit of the cherry tomato cv. Conchita F_1 cultivated in a high, polyethylene tunnel.

The chemical analyses of tomato fruits proved that in 2004 fruits contained more total-N, P, Ca, Mg and Zn and less K and Fe in comparison with 2005 (Table 1). During fruit ripening in 2004 the weather conditions were very convenient (greater insolation). Koźmiński and Michalska (2004) observed that insolation in Poland is a highly varied factor. The results

Table 1

The effect of Bio-algeen S-90 spraying on minerals and nitrates in cherry tomato fruits cv. Conchita F_1

Number of treatments	Year	Macroelements ($g \cdot kg^{-1}$ d.m)					Microelements ($mg \cdot kg^{-1}$ d.m)		Nitrates (mg $NO_3^- \cdot kg^{-1}$ d.m)
		N	P	K	Ca	Mg	Zn	Fe	
Control	2004	20.50	5.10	24.90	1.70	1.40	20.0	60.0	205.0
	2005	16.10	4.86	31.85	1.55	1.03	11.0	170.0	200.0
	x	18.30	4.98	28.38	1.63	1.22	15.5	115.0	202.5
1 treatment	2004	20.80	5.90	26.70	1.70	1.40	20.0	80.0	220.0
	2005	15.89	5.54	31.85	1.55	1.05	14.0	170.0	200.0
	x	18.35	5.72	29.28	1.63	1.23	17.0	125.0	210.0
2 treatments	2004	20.60	5.90	26.30	1.70	1.40	20.0	80.0	245.0
	2005	16.52	5.92	31.85	1.94	1.03	14.0	180.0	210.0
	x	18.56	5.91	29.08	1.82	1.22	17.0	130.0	227.5
3 treatments	2004	21.65	6.40	28.20	2.10	1.30	28.0	100.0	235.0
	2005	16.52	5.82	32.37	1.74	1.03	14.0	180.0	210.0
	x	19.09	6.11	30.29	1.92	1.17	21.0	140.0	222.5
4 treatments	2004	23.50	6.40	28.60	1.90	1.30	26.0	80.0	245.0
	2005	17.64	5.28	32.79	1.55	1.00	14.0	180.0	230.0
	x	20.57	5.84	30.70	1.73	1.15	20.0	130.0	237.5
Mean		18.97	5.71	29.55	1.75	1.20	18.1	128.0	220.0
$LSD_{\alpha=0.05}$		0.85	0.41	1.22	0.09	n.s.	1.20	13.8	15.5

of our chemical analyses on samples obtained in 2004-2005 proved that total-N content increased with increase of the preparation doses. Fruits obtained from plants sprayed four times with Bio-algeen accumulated most total-N. Content of total-N increased in comparison with the control object by 2.22 $g \cdot kg^{-1}$ d.m. Phosphorus content in fruits also increased from 4.98 $g \cdot kg^{-1}$ d.m. in the control object to 6.11 $g \cdot kg^{-1}$ d.m. when plants were treated three times with Bio-algeen. All the sprayings increased significantly P content in comparison with control.

Bio-algeen sprays significantly differentiated potassium content in tomato fruits, which in turn affected their colour. The preparation used three and four times increased K level in fruits to 30.49 $g \cdot kg^{-1}$ d.m. on average, whereas fruits of control plants contained by 2.11 $g \cdot kg^{-1}$ d.m. less potassium.

Table 2

The influence of Bio-algeen S-90 spraying on the assimilatory pigments content in small-sized tomato leaves ($mg \cdot g^{-1}$ f.m.)

Number of treatments	Years	Content of assimilatory pigments ($mg \cdot g^{-1}$ f.m.)			
		chlorophyll a	chlorophyll b	total chlorophyll	carotenoids
Control	2004	0.94	0.42	1.36	0.45
	2005	1.39	0.56	1.94	0.56
	x	1.17	0.49	1.65	0.51
1 treatment	2004	0.99	0.47	1.46	0.43
	2005	1.42	0.56	1.98	0.57
	x	1.21	0.52	1.72	0.50
2 treatments	2004	0.99	0.47	1.46	0.48
	2005	1.52	0.62	2.15	0.62
	x	1.26	0.55	1.81	0.55
3 treatments	2004	1.02	0.49	1.51	0.55
	2005	1.51	0.62	2.13	0.60
	x	1.27	0.56	1.82	0.58
4 treatments	2004	1.09	0.51	1.60	0.54
	2005	1.57	0.64	2.22	0.62
	x	1.33	0.58	1.91	0.58
Mean		1.25	0.60	1.78	0.54
$LSD_{\alpha=0.05}$		0.11	0.07	0.13	n.s

Calcium content in fruits increased as a result of double, triple and fourfold plant spraying with Bio-algeen. Fruits treated three times with the preparation contained most Ca (1.93 $g \cdot kg^{-1}$ d.m.).

Magnesium content did not depend on treatments involving the tested preparation, reaching on average 1.19 $g \cdot kg^{-1}$ d.m. Zn level in tomato fruits depended significantly on the number of sprays with Bio-algeen. As the number of sprays increased, the contnet of this element in tomato fruit likewise increased, especially when triple and fourfold sprays were used. As a mineral component of foodstuffs, zinc is very important to human health because it is included in an enzyme which reduces free radicals (MANGEL and KIRGBY 1983). Fe deficiency causes poor tomato fruit setting (WYSOCKA-OWCZAREK 2001). The Fe level in tomato fruit of cv. Conchita F_1 reached to 128 $mg \cdot kg^{-1}$ d.m. on average and was dependent on a number of sprays with the preparation. A significantly smaller (115 $mg \cdot kg^{-1}$ d.m.) content

of this chemical component was estimated in control than in fruits of the plants sprayed two, three and four times (on an average 133 $mg \cdot kg^{-1}$ d.m.).

Bio-algeen caused a significant increase in the content of nitrates in fruits, especially in 2004. Fruits of the control plants contained on average, for both years of the experiments, 26.7 mg $NO_3^- \cdot kg^{-1}$ d.m. less than the plants sprayed two, three and four times.

Our analysis of the determination of assimilatory pigments in tomato leaves proved that chlorophyll and carotenoids were less abundant in 2004 than in the following year (Table 2). High temperature and higher insolation in August 2004 accelerated fruit ripening, yellowing of leaves and earlier termination of the vegetative season. Leaves of plants treated four times with Bio-algeen contained more total, a and b chlorophyll than leaves of the control plants (0.19, 0.09 and 0.26 $mg \cdot g^{-1}$ f.m., respectively). Bio-algeen did not differentiate the level of carotenoids in tomato leaves.

Table 3

The effect of Bio-algeen S-90 spraying on assimilation and transpiration in cherry tomato

Number of treatments	Years	Assimilation ($\mu mol\ CO_2 \cdot m^{-2} \cdot s^{-1}$)	Transpiration ($mmol\ H_2O \cdot m^{-2} \cdot s^{-1}$)	Water use efficiency index ($mmol \cdot mol^{-1}$)
Control	2004	7.01	0.82	8.55
	2005	4.73	0.05	94.60
	x	5.87	0.44	13.34
1 treatment	2004	7.22	0.98	7.37
	2005	4.61	0.15	30.73
	x	5.92	0.57	10.39
2 treatments	2004	8.39	1.87	4.49
	2005	9.78	1.06	9.23
	x	9.09	1.47	6.18
3 treatments	2004	11.46	1.99	5.76
	2005	9.23	1.20	7.70
	x	10.35	1.60	6.47
4 treatments	2004	7.74	0.94	8.23
	2005	3.28	0.46	7.13
	x	5.51	0.70	7.87
Mean		7.35	0.96	7.66
$LSD_{\alpha=0.05}$		1.21	0.12	3.97

Photosynthetic water use efficiency index, defined as a relation of assimilation (A) to transpiration (E), largely conditions plant productivity, especially under stress conditions of water deficit and deficient supply of nutrients (TUNER 1997). No dependence of high water use efficiency and high transpiration intensity was found, which confirms the assumption that tomato plants do not tolerate low supply of nutrients in soil (Table 3). Plants treated two and three times with Bio-algeen were characterized by more intense transpiration and assimilation, but also by the smaller photosynthetic water use efficiency index.

Under suitable plant growth conditions, intensity of CO_2 assimilation and transpiration are correlated with each other, as intense synthesis of organic compounds increases demand for water and nutrients. Plants which transpire more intensely are capable of nourishing all their organs better (WRÓBEL 2006).

CONCLUSIONS

1. Triple spraying tomato plants with Bio-algeen S-90 in the concentration of 0.3% significantly increased total and marketable yield.

2. Bio-algeen increased mineral components in fruits of the cherry tomato cv. Conchita F_1 (N, P, K, Ca, Zn and Fe), especially when was used several times.

3. Bio-algeen used in tomato cultivation increased a, b and total chlorophyll content in leaves.

4. Spraying of tomato plants with Bio-algeen two and three times depressed water use efficiency index in the process of photosynthesis.

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