THE EFFECT OF ORGANIC BORON COMPOUNDS AS FERTILIZERS ON ASSIMILATORY PIGMENTS FROM TOMATOES

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Abstract

Boron is an essential micronutrient for plants. From those experiments made for the foliar fertilizations and on the soil with boron organic compounds, it was observed a significant increase in the β-carotene and lycopene content at the treated tomatoes. The β-carotene content was higher for the cases where combined treatment (root + foliar) was applied, compared to only root treatment cases and to blank samples, the values being situated between 23.50 and 47.5 mg/100g of fresh substance. The lycopene content presented an important increase by applying the combined treatment and only the root one, as compared to the blank sample. The values for the treatment cases were between 0.39 and 1.33 mg/kg fresh substance and 0.18 mg/kg fresh substance for the blank case. The content in chlorophyll a and b is lower in the case of combined treatment samples with fertilizers, as compared to only root treated case and untreated blank sample. The values for the combined treatment cases were in the range 18.75-25.75 mg/100g of fresh substance for the chlorophyll a and 6.24-15.50 mg/100g of fresh substance for the chlorophyll b.

Keywords: natural fertilizers, boron, tomatoes, assimilatory pigments

1. INTRODUCTION

Tomatoes are included into the technological group of *solano-fruitful vegetables.* Plants from this group are part of the *Solaneceae* botanical family. Tomatoes occupy large cultivated surfaces on the field and protected areas. They are cultivated by means of seedling or sowing directly on the field and do need special attention regarding the hydration and nutritional regime. Tomatoes have a high nutritive value, thanks to their fruit content rich in vitamins, sugars, mineral substances, amino-acids and organic acids. (Singureanu, 2008).

Vegetal pigments are natural dyes of the flowers, leaves, fruits and plant tissues. Some of them are spread all over the vegetable kingdom, others are found only in some plants or in some plants organs. In plants, the pigments exist in a free state or under combinations of holoproteides and carbohydrates, forming heteroproteides and glycozides. Vegetal pigments give the flavour, the taste and the colour for the vegetables products (Moța et al., 2004).

The lycopene is the red pigment, the one that gives tomatoes the red colour. It is an anti-oxidant with various beneficial effects on our organism. Like other anti-oxidants, licopen neutralizes the negative effect of the free radicals. Moreover, recent studies have demonstrated that lycopene has a double action against free radicals, compared to betacaroten, another well-known anti-oxidant.

The nutritive elements from the nourishment factor, if present in sufficient quantities and being easily assimilable, influence the development and growth of the horticultural plants. From the practical aspect, they are materialised by:

- quantitative and qualitative increase of the production;
- shortening the vegetation period.

The role of the macro-elements: N, P, K, Ca, Mg, Al, etc. is broadly shown, unlike the one of the micro-elements: B, Cu, Mn, Mo, Zn, Fe, Al, etc. that is known in a narrower way. The nutritive complex should contain both macro- and micro-elements, but they should not be in excess because they could generate undesired changes (Ciofu et al., 2003).

Boron is recognised as an essential micronutrient for plants and animals, with a very important role in their growth and development (Warington, 1923; Lewis, 1980 quoted by Scorei R - 2006). It has a favourable effect onto flowering and fruiting of plants, because it stimulates the rapid pollen germination (D. Davidescu, 1974, 1981; G.Neamțu, Gh.Câmpeanu, Carmen Socaciu, 1995, quoted by Scorei R. 2006).

Romania is one of the European countries with low boron content in the soil and groundwater. This fact determines a boron deficiency in plants, animals and people nourishment (Scorei, 2005).

Researches show that boron is a bioactive element for the human body (Nielsen, 2008). However, the boron effect on the human body is not completely elucidated (Armstrong, 2001).

The issue of boron deficiency in the soil is not only limited to the harvest quantity effect, but it also affects the quality of leaves and fruits (Dong et al.; Zude et al. quoted by Scorei, 2006).

Applying the nutritive elements by means of foliar spraying represents an unconventional and non-pollutant stimulation technological process, by small doses during the vegetation of the plants metabolism (Bireescu et al., 2002).

Calcium fructoborate is a complex of boron and fructose, a carbohydrate that appears naturally in many fruit and vegetables. It is a stable compound (Scorei, 2007).

The fertilization with boron natural compounds gives advantages related to the accessibility at the plants level. Moreover, natural fertilizers can also be used without restrictions to obtain ecological products, even in agriculturally disadvantaged areas or in soils with nutrition deficiencies.

2. MATERIALS AND METHODS

The experiments were performed at S.D. Banu Maracine, Dolj County, inside a greenhouse, in 2010, repeated four times, having the following experimental cases:

A1b1 = untreated or blank sample;
A2b1 = root treatment with calcium fructoborate;
A3b1 = root treatment with calcium glucoborate;
A1b2 = foliar treatment with Folibor with glucose (Folibor A);
A1b3 = foliar treatment with Folibor with fructose (Fortex B);
A2b2 = root treatment with calcium fructoborate + foliar treatment with Folibor with glucose;
A2b3 = root treatment with calcium fructoborate + foliar treatment with Folibor with fructose;
A3b2 = root treatment with calcium glucoborate + foliar treatment with Folibor with glucose;
A3b3 = root treatment with calcium glucoborate + foliar treatment with Folibor with fructose.

A quantity of commercial fertilizer was administrated. This fertilizer was produced by S.C. Natural Research S.R.L. and it was calculated for the surface unit of 5L/ha. The solution concentration for each foliar fertilizer was of 1%. For the root fertilization, a solid product quantity of 200 Kg/ha was applied. Root fertilization was realized 10 days before planting the tomatoes.

Two foliar treatments were applied for each individual case, during the vegetation period, as follows:

- first treatment when tomato plants had 8-10 leaves formed and normally developed;
- second treatment at 15 days after the first application.

Antalia tomato hybrid was used as biological material.

During this experiment, determinations and biometric measurements (mean height of the plant, mean number of inflorescences per plant), and production measures (mean number of fruits per plant, production obtained at the surface unit) were performed. In addition, determinations of the assimilatory pigments from the tomatoes fruits (chlorophyll a and b, β-caroten and licopen) were realized. The assimilatory pigments from the fruits were determined by extraction with a mixture of acetone and water (80%). The extract was colorimetered on a Caray 50 spectrophotometer by an 80% blanc acetone (using a vat of 1 cm in diameter). The wavelengths were 663.2 nm, 646.8 nm and 470 nm. The results were calculated based on the Mackiney relations and the values were expressed in mg/100 g of vegetal material.

The results presented in this work are partial outcomes from a complex study regarding the effect of boron organic compounds used as fertilizers on tomatoes. The novelty of the study consists in testing, for the first time in Romania, the applying efficiency of the boron based organic compounds on the soil. Until now, there are only results concerning their foliar application.

3. RESULTS AND DISCUSSIONS

Intensely red-pigmented fruits are more juicy, sweeter, more aromatic, and richer in vitamins and have a longer shelf life compared with those poorly pigmented.

Assimilation of pigments in fruits of tomato plants was influenced by their mode of fertilization.

In the case of chlorophyll A content, statistically speaking graduation factor A (Table 1), the differences between variants were classified as significant at A2 (root treatment with calcium fructoborate) and A3 (root treatment with calcium glucoborate). At the graduation factor B (Table 2), it is observed a significant distinct difference at foliar treatment application with Folibor with fructose and insignificant in variant B2 (foliar treatment with glucose). For foliar treatment influence (B) on constant levels of root canal (Table 3) chlorophyll A content was significant for the A2b3 variant (root treatment with calcium fructoborate + foliar treatment with Folibor with fructose), significant distinct to A2b2 (root treatment with calcium fructoborate + foliar treatment with Folibor with glucose) and very significant to A1b3 (foliar treatment with Folibor with fructose).

The content of chlorophyll B, from the statistical point of view at the graduation factor A (Table 4) showed significant differences for variants A2 (root treatment with calcium fructoborate) and A3 (root treatment with calcium glucoborate). At the graduation factor B (Table 5) it is observed a very significant difference in variant b3 (foliar treatment application with Folibor with fructose) and significant in variant b2 (foliar treatment with glucose). In foliar treatment influence (B) at constants levels of root canal (Table 6) the chlorophyll B content was significantly distinct for A1b2 variant (foliar treatment with Folibor with glucose), A2b3 (root treatment with calcium fructoborate + foliar treatment with Folibor with fructose) and A3b3 (root treatment with calcium glucoborate + foliar treatment with Folibor with fructose) and very significantly to A3b2 (root treatment with calcium glucoborate + foliar treatment with Folibor with glucose).

The influence of root treatment on β-carotene content of tomatoes grown in greenhouses (Table 7) resulted in significant distinct differences for both root treatment variances A2 and A3. Foliar treatment influenced only version b3 (foliar treatment with Folibor with fructose) in which there were significant distinct values from the version control and to b2 (foliar treatment with Folibor glucose) (Table 8). Influence of foliar treatment on constant levels of β-carotene treatment root of tomato (Table 9) was significant at A3b3 variant (root treatment with calcium glucoborate + foliar treatment Folibor with fructose) and distinct significant at A2b3 variant (root treatment with calcium fructoborate + foliar treatment with Folibor with fructose) and at A3b2 (root treatment with calcium glucoborate + foliar treatment with Folibor with glucose).

At root treatment application on tomatoes, the lycopene content showed highly significant values in both root treatments (calcium fructoborate and calcium glucoborate) (Table 10). Foliar treatment influenced lycopene content of the variant b3 (foliar treatment with Folibor with fructose), recording very significant differences as compared to b2 version (foliar treatment with calcium glucoborate, where there were significant differences from the untreated control blank sample (Table 11). Influence of foliar treatment on constant levels of root treatment of lycopene from tomato (Table 12) was insignificant for the A2b2 variances (root treatment with calcium fructoborate + foliar treatment with Folibor with glucose), A2b1 (root treatment with calcium fructoborate) and A3b1 (root treatment with calcium glucoborate), significant at A3b3 variant (root treatment with calcium glucoborate + foliar treatment with Folibor with fructose), significant distinct at A1b2 variances (foliar treatment with Folibor with glucose) and A3b2 (root treatment with calcium glucoborate + foliar treatment with Folibor with glucose) and very significant in the case of the A2b3 variant (root treatment with calcium fructoborate + foliar treatment with Folibor with fructose).

Table 1. Root treatment influence (A) over chlorophyll A at greenhouse grown tomatoes, with the pedo-climate conditions from S.D. Banu Maracine (2010)

A factor graduation	Root treatment	Absolute values mg/100g s.p.	Relative values %	Absolute difference ± mg/100g s.p.	Significance of absolute differences
a1	-	35.50	100.00	Mt.	
a2	Calcium fructoborate	22.92	64.56	- 12.58	o
a3	Calcium glucoborate	23.42	65.97	- 12.08	o

DL 5 % = 8.65 mg/100 g s.p. ; DL 1 % = 13.10 mg/100 g s.p. ;DL 0.1 % = 21.04 mg/100 g s.p.

Table 2. Foliar treatment influence (B) over chlorophyll A at greenhouse grown tomatoes, with the pedo-climate conditions from S.D. Banu Maracine (2010)

B factor graduation	Foliar treatment	Absolute values mg/100g s.p.	Relative values %	Absolute difference ± mg/100g s.p.	Significance of absolute differences
b1	-	29.67	100.00	Mt.	
b2	Folibor A	23.38	78.80	- 6.29	
b3	Fortex B	19.38	65.32	- 10.29	oo

DL 5 % = 7.50 mg/100 g s.p. ; DL 1 % = 10.28 mg/100 g s.p. ; DL 0.1 % = 13.99 mg/100 g s.p.

Table 3. Foliar treatment influence (B) on constant levels of root treatment (A) over chlorophyll A at greenhouse grown tomatoes, with the pedo-climate conditions from S.D. Banu Maracine (2010)

A	a1				a2				a3			
B	Absolute values mg/100g s.p.	Relative values %	Absolute difference ±mg/100g s.p.	Significance of absolute differences	Absolute values mg/100g s.p.	Relative values %	Absolute difference ±mg/100g s.p.	Significance of absolute differences	Absolute values mg/100g s.p.	Relative values %	Absolute difference ±mg/100g s.p.	Significance of absolute differences
b1	35.50	100.0	Mt.		32.59	100.0	Mt.		27.44	100.0	Mt.	
b2	28.00	78.87	- 7.50		18.75	57.53	- 13.84	oo	24.25	88.37	- 3.19	
b3	17.00	47.89	- 18.50	ooo	21.75	66.74	- 10.84	o	25.75	93.84	- 1.19	

DL 5 % = 9.14 mg/100 g s.p. ; DL 1 % = 12.53 mg/100 g s.p. ;DL 0.1 % = 17.05 mg/100 g s.p.

Table 4. Root treatment influence (A) over chlorophyll B at greenhouse grown tomatoes, with the pedo-climate conditions from S.D. Banu Maracine (2010)

A factor graduation	Root treatment	Absolute values mg/100g s.p.	Relative values %	Absolute difference ± mg/100g s.p.	Significance of absolute differences
a1	-	19.50	100.00	Mt.	
a2	Calcium fructoborate	11.50	58.97	- 8.00	oo
a3	Calcium glucoborate	11.33	58.10	- 8.17	oo

DL 5 % = 4.36 mg/100 g s.p. ;DL 1 % = 6.61 mg/100 g s.p.; DL 0.1 % = 10.61 mg/100 g s.p.

Table 5. Foliar treatment influence (B) over chlorophyll B at greenhouse grown tomatoes, with the pedo-climate conditions from S.D. Banu Maracine (2010)

B factor graduation	Foliar treatment	Absolute values mg/100g s.p.	Relative values %	Absolute difference ± mg/100g s.p.	Significance of absolute differences
b1	-	16.33	100.00	Mt.	
b2	Folibor A	11.50	70.43	- 4.83	o
b3	Fortex B	8.00	48.99	- 8.33	ooo

DL 5 % = 3.78 mg/100 g s.p. ;DL 1 % = 5.18 mg/100 g s.p. ;DL 0.1 % = 7.06 mg/100 g s.p.

Table 6. Foliar treatment influence (B) on constant levels of root treatment (A) over chlorophyll A at greenhouse grown tomatoes, with the pedo-climate conditions from S.D. Banu Maracine (2010)

A	a1				a2				a3			
B	Absolute values mg/100g s.p.	Relative values %	Absolute difference ±mg/100g s.p.	Significance of absolute differences	Absolute values mg/100g s.p.	Relative values %	Absolute difference ±mg/100g s.p.	Significance of absolute differences	Absolute values mg/100g s.p.	Relative values %	Absolute difference ±mg/100g s.p.	Significance of absolute differences
b1	19.50	100.0	Mt.		16.33	100.0	Mt.		18.13	100.0	Mt.	
b2	12.75	65.38	- 6.75	oo	15.50	94.92	- 0.83		7.50	88.37	- 10.63	ooo
b3	16.75	85.90	- 2.75		6.25	38.27	- 10.08	oo	9.75	93.84	- 8.38	oo

DL 5 % = 4.61 mg/100 g s.p.; DL 1 % = 6.32 mg/100 g s.p.; DL 0.1 % = 8.60 mg/100 g s.p.

Table 7. Root treatment influence (A) over β carotene at greenhouse grown tomatoes, with the pedo-climate conditions from S.D. Banu Maracine (2010)

A factor graduation	Root treatment	Absolute values mg/100g s.p.	Relative values %	Absolute difference ± mg/100g s.p.	Significance of absolute differences
a1	-	15.50	100.00	Mt.	
a2	Calcium fructoborate	37.08	239.26	22.58	**
a3	Calcium glucoborate	38.08	245.77	23.58	**

DL 5 % = 11.95 mg/100 g s.p.; DL 1 % = 18.09 mg/100 g s.p.; DL 0.1 % = 29.06 mg/100 g s.p.

Table 8. Foliar treatment influence (B) over β carotene at greenhouse grown tomatoes, with the pedo-climate conditions from S.D. Banu Maracine (2010)

B factor graduation	Foliar treatment	Absolute values mg/100g s.p.	Relative values %	Absolute difference ± mg/100g s.p.	Significance of absolute differences
b1	-	27.42	100.00	Mt.	
b2	Folibor A	35.88	130.85	8.46	
b3	Fortex B	43.50	158.64	16.08	**

DL 5 % = 10.38 mg/100 g s.p.; DL 1 % = 14.20 mg/100 g s.p.; DL 0.1 % = 19.32 mg/100 g s.p.

Table 9. Foliar treatment influence (B) on constant levels of root treatment (A) over β carotene at greenhouse grown tomatoes, with the pedo-climate conditions from S.D. Banu Maracine (2010)

A	a1				a2				a3			
B	Absolute values mg/100g s.p.	Relative values %	Absolute difference ±mg/100g s.p.	Significance of absolute differences	Absolute values mg/100g s.p.	Relative values %	Absolute difference ±mg/100g s.p.	Significance of absolute differences	Absolute values mg/100g s.p.	Relative values %	Absolute difference ±mg/100g s.p.	Significance of absolute differences
b1	27.42	100.00	Mt.		25.38	100.00	Mt.		23.50	100.00	Mt.	
b2	30.50	111.23	3.08		28.50	112.93	3.12		43.25	184.04	19.75	**
b3	34.17	124.62	6.75		47.50	187.16	22.12	**	39.50	168.09	16.00	*

DL 5 % = 12.62 mg/100 g s.p.; DL 1 % = 17.31 mg/100 g s.p.; DL 0.1 % = 23.55 mg/100 g s.p.

Table 10. Root treatment influence (A) over lycopene at greenhouse grown tomatoes, with the pedo-climate conditions from S.D. Banu Maracine (2010)

A factor graduation	Root treatment	Absolute values mg/kg s.p.	Relative values %	Absolute difference ± mg/kg s.p.	Significance of absolute differences
a1	-	0.18	100.00	Mt.	
a2	Calcium fructoborate	0.84	466.67	0.66	***
a3	Calcium glucoborate	0.91	505.56	0.73	***

DL 5 % = 0.27 mg/kg s.p.; DL 1 % = 0.42 mg/kg s.p.; DL 0.1 % = 0.65 mg/kg s.p.

Table 11. Foliar treatment influence (B) over lycopene at greenhouse grown tomatoes, with the pedo-climate conditions from S.D. Banu Maracine (2010)

B factor graduation	Foliar treatment	Absolute values mg/kg s.p.	Relative values %	Absolute difference ± mg/kg s.p.	Significance of absolute differences
b1	-	0.52	100.00	Mt.	
b2	Folibor A	0.79	151.92	0.27	*
b3	Fortex B	1.13	217.31	0.61	***

DL 5 % = 0.23 mg/kg s.p.; DL 1 % = 0.32 mg/kg s.p.; DL 0.1 % = 0.43 mg/kg s.p.

Table 12. Foliar treatment influence (B) on constant levels of root treatment (A) over lycopene at greenhouse grown tomatoes, with the pedo-climate conditions from S.D. Banu Maracine (2010)

A	a1				a2				a3			
B	Absolute values mg/kg s.p.	Relative values %	Absolute difference ±mg/kg s.p.	Significance of absolute differences	Absolute values mg/kg s.p.	Relative values %	Absolute difference ±mg/kg s.p.	Significance of absolute differences	Absolute values mg/kg s.p.	Relative values %	Absolute difference ±mg/kg s.p.	Significance of absolute differences
b1	0.18	100.0	Mt.		0.39	100.0	Mt.		0.65	100.0	Mt.	
b2	0.59	327.78	0.41	**	0.45	115.38	0.06		1.14	175.38	0.49	**
b3	0.81	450.00	0.63	***	1.33	341.03	0.94	***	0.94	144.62	0.29	*

DL 5 % = 0.28 mg/kg s.p.; DL 1 % = 0.39 mg/kg s.p.; DL 0.1 % = 0.53 mg/kg s.p.

4. CONCLUSIONS

► The chlorophyll A content of tomato fruits has made a very significant difference in the foliar treated variant with calcium fructoborate, with a value of 17 mg/100g fresh substance; significant in those treated root + foliar with fertilizers based on organic compounds of boron with values ranging between 18.75 and 25.75 mg/100g fresh substance, compared with the blank sample that had very high values (35.50 mg/100g fresh substance).

► Chlorophyll B has made distinct significant and very significant differences at the root + foliar treated variants, with values between 6.25 and 15.50 mg/100g fresh substance; distinct significant differences in foliar treatment with Folibor with glucose (12.75 mg/100g fresh substance) than the untreated control blank sample where the recorded value was 19.50 mg/100g fresh matter.

► B-carotene content showed an increase by applying the combined treatment (root + foliar) from the variants treated only radicular and from the witness; the values at combined treatment variants were between 28.5 and 43.25 mg/100g fresh substance .

► Lycopene content of tomato fruits was directly influenced by the combined fertilization (root + foliar) and foliar fertilization. Thus the values of the variants with combined fertilization were between 0.45 and 1.33 mg / kg fresh substance, and at only foliar treated variants between 0.59 and 0.81 mg / kg fresh substance.

► At the variants treated with fertilizers based on organic boron compounds, the tomato fruits produced are intensely colored in red, more succulent, sweeter, richer in vitamins, compared with those obtained from untreated variant, which are low pigmented.

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