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INVESTIGATION ON THE INFLUENCE OF SOME NATURAL ORGANIC COMPLEX FERTILIZERS OF BORON FOR INCREASING THE METABOLIC ACTIVITY AND QUANTITATIVE AND QUALITATIVE YIELD IN THE PEACH TREE, ON PSAMOSOLS FROM SOUTHERN OLTENIA

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ABSTRACT - Natural organic complex fertilizers of boron are bioactive substances, having many biological activities, especially properties of increasing metabolic activity and production. The obtained results in the Redhaven peach variety have shown the favourable effects of treatments on fruit tree growth and development according to the phenological phase and the number of treatments. The chlorophyll content (a+b) has increased once with the number of treatments, while the highest values were obtained at the stage of shoot maturation, at the variant fertilized with complex boron, 5 l/ha, in four treatments (5.99 mg/g fresh matter). The determinations on the NPK content of leaves at the stage of intense shoot growth pointed out better results at the variants treated with natural complex fertilizers of boron, where four treatments were applied (3.06%Nt, 0.64%Pt, 1.63%Kt at the variant treated with complex boron, in four treatments). The DM content of leaves has shown higher values at all the variants where natural complex fertilizers of boron were applied. It also increased once with the number of treatments. The best results were obtained at the variants treated with Cupribor and Boron complex, in four treatments (41.23%). At all the studied variants, the DM quantity accumulated in leaves through photosynthesis was higher at the variants treated with natural complex fertilizers of Boron in four treatments (43.7mg DM/dm^2/8h at the variant treated with Cupribor and 47.2mg DM/dm^2/8h at the variant treated with Boron complex). As concerns the fruit production, there were significant yield increases at all the variants fertilized with Boron, but the best results were obtained at the variants where four treatments with Folibor (12.2t/ha) and Boron complex (11.5t/ha) were applied. The fruit quality was favourably influenced by

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boron. The obtained fruits had a higher content of DM, glucose, vitamin C and a lower content of nitrates.

Key words: boron, metabolic activity, peach tree, sandy soils

REZUMAT – Cercetări privind influența unor fertilizanți organici naturali complecşi ai borului în creşterea activității metabolice şi a nivelului cantitativ şi calitativ al producției la piersic, pe psamosolurile din sudul Olteniei. Fertilizanții organici naturali complecşi ai borului sunt substanțe bioactive, având multe activități biologice, în special proprietăți de creştere a activității metabolice şi a producției. Rezultatele obținute la soiul de piersic Redhaven au subliniat efectele favorabile ale tratamentelor asupra creşterii şi dezvoltării pomilor, în funcție de fenofază şi numărul de tratamente. Conținutul în clorofilă (a+b) a crescut odată cu creşterea numărului de tratamente, iar cele mari valori au fost obținute în faza de maturare a lăstarilor, la varianta fertilizată cu Bor complex, 5l/ha, patru tratamente (5,99mg/g s.p). Determinările cu privire la conținutul frunzelor în NPK, în faza de creştere intensă a lăstarilor, au scos în evidență rezultate mai bune la variantele tratate cu fertilizanți naturali complecşi ai borului, la care au fost aplicate patru tratamente (3,06% Nt, 0,64% Pt, 1,63% Kt la varianta tratată cu Bor complex, patru tratamente). Conținutul de substanță uscată din frunze a prezentat valori mai mari la toate variantele la care s-au aplicat fertilizanți naturali complecşi ai borului şi, de asemenea, aceasta a crescut odată cu creşterea numărului de tratamente. Cele mai bune rezultate au fost obținute la variantele tratate cu Cupribor şi Bor complex, patru tratamente (41,23%). La toate variantele luate în studiu, cantitatea de substanță uscată acumulată în frunze prin procesul de fotosinteză a fost mai mare la variantele tratate cu fertilizanți naturali complecşi ai borului, patru tratamente (43,7mg su/dm^2/8h la varianta tratată cu Cupribor şi 47,2mg su/dm^2/8h la varianta tratată cu Bor complex) Cât priveşte producția de fructe, au fost obținute sporuri semnificative la toate variantele fertilizate cu bor, dar cele mai bune rezultate au fost obținute la variantele la care au fost aplicate patru tratamente cu Folibor (12,2t/ha) şi Bor complex (11,5t/ha). Calitatea fructelor a fost influențată favorabil de aplicarea borului. Astfel, s-au obținut fructe cu un conținut mai mare de substanță uscată, glucide, vitamina C şi mai redus de nitrați.

Cuvinte cheie: bor, activitate metabolică, piersic, soluri nisipoase

INTRODUCTION

Psamosols or sandy soils are low fertility soils, characterized by a low content of macro- and microelements that correlated to a low content of organic matter (0.1-1.2%) and to the lack of a colloidal system are the factors that may cause major lack of balances in plant nutrition. Next to the mineral and organic fertilization, applying leaf treatments with different microelements are the most often used methods, due to their specific actions in catalysing vital metabolic reactions of oxidation or reduction, stimulating some essential physiological processes, intensifying the activity of different enzymes, vitamins or hormones, etc. (Milică *et al.,* 1982).

The most recent national and international investigations pointed out the essential role of boron for plant nutrition and the great opportunity of plant yield increase, especially in less favourable areas from the agricultural point of view

(Burzo *et al.,* 2000; Răţoi *et al.,* 2007; Durău *et al.,* 2007; Toma *et al.,* 2008; Karagiannidis and Thomidis, 2008; Wojcik *et al.,* 2008).

Fruit trees adsorb from soil the mineral elements necessary to their specific metabolism with various intensities according to the species and even to the variety. Peach tree is a species requiring great amounts of nutrients during the vegetation period that greatly influences the plant metabolism, growth and fructification.

MATERIALS AND METHODS

For establishing the role of complex natural organic fertilizers of boron in the peach crop, a trial was set up, placed in randomized blocks with four replicates. The natural complex products (Folibor standard, Cupribor and Boron complex) were tested at the following variants: V 1- Unfertilized control (soil background); V 2- Folibor standard, 5 l/ha, two treatments; V 3- Folibor standard, 5 l/ha, four treatments; V 4- Cupribor, 5 l/ha, two treatments; V 5- Cupribor, 5 l/ha, four treatments; V 6- Boron complex, 5 l/ha, two treatments; V 7- Boron complex, 5 l/ha, four treatments.

Area of the experimental plot: 37.5 m^2; area of the trial: 1050 m^2; number of leaf treatments: 2-4.

Times of applying leaf fertilizers: the first treatment - at the beginning of intense shoot growth; the second treatment – 14 days after the first treatment; the third treatment – 14 days after the second treatment and the fourth treatment- 14 days after the third treatment.

Redhaven is the studied peach variety. The experimental area was uniformly fertilized with N 150 P_2O_5 100 K_2O 100. The other technological works were recommended in the growing technology of the peach tree, elaborated by the Research and Development Station for Plant Growing on Sands, Dăbuleni, Dolj County.

The chemical content of boron leaf fertilizers proceeded from complex natural products was the following: Folibor standard: Boron (B) 6.5 g/l; Calcium (Ca) 17.0 g/l; Cupribor: Boron (B) 13.6 g/l; Copper (Cu) 16.2 g/l; Boron complex: Boron (B) 18.7 g/l; Calcium (Ca) 16.27 g/l, K_2O 12.0 g/l, P_2O_5 1.80 g/l, Mg 1.36 g/l, Mn 0.0065 g/l, Zn 0.0008 g/l, Fe 0.0065 g/l, Cu 16.2 g/l.

We have determined from peach leaves at different vegetation stages: chlorophyll content (a+b) (mg/g) – colorimetric method; carotene content (mg/g) - colorimetric method; activity of enzyme catalyze (ml $KMnO_4$) – permanganate method; photosynthesis (mg $DM/dm^{2/}/8h$) – Method of Sach; water and DM content (%) – gravimetric method; NPK content from peach leaves; total nitrogen (%) – Kjeldahl method; total phosphorus l(%) - colorimetric method; total potassium (%) – method of photometry at flame; fruit biochemical content; total water and DM (%)– gravimetric method; soluble DM (%) – refractometric method; glucides (%) – Fehling Soxleth method; titrable acidity (g acid malic /100g fresh matter) – titrimetric method; vitamin C (mg/100g fresh matter) – iodometric method; nitrate content (mg/kg product) –Bremner method and fruit production (t/ha).

RESULTS AND DISCUSSION

The trial was placed on a soil with low nitrogen content (0.02-0.1%), meanly supplied in extractable phosphorus (25- 35 ppm), and in

exchangeable potassium (60-110 ppm) and with low content of organic matter (0.33-0.79%) (*Table 1*). The pH values were comprised between 6.15 and 6.81, showing a moderately acid to neuter response. The best pH field for plant nutrition was comprised between 6.0 and 6.5, field characterized by the best solubility and accessibility for most of soil nutrients. The boron content was very low (0.15-0.16 ppm), which was characteristic to sandy soils.

Table 1 – Soil supply with main chemical components in peach crop

Depth (cm)	Nt (%)	P-AL (ppm)	K-AL (ppm)	Organic carbon (%)	PH in H_2O	Boron in H_2O (ppm)
0-30	0.10	34	60	0.79	6.15	0.16
31-60	0.02	25	110	0.40	6.52	0.15
61-90	0.04	35	60	0.33	6.81	0.16

On these soil types, which are poor in other nutrients and with a very low content of organic matter, boron deficit was found, mainly in vine and fruitful trees. Under conditions of an intensive agriculture, without the periodical application of some fertilizer types as boron source, these soils may be exhausted after short time since cultivation.

Applying some natural complex organic fertilizers of boron at different vegetation stages on a soil background made of chemical fertilizers has influenced the accumulation of some biochemical components in leaves (chlorophyll and carotene), the activity of catalase and a series of physiological indices. Determinations were carried out in two different years from the production and climatic point of view, at two vegetation stages (intense growth of shoots and their maturation, which correspond to June and August). At the stage of shoot intense growth (a period with the highest uptake of mineral elements), the chlorophyll content from leaves has shown higher values at all the variants where we applied treatments with complex natural fertilizers of boron compared to the control, fertilized only with mineral fertilizers (*Table 2*). The differences between variants were not significant, while the best results were obtained at the variants treated with Folibor, in four treatments (4.35 mg/g fresh matter) and Boron complex, in four treatments (3.76 mg/g fresh matter). At the same variants, we have obtained the highest carotene content (1.00 mg/g fresh matter– 0.95 mg/g fresh matter).At the same vegetation stage, the activity of catalase was more intense at the variants where boron products were applied, while the highest values were determined at the variants treated with Cupribor 5l/ha, in four treatments (6.0 ml) and

Boron complex 5l/ha, in four treatments (5.80 ml).

Treatments with natural complex fertilizers of boron have influenced the chlorophyll and carotene content and the activity of catalase from leaves during the vegetation period.

At shoot maturation, where we have applied the four treatments with natural complex fertilizers of boron, the chlorophyll from peach leaves was increasing, while the best results were obtained at the variants were four treatments were applied (5.84 mg/g at the variant treated with Folibor, 5.74mg/g at the variant treated with Cupribor, 5.99 mg/g at the variant treated with Boron complex). The carotene content has shown higher values at this vegetation stage while the growth was correlated to the number of treatments (*Table 2*). The activity of catalase was more intense at shoot maturation stage, while the best results were obtained at the variant with Boron complex, in four treatments, 10.10 ml.

Table 2 – Influence of some natural complex organic fertilizers of boron on the chlorophyll and carotene content and the activity of catalase from leaves in peach tree, at intense shoot growth and maturation (June and August) (on the average of 2005-2006)

Variant	Chlorophyll (a+b) (mg/g fresh matter)		Carotene (mg/g fresh matter)		Catalase (ml KMnO4)	
	June	August	June	August	June	August
Control	3.19	4.55	0.73	0.96	4.10	7.60
Folibor 5l/ha, two treatments	3.42	5.31	0.92	0.97	4.70	8.95
Folibor 5l/ha, four treatments	4.35	5.84	1.00	1.01	4.50	9.35
Cupribor 5l/ha, two treatments	3.75	5.09	0.81	0.96	6.10	9.15
Cupribor 5l/ha, four treatments	3.69	5.74	0.91	1.07	5.60	9.55
Boron complex 5l/ha, two treatments	3.49	5.76	0.84	1.00	4.40	9.25
Boron complex 5l/ha, four treatments	3.76	5.99	0.95	1.07	5.80	10.10

If we analyse the chlorophyll content at the two stages of vegetation in the two years of study and according to the tested variants, we may notice the differences between the two stages in the two years of study. The year 2005 was a year without production with climatic conditions favourable to tree growth and development (rainfall, soil moisture, not very high temperatures), resulting in the accumulation of chlorophyll in peach leaves during the growth period, while the highest values were obtained at the variants where natural complex fertilizers of

boron and the chlorophyll content has increased once with the number of treatments (7.47mg/g at the variant treated with Boron complex, in four treatments) (*Table 3*). In 2006, a fruitful year, with very significant yield increases, we noticed at the stage of shoot maturation an increase in the content of chlorophyll only at the variants where natural complex fertilizers of boron were applied in four treatments (4.51mg/g at the variant with Boron complex) (*Table 3*).

For all the fruitful species, the shoot growth is the period with the highest uptake of mineral elements. The determination on the NPK leaf content at the intense shoot growth pointed out better results at the variants treated with natural complex fertilizers of boron, where four treatments were applied (3.06% Nt, 0.64%Pt, 1.63%Kt at the variant treated with Boron complex, in four treatments) (*Table 4*).

Table 3 – Influence of complex natural organic fertilizers of Boron on the chlorophyll content in peach trees, at intense growth and shoot maturation in the two years of study (2005-2006)

Variant	Chlorophyll (a+b) (mg/g fresh matter)			
	2005		2006	
	June	August	June	August
Control	3.33	6.17	3.04	2.93
Folibor 5 l/ha ,two treatments	3.04	7.05	3.80	3.57
Folibor 5 l/ha, four treatments	4.56	7.35	4.13	4.32
Cupribor 5 l/ha, two treatments	3.82	6.69	3.67	3.48
Cupribor 5 l/ha, four treatments	4.25	7.65	3.12	3.75
Boron complex 5 l/ha, two treatments	3.16	7.14	3.82	4.38
Boron complex 5l/ha, four treatments	3.72	7.47	3.87	4.51

Table 4 – Influence of natural complex organic fertilizers of boron on the NPK content from the peach leaves

Variant	Nt (%)	Pt (%)	Kt (%)
Control	2.36	0.46	1.22
Folibor 5l/ha, two treatments	2.46	0.53	1.33
Folibor 5l/ha, four treatments	2.86	0.55	1.42
Cupribor 5l/ha, two treatments	2.84	0.56	1.48
Cupribor 5l/ha, four treatments	3.06	0.61	1.62
Boron complex 5l/ha ,two treatments	2.84	0.62	1.42
Boron complex 5l/ha, four treatments	3.06	0.64	1.63

The DM of leaves and the intensity of photosynthesis were influenced by the application of natural complex Boron fertilizers. Leaf dry matter content has shown higher values in all the variants where natural complex boron fertilizers were applied and it has increased once with the number of treatments. The best results were obtained at the variants treated with Cupribor and Boron complex, in four treatments (41.23%) (*Table 5*). More the quantity of DM increases, more the water quantity from leaves decreases. The intensity of photosynthesis was influenced both by boron and by climatic conditions. At all the studied variants, the quantity of DM accumulated in leaves through photosynthesis was greater at the variants treated with complex natural boron fertilizers in four treatments (43.7mg DM/dm^2/8h at the variant treated with Cupribor and 47.2mg DM/dm^2/8h at the variant treated with Boron complex).

As concerns the fruit production, significant yield increases were obtained at all boron variants, but the best results were obtained at the variants treated with Folibor, four treatments (12.2t/ha) and Boron complex, four treatments (11.5t/ha) (*Table 5*).

Table 5 – Influence of natural complex boron fertilizers on some physiological indices of peach leaves and fruit production

Variant	Dry matter (%)	Water (%)	Photosynthesis (mg DM/dm^2/8h)	Production (t/ha)	Significance
Control	37.72	62.28	32.5	9.5	
Folibor 5 l/ha, two treatments	40.36	59.64	38.4	10.6	*
Folibor 5 l/ha, four treatments	40.88	59.12	40.6	12.2	***
Cupribor 5 l/ha, two treatments	38.60	61.40	41.5	10.8	*
Cupribor 5 l/ha, four treatments	41.23	58.77	43.7	10.9	*
Bor complex 5 l/ha, two treatments	39.48	60.52	43.5	11.0	**
Bor complex 5 l/ha four treatments	41.23	58.77	47.2	11.5	***

LSD 5% = 1.0; LSD 1% = 1.3; LSD 0.1% = 1.8

Treatments with different natural complex boron fertilizers applied in peach trees have also influenced fruit biochemical composition (*Table 6*). At all the leaf variants treated with boron, a greater total DM and soluble content was determined, compared to the leaf unfertilized control, while the best results were obtained at the variants where four treatments were applied (15.8% total DM, 12.8% soluble DM at the variant treated with

Folibor, 16% total DM, 12.6% soluble DM at the variant treated with Boron complex). Once with the accumulation of total DM, water content from leaves decreased; it was comprised between 84% at the Boron complex treated variant, in four treatments and 85.5 % at the leaf unfertilized control).

Fruit acidity was less influenced by the presence of boron, varying between 0.39 and 0.48g acid malic per 100g fresh matter, normal values for the peach tree. As concerns the fruit acidity, the influence of climatic conditions was felt much more. At very high air temperatures (40^0C) during fruit maturation, the respiration process increases and organic acids are used as respiratory substrate. Total glucoses from peach fruits have shown higher values at the variants treated with boron products, in four treatments (8.85% at the variant treated with Folibor, 8.61% with Cupribor, 8.61% with Boron complex). Boron makes easier the transportation of carbon hydrates of the cell membrane, favouring the glucose accumulation in fruits. Many studies pointed out the increase in the glucose content from fruits and vegetables after boron fertilization (Milică, 1982).

Table 6 – Influence of natural complex organic boron fertilizers on the biochemical composition of peach fruits

Variant	TDM* (%)	Water (%)	SDM** (%)	Titrable acidity (g malic acid per 100 g fresh matter)	Glucose (%)	Nitrates NO_3^- (mg/Kg fruit)	Vitamin C (mg/ 100 g fresh matter)
Control	14.5	85.5	12.2	0.44	8.38	62.02	6.51
Folibor 5 l/ha, two treatments	14.7	85.3	12.6	0.42	8.50	49.61	6.95
Folibor 5 l/ha, four treatments	15.8	84.2	12.8	0.48	8.85	37.21	7.39
Cupribor 5 l/ha, two treatments	14.7	85.3	12.4	0.43	8.38	18.60	7.83
Cupribor 5 l/ha, four treatments	15.5	84.5	12.7	0.42	8.61	31.01	8.27
Boron complex 5 l/ha, two treatments	15.5	84.5	12.4	0.39	8.50	49.61	8.53
Boron complex 5 l/ha, four treatments	16.0	84.0	12.6	0.40	8.61	37.21	8.71

TDM*– total dry matter ; SDM**– soluble dry matter

Vitamin C was also influenced by the treatments with different natural complex boron fertilizers. At these variants, the content of vitamin C was higher, compared to the leaf unfertilized control. The greatest values were found at the variants treated with complex boron (8.53 – 8.70 mg/100g fresh matter).

The content of nitrates in fruits was very variable, being comprised between 18.60mg/kg at the variant with Cupribor in two treatments and 62.02mg/kg at the control variant (fertilized only chemically). The very low values of nitrates at the variants treated with Cupribor may be caused by copper implication in nitrogen metabolism, by activating nitrate and nitrite reductase, enzyme that capitalizes the nitrate and nitrite reduction. In case of copper lack, because of the disturbance of nitrogen metabolism, the proteic fraction decreases to the favour of nitrogen soluble fractions, having negative consequences on fruit quality.

CONCLUSIONS

Our results pointed out the favourable effects of treatments with complex natural organic boron fertilizers on plant growth and development, according to the phenological phase and the number of applied treatments.

The chlorophyll content (a+b) has increased once with the number of treatments while the greatest values were obtained at shoot maturation stage, at the variant treated with Boron complex, 5l/ha, in four treatments (5.99 mg/g fresh matter).

The determinations on the NPK content from leaves at the intense shoot growth emphasized the best results at the variants treated with complex natural organic boron fertilizers on four treatments (3.06% Nt, 0.64% Pt, 1.63% Kt at the variant treated with Boron complex, in four treatments).

The DM of leaves has shown greater values in all the variants where complex natural organic boron fertilizers were applied and it increased once with the number of treatments. The best results were obtained at the variants treated with Cupribor and Boron complex, in four treatments (41.23%).

At all the studied variants, DM accumulated in leaves through photosynthesis was greater at the variants treated with complex natural organic boron fertilizers, in four treatments (43.7 mg DM/ dm^2/8h at the variant treated with Cupribor and 47.2 mg DM/dm^2/8h at the variant treated with Boron complex).

As concerns the fruit production, significant yield increases were obtained at all the variants treated with complex natural organic boron fertilizers, but the best results were obtained at the variants treated with Folibor, in four treatments (12.2 t/ha) and Boron complex, in four treatments (11.5 t/ha).

The fruit quality was favourably influenced by boron application. The obtained fruits had a greater content

of DM, glucose and vitamin C and a lower content of nitrates.

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