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RESEARCH ON THE CONSUMPTION OPTIMIZATION OF CHEMICAL AND ORGANIC FERTILIZERS BY USING FOLIAR FERTILIZERS BASED ON NATURAL ORGANIC COMPOUNDS OF BORON IN THE PRODUCTION OF WATERMELONS

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Abstract

Agricultural soils in Romania contain in average around 15-68 ppm of boron, and the mobile boron quantity is between 0.1-0.8 ppm. The interest in the watermelon culture in Romania, especially in the south of the country, in Dolj County (*is reflected by over 3,000 ha cultivated only in the Danube Plain). The Folibor product were applied in a quantity of 5 liters/ha, in 4 treatments, recording some productions of 58.3 t/ha the gains being of 17.8% comparing with the non-fertilized foliar variant. The fertilization with organic compounds of boron determined the increasing of average weight of fruits (1-10 %), increasing of glucose content (7.92-8.50%) and vitamin C content (from 7.08 mg/100 FWg to 13.28 mg/100 FWg).*

Key words: *foliar fertilization, organic compounds, watermelons.*

INTRODUCTION

Watermelon belongs to the gourd family called Cucurbitaceous and the genus *Citrullus* (Edwards *et al*., 2003). In watermelon is mostly water (about 92 %) but this refreshing fruit is full with nutrients. Has significant levels of vitamins A, B6 and C, lots of lycopene and antioxidants (Inuwa *et al*., 2011). Watermelon rind and seed also have many health benefits due to the presence of important amino acids citrulline, fibres, minerals and phenolic compounds (Masudul& Abdullah, 2015, Reetu & Tomar, 2017, Zubairu *et al*., 2018). The boron content in plants varies from 5 ppm to 654 ppm according to species. Boron fertilization is an efficient technological work, especially when boron is applied on crops that are fertilized organically (Jifon & Lester, 2006; Dawson & Hilton, 2011; Medeiros *et al*., 2016). The organs of plant which contain the most quantity of boron are the reproductive ones (anthers, stamen, stigma, ovary), a fact which explains the role of boron in the fructification process (Sienkiewicz-Cholewa, 2002; Razavi & Milani, 2006; Wang *et al*., 2013; Gil *et al*., 2006; Aguyoh *et al*., 2011; Dawson *et al*., 2011; Geleta *et al*., 2011; Dimkpa & Bindraban, 2016; Bommesh *et al*., 2017). Also a higher quantity of boron is found in the young tissues than in the old ones, the leaves containing more boron than the seeds and roots (Kashi *et al*., 2003; Reid *et al*., 2004; Young *et al*., 2005; Wang *et al*., 2013; Kadu *et al*., 2018). Generally speaking, the need of boron of dicotyledonous plants is higher in comparison to those of monocotyledonous plants (Guppy *et al*., 2005; Deswal & Patil, 1984; El-Bassiony *et al*., 2012; Do Nascimento *et al*., 2016). The agricultural soils in Romania contain in average around 15–68 ppm boron, and the mobile boron quantity is between 0.1 – 0.8 ppm (Rățoi *et al*., 2010; Popescu, 2012). The correction of boron deficit into the plant nutrition is made frequently through administration of foliar fertilizers with boron (Jifon *et al*., 2006; Medeiros *et al*., 2016). The interest in the watermelon culture in Romania, especially in the south of the country, in Dolj County is reflected by over 6500 ha cultivated only in the Danube Plain. Besides mineral fertilization, the supply of organic matter to the soil is of great importance for the cultivation of watermelon and other vegetables, especially in sandy soils of arid regions that have low contents, because the climate conditions favor the acceleration of oxidation of soil organic matter (Nicolae *et al*., 2014). Regarding the fertilization strategies, the classical fertilizers in reduced doses correlated with consumption from the expecting crops, and also the partially substitution of fertilization through supplementary foliar fertilizers was observed (Nicoli *et al*., 1999; Jifon *et al*., 2006; Santos *et al*., 2016). By applying a modern technology, the watermelons culture on sandy soils in the south of Oltenia is profitable (Rățoi *et al*., 2010).

MATERIALS AND METHODS

In the 2019 period, the Folibor product, based on organic compounds of boron, was used on different agrofunds, the variants of the experiment being as following:

V1 - non-fertilized;

V2 - chemically fertilized with N 150 P_2O_5 100 K_2O 100;

V3 - fertilized organically with 30 t/ha, dung

V4 - Non-fertilized agrofund, Folibor, 5 l/ha, 2 treatments;

V5 - N 150 P_2O_5 100 K_2O 100+ Folibor, 5 l/ha, 2 treatments

V6 - N 75 P_2O_5 50 K_2O 50+Folibor, 5 l/ha, 2 treatments;

V7 - Dung, 30 t/ha+Folibor, 5 l/ha, 2 treatments;

V8 - Dung, 15 t/ha+Folibor, 5 l/ha, 2 treatments.

The experiment was placed in randomized blocks, four times.

The surface of the experimental place: 18 m^2.

The surface of the experiment: 720 m^2;

The moments of applying the foliar fertilizations were:

- treatment I at the beginning of forming the stem, on 6th of June, 2018;
- treatment II at 10 days after the first treatment, on 16th of June, 2018.

Quantity of solution was 600 l/ha. The watermelon crop was grown on a sandy soil in the field under a dripping irrigation system. All fruits were grown in an open field in the same area (Dăbuleni). During the 2018 campaign, samples were transported to our laboratory (Research Center for monitoring of the ecological and bioeconomical indicators for some horticultural species at regional level (BCUM) from University of Craiova) within a day after harvest and processed.

The dry matter content (%) was determined by dehydration of the plant material at 105°C, up to a constant mass.

Chemical content of watermelons in the following substances: water and TDM (total dry matter) (%) by the gravimetric method; SDM (soluble dry matter) (%), by the refractometric method.

A Boehringer enzymatic kit (combination test) was used to determine the D-glucose content. Samples for the above test were prepared from fresh material taken from the heart of the fruit which was triturated to extract the juice. The results are expressed in % of sample solution. Sweetness values were calculated on the basis of those reported by Eisenberg (1955).

For the determination of titratable acidity (g malic acid/100 g f.m.), the bromothymol blue indicator reagent was prepared in a concentration of 10.4 mol/1 in 5 x 10-3 tool/1 Britton-Robinson buffer (pH 7.5) (from a stock buffer solution containing 0.1 mol/1 sodium acetate, 0.1 mol/1 boric acid and 0.1 mol/1 potassium dihydrogen phosphate and adjusting the pH to 7).

Vitamin C standard solution was prepared by dissolving 0.250 g ascorbic acid in the beaker with 100 ml distilled water. The solution was transferred into 250 ml volumetric flask and diluted to 250 ml with distilled water. Standardization of iodine solution with the vitamin C standard solution was by pipetting 25ml of vitamin C solution into a 125 ml Erlenmeyer flask. 10 drops of 1% starch solution were added and then titrated against iodine solution until blue-black colour was observed. Titrations were repeated in triplicates. The volume of each fruit sample used was measured and the concentration of ascorbic acid per 100 ml fruits was calculated using: Concentration of ascorbic acid used in mg/100ml = Concentration (mg/ml standard)/ Weight of samples in gram x 1000 (Nweze *et al*., 2015).

The NPK content of watermelon leaves: total nitrogen (%) - Kjeldahl method, total phosphorus (%) - colorimetric method, total potassium (%) - flame photometric method.

The nitrate concentration can be estimated visually or determined spectrophotometerically at λ_{max} 400 nm in the range of 4-40 mg/l N. When the color change is very small, a coupling solution is added, and the violet color that develops can be measured colorimetrically at λ_{max} 545 nm in the range of 0.5-5 mg/l N (Szekely, 1991).

RESULTS AND DISCUSSIONS

The fertilization of watermelon culture on sandy soils determines higher production gains for the studies variants, being in average for two years between 45.6 and 58.9 t/ha. The highest production was obtained when the mineral fertilization at the level of N 150 P_2O_5 100 K_2O 100 was complemented with extraradicular fertilization through two treatments with Folibor in a dose of 5 l/ha/treatment, determining a production gain of 157%, the average difference of 21.4 t/ha being very significant (Table 1). It is important to mention the fact that the treatments with Folibor in the organic fertilized variant with 15 t/ha dung, determined the production gain to be 9.6 t/ha, and in the organic fertilized variant with 30 t/ha dung, the production gain was 10.7 t/ha.

The using of Foliborfor the foliar fertilization in watermelons cultures that were organic fertilized, leads to a better usage of fertilized substances, so that the reducing by half of quantities of 30 t/ha dung has determined in the average on two years of study an insignificant loss of production, 1.1 t/ha. It can be concluded that on the sandy soils the efficiency of fertilization based on organic compounds of boron in the watermelons culture is high, especially in the case of exclusive fertilization with mineral fertilizers. The cultures that are exclusively fertilized with organic fertilizers allow the reducing by half of the fertilizer quantity. Using the fertilizers based on organic compounds of boron in combination with organic and chemical fertilizers showed the role of boron in the development and growth of plants (Table 2). The content of total dry matter (TDM), soluble dry matter (SDM), glucose and vitamin C has recorded higher values in the variants that were fertilized in comparison to the non-fertilized variant.

The best results were obtained in the variants fertilized with dung, Folibor, Folibor + N 150 P_2O_5 100 K_2O 100, Folibor + dung 15 t/ha (8.85-9.30% TDM, 8.80-9.20 SDM, 8.50-8.77 % glucose and 11.44-16.80 mg to 100 g FW vitamin C.

The acidity of fruits recorded the lowest values in the variants with dung 30 and respectively 15 t/ha in combination with Folibor (0.076-0.089 g malic acid to 100 g FW), which are representative values for watermelons.

The content of nitrates was very variable, ranging from 12.40 mg/Kg fruit in the non-fertilized variant or fertilized with dung + Foliborto 105.43 mg/kg fruit in the variant fertilized with N 150 P_2O_5 100 K_2O 100, value which exceeds the effective standard of 100 mg/kg fruit.The lowest values were recorded by variants fertilized with dung 30 t/ha, dung 30 t/ha and 15-t/ha +Folibor (24.42 mg/kg fruit, 18.60 mg and 16.40 mg/kg fruit).

The soluble dry matter and glucose presented close values.

The climatic factors, especially the intensity of light, have a special influence on the content of nitrates in plants, the activity of nitrate reductasis being caused by high temperature. Excess of darkness and humidity and low temperature create conditions which contribute to accumulation of nitrates in the plant and fruit. When reducing by half the doses of chemical and organic fertilizers and applying Folibor ferti-stimulator to vegetation, during the phenophases of growing and development of plants, the titratable acidity and the content of nitrates decreased, but the content of vitamin C increased. Scientific evidence have shown that watermelon contains vitamin C which is an essential nutrient for humans because it aids in the synthesis of collagen in addition to protecting against oxidative damage. Inuwa et al. (2011) have also performed such studies and obtained similar results (15.0 mg/100 FWg ascorbic acid).And Reetu & Tomar (2017) obtained similar results (8.1 mg//100 FWg Vitamin C) in their study.

In terms of the content of macroelements in leaves, the best results were obtained bythe variants treated with Folibor + chemical fertilizers and Folibor + dung, 4.12-4.52 % Nt, 0.20-0.30% Pt and 1.50-2.07 % Kt (Table 3).

Table 1.The influence of organic, mineral and Folibor foliar fertilization on the watermelons production

Variant of fertilization	Year 2017 t/ha	Year 2018 t/ha	Average 2018-2019			
			t/ha	%	Difference t/ha	Significance
V1 - non-fertilized	27.0	47.9	37.5	100	Mt	Mt
V2 - chemically fertilized with N 150 P_2O_5 100 K_2O 100	42.06	69.4	55.7	148	+18.2	***
V3 - fertilized with dung, 30 t/ha	37.6	43.6	45.6	122	+8.1	
V4 - Non-fertilized agrofund, Folibor, 5 l/ha, 2 treatments	34.8	47.5	46.2	123	+8.7	
V5 - N150 P_2O_5 100 K_2O 100 + Folibor, 5 l/ha, 2 treatments	44.2	73.5	58.9	157	+21.4	***
V6 - N75 P_2O_5 50 K_2O 50 + Folibor, 5 l/ha, 2 treatments	39.6	58.3	47.5	127	+10.0	*
V7 - Dung, 30 t/ha + Folibor, 5 l/ha, 2 treatments	39.5	56.8	48.2	126	+10.7	*
V8 - Dung, 15 t/ha + Folibor, 5 l/ha, 2 treatments	38.2	56.0	47.1	126	+9.6	*

DL 5% = 10.8 7.1 8.9
DL 1 % = 15.0 9.6 12.4
DL 0.1% = 20.7 13.0 16.9

Table 2. The biochemical compound of watermelons fruit according to boron treatment on agrofunds of chemical and organic fertilizers (the 2017-2018 average)

Variant of fertilization	TDM[1] (%)	Water (%)	SDM[2] (%)	Titratable Acidity (g malic acid/ 100 FW[3]g)	Vitamin C (mg/100 FW[3]g)	Nitrate (NO_3) (mg/Kg fruit)	Glucose (%)
V1 - non-fertilized	8.20	91.8	8.0	0.128	7.08	12.40	7.92
V2 - chemically fertilized with N 150 P_2O_5 100 K_2O 100	8.60	91.4	8.5	0.110	10.56	105.43	8.22
V3 - fertilized with dung, 30 t/ha	9.00	91.0	8.95	0.110	9.68	24.42	8.73
V4 - Non-fertilized agrofund, Folibor, 5 l/ha, 2 treatments	9.30	90.7	9.2	0.102	11.44	74.42	8.50
V5 - N150 P_2O_5 100 K_2O 100 + Folibor, 5 l/ha, 2 treatments	8.85	91.1	8.8	0.110	13.28	68.04	8.50
V6 - N75 P_2O_5 50 K_2O 50 + Folibor, 5 l/ha, 2 treatments	8.50	91.5	8.3	0.108	14.16	37.21	8.15
V7 - Dung, 30 t/ha + Folibor, 5 l/ha, 2 treatments	8.60	91.4	8.5	0.076	11.52	18.60	8.30
V8 - Dung, 15 t/ha + Folibor, 5 l/ha, 2 treatments	9.00	91.0	9.0	0.089	16.80	16.40	8.77

[1]TDM = total dry matter, [2]SDM = soluble dry matter, FW[3] = fresh weight

Table 3. The influence of fertilizers based on organic compounds of boron in complex with organic and chemical fertilizers on the content of NPK in the leaves of watermelons (the 2017-2018 average)

Variant of fertilization	Nt (%)	Pt (%)	Kt (%)
V1 - non-fertilized	3.12	0.14	0.97
V2 - chemically fertilized with N 150 P_2O_5 100 K_2O 100	3.68	0.22	1.37
V3 - fertilized with dung, 30 t/ha	3.88	0.23	1.45
V4 - Non-fertilized agrofund, Folibor, 5 l/ha, 2 treatments	4.36	0.16	1.25
V5 - N150 P_2O_5 100 K_2O 100 + Folibor, 5 l/ha, 2 treatments	4.12	0.25	1.57
V6 - N75 P_2O_5 50 K_2O 50 + Folibor, 5 l/ha, 2 treatments	4.40	0.20	1.50
V7 - Dung, 30 t/ha + Folibor, 5 l/ha, 2 treatments	4.32	0.30	2.07
V8 - Dung, 15 t/ha + Folibor, 5 l/ha, 2 treatments	4.52	0.28	1.84

All the fertilized variants recorded a higher content of NPK in leaves in comparisonto the non-fertilized variant.

CONCLUSIONS

Applying foliar fertilization based on the organic compounds of boron to different agrofunds of watermelons culture on sandy soils it has influenced positively the quantitative and qualitative indexes of production.

The highest production was recorded when mineral fertilization at the level of $N150P_2O_5$ $100K_2O100$ was complemented with extraradicular fertilization through two treatments with Foliborin a dose of 5 l/ha/treatment, determining a production gain of 157%, the average difference of 21.4 t/ha being very significant.

It is worth mentioning the fact that the treatments with Folibor applied on the organic fertilized variant with 15 t/ha dung has determined a production gain of 9.6 t/ha, and on the organic fertilized variant with 30 t/ha dung, the production gain was 10.7 t/ha, the difference of 1.1 t/ha obtained by reducing by half the organic fertilizer quantity per surface unit is not significant.

Reducing by half the doses of chemical and organic fertilizers and applying the Folibor ferti-stimulator on vegetation, during the phenophases of growing and development of plants, the titratable acidity and content of nitrates decreased, the content of vitamin C increased, and the soluble dry matter and glucose presented close values.

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