THE IMPACT OF BIOLOGICAL PRODUCTS ON CERTAIN BIOCHEMICAL CHARACTERISTICS OF TOMATO FRUITS

DOI:10.24411/2588-0209-2018-10031

УДК 332.3

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This article shows the results of measuring the beta-carotene, lycopene, ascorbic acid and sugar levels, acidity and other indicators in tomato fruits grown using Organic and Double Roots, biological products manufactured by Bioelements Ltd (York, UK) and containing spore-forming soil bacilli, nitrogen-fixing bacteria and mycorrhizal fungi. The products are certified for use in organic agriculture by the Soil Association (UK). The research results demonstrate that the use of these biological products contributes to an increase in the content of powerful antioxidants (lycopene and beta-carotene) and sugar in tomato fruits; such indicators as taste index, dry matter content, and mineral content have also increased.

Keywords: *organic agriculture, biological products, tomatoes, beta-carotene, lycopene, sugar*

Soil microorganisms are an essential part of any ecosystem. They are participate in the cycle of chemical elements, thus ensuring sustainability of an ecosystem. However, the environmental

impacts of microorganisms on the soil-plant system are poorly understood. The problem of insufficient nutrient availability may be solved with the help of biological products making agriculture more bio-friendly [1-4]. Modern biological products that contain beneficial microorganisms are safe for the environment due to their natural origin and low rates of application. This makes them one of the most promising solutions for mitigating environmental impacts of farming. These products promote yield growth and improve quality of crops, including tomatoes, by enhancing plant resistance and tolerance to adverse natural impacts [5, 7, 9]. Therefore, one of the most vital tasks of the agricultural scientists and farmers is to produce organic crops with a high nutrient content using microbiological products.

The main goal of this study was to assess the impact of Organic and Double Roots on certain biochemical characteristics of tomato fruits.

The manufacturer of the these products is Bioelements Ltd (York, UK). These products were certified for use in organic farming by the Soil Association (United Kingdom), and contain spore-forming soil bacteria (Bacilli spp.), symbiotic nitrogen-fixing bacteria (Azotobacter spp.) and mycorrhizal fungi. In terms of technology, the endospores of Bac. subtilis are better than live cells since they are tolerant of extreme pH levels, far more tolerant of drying when they are made into powder, and their production technology is relatively simple and based on industrial fermentation. Therefore, they remain viable for many years if the product is stored in proper conditions. When applied to soil as part of biological products, mycorrhizal fungi create optimum conditions for crop growth [4], since they form a vast mycorrhiza providing an adequate nutrition to plants, thus enhancing the quality of crops.

Tomato is one of the most consumed vegetable crops in the developed countries. It is a valuable food product rich in enzymes, proteins, organic acids, vitamins, macronutrients and trace elements essential for human health.

In our research, we assessed the impact of Organic and Double Roots on biochemical characteristics of tomato fruits of Shuntukski Velikan (trial 1) and Ogni Moskvy (trial 2) varieties.

Shuntukski Velikan is a popular mid-season tomato variety notable for its high yield capacity, fine taste qualities, attractive appearance, large fruits, bright red solid skin, a long shelf life, and outstanding resistance to fungal diseases and pests. The variety has high plants which bear rounded fruits with a total weight of 600–800 g (sometimes above 1,000 g) per plant.

Ogni Moskvy is an early-season tomato variety producing stable yields and having excellent storability. The time from germination to fruiting is around 100 days. The plant reaches up to 45 cm in height and has medium-sized foliage. Its fruits have 3–4 seed cavities. The variety features red and round solid fruits weighing roughly 100 g each.

The trials were based on the best practices. In each trial, we divided the crops into control and experimental (those treated with the products). The tomato seedlings were planted on 10 sq m trial plots (greenhouses) with 4 replications. Both products were applied twice – to the seedbeds before planting (application rate: 1 kg/ha) and one month later during the vegetation (application rate: 0.5 kg/ha). Each product was dissolved in water prior to application and used on the same day.

The ripened fruits were analyzed for dry matter (by gravimetry), ascorbic acid (by spectrophotometry), sugar (by cyanide method), pH (by potentiometry), mineral content (by spectrometer), acid content (by alkaline titration) and taste index (analyzed by sugar and acid balance). Carotenoid content was determined by spectrophotometric analysis carried out after chromatographic separation of lycopene and beta-carotene using Whatman 3A chromatographic paper. Absorption was measured at 450 nm (beta-carotene) and 474 nm (lycopene) [6].

The measured biochemical characteristics of both varieties are presented in the table below.

Biochemical characteristics of tomato fruits

Parameter	Shuntukski Velikan tomato variety (Trial 1)		Ogni Moskvy tomato variety (Trial 2)	
	Mean content in the trial samples			
	Control	Organic	Control	Double Roots
Dry matter, %	5.8	6.0	5.5	5.6
Ascorbic acid, mg/100 g	16.7	16.3	17.6	15.7
Beta-carotene, mg/100 g	0.35	0.65	0.82	0.90
Lycopene, mg/100 g	2.70	4.76	6.15	7.11
Total carotenoids, mg/100 g	3.05	5.41	6.97	8.01
pH	Not	Not determined	4.83	4.85

	determined			
Malic acid content, %	Not determined	Not determined	0.57	0.54
Sugar content, %	Not determined	Not determined	2.45	2.81
Taste index	Not determined	Not determined	0.78	0.80
Mineral content, mg/kg	Not determined	Not determined	2,387	2,699

As seen from the above data, both products have caused a growth of the DM content by 5.8–6.0% (for Shuntukski Velikan tomatoes treated with Organic) and 5.5–5.6% (for Ogni Moskvy tomatoes treated with Double Roots) as compared to the controls. The main components in the dry matter of tomatoes are carbohydrates, organic acids, fats, and various mineral salts, half of which are easily digestible.

Ascorbic acid (vitamin C) content is a very important chemical parameter for tomato fruits. Ascorbic acid plays several key roles in plant metabolism (photosynthesis and respiration), water exchange in plant tissues, protein synthesis, regulation of the enzymatic activity, growth and flowering processes, and improves disease resistance of plants [8]. It is widely known that vitamin C is essential for human health. As one of the main antioxidants, it regulates oxidation and reduction reactions. Vitamin C consumption stimulates human immune system and facilitates removal of toxins from the body, enhances calcium uptake, metabolism and blood formation. Therefore, the biological value of tomatoes is partly attributed to the high content of ascorbic acid.

Both Shuntukski Velikan and Ogni Moskvy varieties did not demonstrate any growth of ascorbic acid content. Vitamin C content in the control and experimental crops was almost the same. Vitamin C content was 16.7 mg/100 g in the control crops and 16.3 mg/100 g in the experimental crops treated with Organic in Trial 1 (Shuntukski Velikan), and 17.6 mg/100 g in the control crops and 15.7 mg/100 g in the experimental crops treated with Double Roots in Trial 2 (Ogni Moskvy).

Carotenoids are another important biochemical element which, along with vitamin C, demonstrates high antioxidant activity. Red tomato varieties are rich in lycopene and beta-carotene, while orange and yellow tomato varieties may contain other carotenoids, such as lutein and neurosporene.

Beta-carotene is a powerful antioxidant which increases HDL cholesterol level, and reduces heart disease risks. Lycopene is an acyclic analog of beta-carotene. As an antioxidant, it is about twice as powerful as beta-carotene [12].

Lycopene is a unique natural substance helping treat many diseases as it regulates appetite and cholesterol metabolism, promotes weight loss, activates digestive processes, suppresses gut pathogens, maintaining acid-base balance, reduces prostate and stomach cancer risks, strengthens blood vessels, and reduces heart disease risks. Humans do to not synthesize lycopene, and thus depend on dietary sources. Up to 85% of lycopene come from red tomatoes, which are the major dietary source of lycopene [10].

During the trials, the application of Organic to the variety Shutukski Velikan resulted in a 1.9-fold increase in beta-carotene content (from 0.35 mg/100 g in the control crops to 0.65 mg/100 g in the experimental crops), while the use of Double Roots caused it to grow 1.1-fold in the variety Ogni Moskvy (from 0.82 mg/100 g in control crops to 0.90 mg/100g in experimental crops).

The use of Organic led to a 1.8-fold increase in lycopene content (from 2.70 mg/100 g in the control crops to 4.76 mg/100 g in the experimental crops). Double Roots caused a 1.2-fold increase lycopene content (from 6.15 mg/100 g in control crops to 7.11 mg/100g in experimental crops). Although the total carotenoid content in Ogni Moskvy tomatoes was higher (6.97 mg/100 g in the controls and 8.01 mg/100 g in the experiments) than that in Shnutukski Velikan tomatoes (3.05 mg/100 g in controls and 5.41 mg/100 g in experiments), Organic ensured a significantly higher rate of carotenoid uptake (1.8 times the amount seen in the controls) than Double Roots (only 1.1 times the higher than the controls).

Sugar content is an important biochemical indicator for tomatoes. The use of Double Roots caused the tomato sugar content to change from 2.45% in the controls to 2.81% in the experiments. The taste of tomatoes depends in large measure on the varietal capability to accumulate a moderate organic acid content. The malic acid content in the Ogni Moskvy variety amounted to 0.57% in the control crops and 0.54% in the experimental ones. It is believed that tomatoes have a good taste when their sugar content is several times more than the level of acids. As a result of using Double Roots, the tomatoes had a sugar-to-acid ratio of 5.2 vs. 4.3 in the controls, which means that the tomato taste was improved. The taste index, which we calculated under the currently used formula (taste index = sugar content : (20 x sugar index) + acidity), also grew from 0.78 in the controls to 0.80 in the experiments. The tomato juice pH level also showed a slight increase (from pH 4.83in the controls to pH 4.85 in the experiments).

Tomatoes also have a significant concentration of various minerals. Essential minerals they contain include calcium (ensures bone integrity), phosphorus (active in metabolic processes), iron (recommended for anemia), potassium (facilitates removal of excessive fluids from the body, improves the heart function), zinc (necessary for skin cell and hair growth and wound healing), etc. The application of Double Roots to Ogni Moskvy tomatoes increased the mineral content by 13% (from 2,387 mg/kg in the controls to 2,699 mg/kg in the experimental crops).

This shows that the use of Organic and Double Roots containing spore-forming bacilli, nitrogen-fixing bacteria and mycorrhizal fungi has increased the dry matter, anti-oxidant (beta-carotene and lycopene) and sugar content and the total concentration of minerals in tomatoes, and improved their taste. Therefore, it is advisable to use these products while planting tomato seedlings and during vegetation to improve soil microbiota and enhance nutrient uptake.

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