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THE EFFECTS OF FERTILIZATION WITH ORGANIC SUBSTANCES ON TOMATO (*SOLANUM LYCOPERSICUM* L.)

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Abstract

Among the alternative agricultural systems that have been developed, organic agriculture has deserved increasing interest. This fact is due to the demand of a certain segment of consumers for products with taste, the aspect not being a determining factor for the acquisition. The study aimed to assess whether the application of fertilizers with algae and protein hydrolysate affects the quality of tomato fruits, Siriana cultivar. The applied fertilizers contained substances that are allowed to be used in organic agriculture. The research has been conducted in vegetation pots and quality indicators (chlorophyll pigments, total phenolic content, titratable acidity, soluble solid content, organoleptic characteristics) and production (mean weight per fruit and number of fruits) indicators have been evaluated. The results obtained showed that both organic substances (algae and hydrolyzed proteins) improve the quality of tomato fruits, and production indices were higher by about 5.4% for variant B_AN, respectively by 5.8% for variant B_HP compared to variant control (without organic substances).

Key words*: tomato, biostimulants, Ascophyllum nodosum, hydrolyzed protein, fertilizer.*

INTRODUCTION

The Commission's Farm to Fork and Biodiversity Strategies include the target of reaching 25% of agricultural land under organic farming by 2030 (European Green Deal, 2020).

The EU's harvested production of fresh vegetables (including melons) was 64.8 million tonnes in 2017, a very similar level to that in 2016, of which 17.4 million tonnes were tomatoes, 6.7 million tonnes were onions and 5.8 million tonnes were carrots (EUROSTAT, 2018).

Consumption of tomatoes, like many other plant species that are part of the human diet, is considered to have some positive effects on health.

There are many evidences supporting the anti-inflammatory and anticancer action of tomato fruit bioactive compounds (Raiola et al., 2014*)*.

A regional survey of farmers conducted by Bojacá et al. (2014) in Colombia, found that the fertilization was a cause of abiotic soil depletion.

As a consequence, N losses are dependent on N mineralization, which supplies the excess N in the balance. Assuming a mean N mineralization rate of 0.75 kgN/ ha/day in tunnels during the tomato cropping period, N losses can be equated to 28% of N inputs (Boulard et al., 2011).

The use of biostimulators has played a beneficial role in mitigating the effects due to water shortage and maintaining a level of production (Peripolli et al., 2021).

Ascophyllum nodosum belongs to the class of brown algae and has a wide use in the category of products used in agriculture as a biostimulator with positive effects on some quality indices of crops (Battacharyya et al., 2015; Peripolli et al., 2021).

Protein hydrolysates have great potential to improve crop performance, especially under environmental stress conditions (Colla et al., 2015; 2017).

Seaweed extracts are part of many biostimulators because they have been shown to be factors that promote plant growth and can be applied with good results in conditions of

abiotic stress (Battacharyya et al., 2015; De Saeger et al., 2019).

MATERIALS AND METHODS

Plant materials and treatments

This study is focused on the effect of fertilizers with algae and protein hydrolysate on tomato, Siriana cultivar. The research has been conducted in vegetation pots.

The cultivar Siriana F1 of *Lycopersicon esculentum* was used in experiment. Siriana F1 is an early growing cultivar with indeterminate growth, known to produce its first fruits after ~100 days. The fruits are red, spherical and slightly flattened, with a medium weight of 140g/fruit. One plant can produce 5-5.5 kg of fruits (Inculet et al., 2019).

It has been observed that cultivar Siriana F1 has good resistance to the most important pathogens on tomato crops (Sovarel, 2015).

The applications of all fertilizer were performed by fine atomization on the whole foliage surface, during the vegetation period, using four foliar treatments including 1% concentrated solutions, as follows: first treatment at 21 days after planting and the next three treatments la interval de 7 days after the previous one.

It has been observed that foliar application of seaweed extract is effective in the morning when the stomata leaf is open (Battacharyya et al., 2015).

During the experiment, when fruits were fully ripened, a minimum of three medium fruits were collected for further analyses.

Obtaining and characterizing fertilizers

Fertilizers were obtained in the laboratory using raw materials that are allowed to be used in organic agriculture and were coded thus taking into account the components of each:

Control with code **Bm**: contains secondary nutrients and micronutrients (B, Cu, Fe, Mg, Mn, S, Zn), without organic matter;

Variant 1 with code **B_AN**: contains secondary nutrients and micronutrients (B, Cu, Fe, Mg, Mn, S, Zn) + algae extract (*Ascophyllum nodosum*);

Variant 2 with code **B_HP**: contains secondary nutrients and micronutrients (B, Cu, Fe, Mg, Mn, S, Zn) + hydrolyzed soy protein;

The composition of secondary nutrients and micronutrients (B, Cu, Fe, Mg, Mn, S, Zn) for all 3 samples were in the concentration ranges: B 1.92-2.12 g/L, Cu 0.44-0.55 g/L, Fe 0.44-0.53 g/L, Mg 2.40-2.59 g/L, Mn 0.42-0.54 g/L, S 2.06-2.39 g/L, Zn 0.43-0.51 g/L.

The amounts of algae extract (*Ascophyllum nodosum*) and hydrolyzed soy protein were added so that the organic matter in each of the two products was 30 g/L. The laboratory tests used to determine the composition of the biostimulators were based on the adapted methods described in the Regulation (EC) No 2003/2003 of the European Parliament and of the Council of 13 October 2003 relating to fertilisers.

Agrochemical experiments were performed on a soil with the following characteristics:

total nitrogen (Nt) - 0.615%, mobile phosphorus (P_{AL}) - 166 mg/kg, mobile potassium (K_{AL}) - 317 mg/kg, organic carbon ($C_{organic}$) - 9.41%.

Soil samples were analysed by ICPA methodology (Stoica et al., 1986) developed to assess soil properties as follows:

- Organic carbon determined by volumetric method Walkley - Black wet oxidation after the change Gogoasa;
- Total nitrogen (Nt): Kjeldahl method digestion with sulphuric acid at 350^0C, a catalyst of potassium sulfate and copper sulphate;
- Phosphorus accessible (P mobile): method Riehm-Domingo and dosed with colorimetric molybdenum blue method after Murphy-Riley (reduction with ascorbic acid);
- Potassium (K mobile) accessible: after extraction method Egner-Riehm-Domingo and determination by flame photometry.

Statistical analysis

Different lowercase letters mean significantly difference from other treatments at the level of $p<0.05$ according to the least significant difference (LSD) tests.

RESULTS AND DISCUSSIONS

Tomatoes are part of the human diet and there is clear evidence that they contain bioactive compounds with positive effects on human health (Raiola et al., 2014).

This study is focused on the effect of fertilizers with algae and protein hydrolysate on tomato, Siriana cultivar.
Throughout the experiment, specific practices to this crop were performed for all variants.
Bordeaux mixture was used to control diseases and pests. All solutions were prepared before each application. During the experiment, when fruits were fully ripened, a minimum of three medium fruits were collected for further analyses.
The results obtained showed that both organic substances (algae and hydrolyzed proteins) improve the quality of tomato fruits, and production indices were higher by about 5.4% for variant B_AN, respectively by 5.8% for variant B_HP compared to variant control (without organic substances) (Figure 1).

Figure 1. Yield and mean weight for variants treated with bio-fertilizers and control

It has been observed that the application of biostimulants leads to an increase in production yield and to a reduction in fruit ripening times (Mannino et al., 2020*)*.
The differences in production between the variants treated with B_HP and B_AN were insignificant but had a significant increase compared to the control, given in accordance with the studies performed by (Colla et al., 2017).
The rational use of biostimulants for a crop on a soil that contains at least the minimum nutrients needed by the plant is a way to provide plants a possibility of adapting to abiotic stresses. In order to obtain positive results, it is important that the application moments, the concentration of the active elements and the type of components respond to the needs of the tested culture.

The application of fertilizers that can be capitalized superiorly by plants and not to create pollution is a priority in agriculture. This situation is very common for fertilizers containing soluble forms of nitrogen (urea, ammonium nitrate) (Liang et al., 2020).

Table 1. The composition of chlorophyll a and b and carotene

Treatments	Chlorophyll a (mg/g FW)	Chlorophyll b (mg/g FW)	Carotene (mg/g FW)
Bm (control)	0.83 a	0.79 a	0.69 a
B_AN	0.89 b	0.86 b	0.77 b
B_HP	0.90 b	0.87 b	0.77 b

Different lowercase letters mean significantly difference at the $p < 0.05$ level

Regarding the effects of the two fertilizers, it was observed that there are no statistically assured differences between the variants with organic matter content (Table 1). Although the Chlorophyll a and b content was higher for the variant in which the organic source came from the protein hydrolyzate, the difference compared to the variant with algae extract content is not significant, being proven that the application of seaweed leads to the increase of chlorophyll content in plants (Battacharyya et al., 2015; Goñi et al., 2018).
Studies have led to the conclusion that the content of carotenoids is influenced by doses of nitrogen fertilization, the nitrogen source being the variant with protein hydrolysate (Erba et al., 2013).

Table 2. Evolution of total soluble solids, titratable acidity and total phenolic content concentration in tomatoes

Treatments	Total soluble solids, TSS (%)	Titratable acidity, TA, (g/L)	Total phenolic content, mg GAE/g FM
Bm (control)	4.21 a	0.33 a	89.2 a
B_AN	4.49 b	0.37 b	95.1 b
B_HP	4.51 b	0.37 b	95.4 b

Different lowercase letters mean significantly difference at the $p < 0.05$ level.

The increase of the concentration in total soluble solids and titratable acidity in tomatoes leads to the improvement of the taste and the values obtained are in the range of values

obtained by other authors (Table 2) (Sora et al., 2019).
The effect of increasing the weight and content of titratable acidity and skin total phenolics is also manifested for grapevines as a result of treatment with *Ascophyllum nodosum* extract (Frioni et al., 2018).
Tomatoes contain antioxidant compounds that plays an important role in maintaining a normal state of plant nutrition (antibiotics and natural pesticides) and positive effects on human health (natural sources of antioxidant and antimicrobial compounds) (Turhan et al., 2011; Dadáková et al., 2020).
Although both fertilized variants showed increases in the composition of nitrogen, phosphorus and potassium in tomato fruits, the significant increases were for N and P (Figure 2).
Studies performed on tomato crop do not indicate a clear correlation between the composition of these elements and the application of organic fertilizers (Demir et al., 2010; Rouphael et al., 2017).

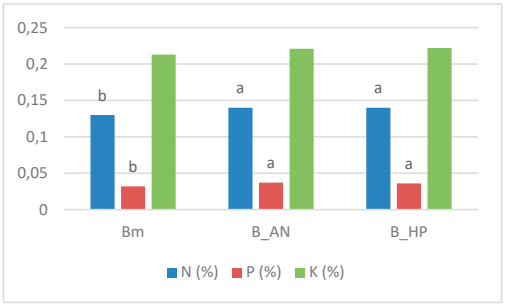

Figure 2. The composition of tomato fruits depending on the variant used for fertilizers.
Different lowercase letters mean significantly difference at the $p < 0.05$ level

Organoleptic determinations were based on 3 criteria: aspect (maximum 15 points), texture (maximum 35 points) and taste (maximum 50 points) (Sora et al., 2019).

Table 3. The results about organoleptic determinations

Variants	Organoleptic evaluation (score)			
	Aspect	Texture	Taste	Total
Bm	11	31	45	87
B_AN	12	33	47	92
B_HP	12	32	48	92

Products treated with fertilizers with organic substances had a better score compared to the variant treated only with the mineral part, due to the ability of biostimulants to produce more marketable tomato fruits (Table 3) (Mannino et al., 2020).

CONCLUSIONS

There is a high demand for the cultivation of quality tomatoes from consumers who are interested in taste and appearance. Because of this there is pressure on farmers to get quality crops with authentic taste. It was observed that the preservation of the taste and quality of the product depends on the treatments performed during the vegetation.
In our study, we obtained 2 products with organic substance with algae extract (*Ascophyllum nodosum*) and hydrolyzed soy proteins. These were applied foliar (4 treatments) to the tomato crop to evaluate the effect on quality and production indicators.
Both products have led to an increase in the content of total soluble solids, titratable acidity and total phenolic content in fruits. Also, a significant increase compared to the control for B_AN and B_HP variants was also for the chlorophyll content in plants.
The improvement of the organoleptic indices is due to a more concentrated composition in nutrients, which leads to the choice of products treated with nutrient solutions that meet the conditions of imputations that can be used in organic agriculture.
Taking into consideration these results, the present work suggests that, the application of the biostimulants represents an efficient method of obtaining quality products for tomato crop in conditions of environmental protection.

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