



THE INFLUENCE OF HUMIC ACID APPLICATION ON TOMATO CULTIVARS UNDER GREENHOUSE CONDITIONS

¹Mirjana JOVOVIĆ, ¹Verica MILOVIĆ, ²Zoranka MALEŠEVIĆ, ³Marko PETKOVIĆ

¹Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina

²Academy of Vocational Studies Sumadija, Arandjelovac, Serbia,

³Faculty of Agronomy, University of Kragujevac, Serbia

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Responses of two tomato (*Lycopersicon esculentum* L) hybrid genotypes Rally F1 (a1) and Pink Rock F1 (a2) to various doses (0 (b1), 0.5 (b2), 1.0 (b3), and 1.5 g L⁻¹ (b4)) of soil application of humic acid (HA) were evaluated in terms of yield traits and quality of fruits, under greenhouse conditions in 2022. The results indicated that soil drenching with different concentrations of humic acid improved fruit productivity and quality in both tomato hybrids. The application of various biostimulant concentrations did not have a statistically significant effect on fruit weight, length, diameter, and yield, nor on the content of citric and malic acids, regardless of the tomato genotype. In contrast, the application of different biostimulant concentrations influenced the content of total acids, total sugars, dry matter, and vitamin C. The a1b3 product was the highest quality product according to the analyzed parameters. The a2 genotype produced a higher-quality product compared to the a1 genotype, without the use of biostimulants (b1). A high negative correlation coefficient was observed between vitamin C and total acids ($r = -0.82$), vitamin C and malic acids ($r = -0.88$), total sugars and total acids ($r = -0.69$), and total sugars and oxalic acid ($r = -0.82$). PCA analysis showed that the statistically significant responses of the analyzed parameters depend more on changes in the concentration of biostimulants than on the genotype.

Key words: fruit quality, genotype, humic acid, tomato, yield

Corresponding author: Mirjana Jovović, University in East Sarajevo, Faculty of Agriculture, e-mail: mirjanamojevic@gmail.com, +38765094774, ORCID: <https://orcid.org/0000-0002-5720-4421>, Verica Milović ORCID: <https://orcid.org/0009-0007-9377-8370>, Zoranka Malešević ORCID: <https://orcid.org/0000-0001-8616-2470>, Marko Petković ORCID: <https://orcid.org/0000-0001-8490-4602>

INTRODUCTION

Humic substances are a mixture of various acids, containing carboxyl and phenolate groups. They are produced through the biodegradation of dead organic matter. Humic acids are important for improving metabolic activities in plant cells and soil (TAVARINI *et al.*, 2018). They have significant potential of vegetable crop production, influencing seedlings, growth, development, yield, and the biochemical content of protein, ascorbic acid, total sugar, and total acid. Humic acids have also been found effective under abiotic stress conditions and in the production of secondary metabolites. Being a major component of humic substances, humic acid may promote the proliferation of beneficial soil microorganisms (SCHOEBITZ *et al.*, 2016), increase soil nutrient content (ZYDLIK *et al.*, 2021) and enhance plant resistance to stress factors, pests, and fungal diseases. Adding humic acid to synthetic or organic fertilizers can accelerate plant development by promoting structural and physiological changes in the roots (SCOTTI *et al.*, 2024) and shoots that are essential for root growth and plant cell development (MASSIMI *et al.*, 2023). These changes can enhance the ability to absorb, assimilate, and distribute nutrients, as well as improve water retention and cation exchange capacity (YANG *et al.*, 2024), which improves growth in horticultural crops. Humic acid (HA) enhances the production of the plants hormone auxin and cytokinin (ASRI and DEMIRTAS, 2015) in many crops, which are responsible for increased photosynthesis, nutrient metabolism, and stress resistance. Tomato (*Lycopersicon esculentum* L.), is one of the leading vegetable species grown in protected areas and in open fields and belongs to the *Solanaceae* family. The tomato was brought to Europe in the 16th century, which led to further improvements in fruit characteristics. Tomato cultivars show vast morphological diversity controlled by a large number of genetic loci (BERGOUX, 2014). According to its botanical characteristics, tomato is considered a fruit, but it is mostly prepared and consumed as a vegetable (RAZIFARD *et al.*, 2020).

Tomato is a rich source of nutrients including minerals, fibres, phenolic acids, flavonoids, and other bioactive compounds. It is also an excellent source of antioxidants, particularly vitamins such as tocopherols, ascorbic acid, retinol, and carotenoids, especially lycopene and beta carotene (ALI *et al.*, 2020). Tomatoes also contain vitamins C, B1, B2, and PP. The color of tomatoes is due to lycopene, but they also contain other pigments, such as carotenoids (carotene and xanthophyll). Also, contains glycoalkaloids, which give them a characteristic smell and bitter taste. The combination of organic acids (malic, citric, and oxalic) and soluble sugars (fructose and glucose), as well as their balanced interaction, contribute to the characteristic tomato flavors. The content of organic acids is important not only for flavor but also for the processing and storage of the fruit. Tomatoes have high potential, and the organization of seedling production is very important. The effects of humic acid on plant growth are very complex and can change depending on many factors.

The present studies were aimed at evaluating the responses of two tomato genotypes to soil applications of various doses of humic acid under greenhouse conditions.

MATERIALS AND METHODS

The experimental site

The experimental site was established in the greenhouse of the Faculty of Agriculture in East Sarajevo (Lukavica, 43° 49' 36.95" N, 18° 22' 59.45" E). Plants of two tomato genotypes

with an indeterminate growth pattern, Rally F1 and Pink Rock F1, were transplanted into prepared soil in the greenhouse during the third decade of April 2022. Rally F1 (a1) is an early hybrid, tall, with a semi-open habitus and very strong root system. Pink Rock F1 (a2) is an indeterminate pink tomato with short internodes, also an early hybrid, very productive, and highly resistance. Average and maximum daily temperatures, air humidity and soil moisture values in the greenhouse during the experimental period are presented in Table 1. The greenhouse was maintained at 23 ± 1 °C during the day, with $59.05 \pm 2\%$ RH (relative humidity) throughout crop growth. The soil had a pH of 7.38, less than 1% CaCO₃, 6.00% organic matter, 0.40 mg kg⁻¹ nitrogen, more than 40 mg kg⁻¹ phosphorus, and 19.60 mg kg⁻¹ potassium. Plants were grown upright and trained onto a single stem, supported by iron wires fixed to their main stems.

Experimental setup

The experiment was set-up as a Randomized Complete Block Design arranged in a split plot system, replicated four times. There were eight combinations with 12 plants per variant. The plants were planted 0.6 × 0.5 m apart, with a population of 333 per 100 m². Before planting, agrotechnical measures of tilling and fertilization with organic manure were carried out. Preventive protection of crops from soil pests and disease was carried out together with pre-sowing preparation in the third decade of April. They were applied Turin, soil insecticide and fungicide Nordox.

Table 1. Average and maximum soil moisture values, air temperatures and air humidity in the greenhouse during the experimental period

Month	Greenhouse daily temperature (°C)		Soil daily moisture (%)		Relative air humidity in the greenhouse (%)	
	Average	max.	Average	max.	Average	max.
April	13,45	23,2	48,87	78,70	59,05	99,9
May	28,96	43,6	36,54	80,80	50,79	90,0
June	34,89	44,0	40,04	79,80	38,15	99,2
July	32,68	42,7	46,46	78,20	44,13	95,5

Application of humic acid

Humistar is manufactured by Rovensa Next (ex. Tradecorp), Spain. He is a special liquid preparation that contains a high amount of humic acids. The product is extracted from leonardite, without heavy metal content. Humistar promotes more intensive absorption of all forms of nutrients from the soil, affects initial root development in plants after transplanting, improves the structure and water-air properties of the soil, and promotes the development of beneficial microbiological fauna. In addition to humic acids, Humistar contains a high amount of other organic compounds (amino acids, peptides, peptones, proteins, biostimulators, etc.) that plant can quickly and efficiently absorb through their roots. Composition: total humus supplement, 16% w/w; humic acid, 12% w/w; fulvic acid, 3% w/w and potassium 5% w/w.

The following variants are represented within the second tested factor (b) biostimulator:

0 (b1), 0.5 (b2), 1.0 (b3), and 1.5 g L⁻¹ (b4).

Five Humistar treatments were applied in growing seasons. The first treatment of Humistar (April 28) thoroughly incorporated into the soil before planting. The second soil drench was applied around the base of the growing plants, about 10 cm from their main stems, using a back-held spray pump and a spade. The control treatment involved soil applications of water only. The second treatment was in the phenophase of tomato flowering, then third after 15 days in the phenophase of fruit formation, the fourth treatment in the phenophase of fruit ripening and the fifth treatment in the phenophase of full fruit ripening. Harvesting started in mid-July and continued until mid of September. Harvest was performed roughly every seven to ten days depending on fruit ripening.

Data recorded

Fruit yield, was recorded for the first five harvests. From each replication, ten fruits were randomly selected, weighed and divided into two equal lots. The first lot (five fruits) in each replication was used to determine average weight, length and diameter of individual fruits while the other five fruits was used for quality analysis. The analysis of fruit plant material was conducted in the laboratory of Faculty of Agriculture in East Sarajevo.

Dry matter (%) was determined by drying the plant material at 105°C to a constant mass. The content of reducing sugars was determined by the Luff - Schoorl method, which is based on the reduction of copper salts in a warm alkaline solution by reducing sugar and on the indirect titration of the rewarded copper oxide with sodium thiosulfate solution. The end of the titration was indicated by the appearance of a gray color. The difference in thiosulfate consumption between the control and experimental samples was used to determine the amount of reducing sugar using a reference table.

The content of total L-ascorbic acid was determined by titration with Tillman's solution. Plant material was mixed with CH₃COOH, and after 30 min the extract was titrated with the Tillman's reagent (2,6-dichloro-indophenol). The end point of the titration was determined by the first permanent, faint pink color that persisted for at least 15 seconds, indicating that all ascorbic acid in the aliquot had reacted with the Tillman's reagent.

The content of total acids, malic, oxalic and citric acids (g100g⁻¹) was measured using a standardized titration method. Tomato samples were macerated in a porcelain mortar. Before titration, the NaOH solution was standardized using anhydrous citric acid. Phenolphthalein was used as the visual indicator due to its distinct color change from colorless to pale pink at the endpoint. Titration was performed by gradually adding standardized 0.1 N NaOH solution to the tomato pulp mixture while stirring continuously until a faint pink color persisted for at least 30 seconds, indicating the endpoint had been reached (RAHMAN *et al.* 2024).

Microclimatic conditions in the greenhouse were also monitored using a digital system. The following parameters were monitored: air and soil temperature, and relative air and soil humidity, via the Virtuino 6 application. The experimental greenhouse was regularly ventilated through this application.

Statistical analysis

Statistical analysis was performed using the Statistical Analysis System (SPSS, version 20). Data were analyzed by analysis of variance (ANOVA), and differences between samples

were determined by Tukey's HSD test. Mean value within each group with different letters (a-e) indicated significant differences at $P < 0.05$. Principal component analysis (PCA) was used to determine interdependence between the traits. The correlation is shown in the Color Correlation Diagram.

RESULTS AND DISCUSSION

The provided data for Table 2 shows that no significant differences were detected among any of the treatments a1 and a2 genotypes across b1 to b4 applications for fruit weight, length, diameter, or yield based on the letter grouping (a for all values). The tested biostimulant concentrations did not induce a statistically measurable effect on these macroscopic yield parameters.

Despite the uniformity of the statistical outcome, genotype a1 showed a notable numerical spike in fruit weight under the b3 treatment (172.19 g), contrasting with its basal value (68.03 g). This substantial, yet non-significant, increase hints at a potential sub-threshold effect or high biological variability inherent in this trait, as evidenced by the considerable standard deviations (e.g., 83.39). Contrary to our results, RUBYATH *et al.* (2024), found a significant influence of humic acid treatments on the yield of tomato fruits produced by each plant. The number of fertilization treatments did not have a significant effect on the average weight of tomatoes. Other studies on the use of biostimulants, including humic acids, have observed a positive effect on fruit weight in tomato (ZYDLIK *et al.*, 2021; KUMAR *et al.*, 2017). Similar results were obtained in cucumber tests (GOVEDARICA – LUČIĆ *et al.*, 2024), broccoli (AL – TAEY *et al.*, 2019), lettuce (RAHEEM *et al.*, 2018). Our experiment agrees with the results of SOLDANIBAND *et al.* (2022), who did not find any significant effect of biostimulants on the weight of strawberries. The effects of treating plants with humic acids may depend on various factors, such as the climatic and soil conditions, the method of application, or the species cultivated. The effect of humic acids on yield parameters, fruit diameter, fruit length and fruit weight was not significant in either genotype, which may be explained by or linked to the influence of high temperatures and lack of water during the flowering period, as well as high temperatures in June and July.

Table 2. Influence of tomato cultivars and humic acid (HA) application on fruits yield traits

	a1				a2			
	b1	b2	b3	b4	b1	b2	b3	b4
Fruit weight g	68,03 ± 3,20 a	95,69 ± 30,81 a	172,19 ± 83,39 a	92,79 ± 38,81 a	114,47 ± 28,71 a	140,24 ± 53,15 a	107,18 ± 29,98 a	87,47 ± 31,94 a
Length cm	4,33 ± 0,38 a	4,57 ± 0,23 a	5,87 ± 1,12 a	4,40 ± 0,40 a	5,50 ± 1,06 a	4,70 ± 1,18 a	5,47 ± 0,75 a	4,40 ± 1,51 a
Diameter cm	4,93 ± 0,12 a	5,83 ± 0,84 a	6,60 ± 1,23 a	5,60 ± 0,78 a	6,16 ± 1,02 a	6,60 ± 1,45 a	5,77 ± 0,67 a	5,23 ± 0,91 a
Yield Yield kg m ⁻²	3,40 ± 0,16 a	4,77 ± 1,52 a	8,61 ± 4,17 a	4,63 ± 1,94 a	5,72 ± 1,43 a	7,01 ± 2,66 a	5,45 ± 1,36 a	4,37 ± 1,59 a

Different letters indicate significant difference at $P < 0.05$ level.

The application of different concentrations of biostimulants to the analyzed tomato genotypes showed in Table 3. The use of various biostimulant concentrations did not have a statistically significant effect on fruit weight, length, diameter, and yield, as well as on the content of citric and malic acids, regardless of the tomato genotype. In contrast, the application of different biostimulant concentrations influenced the content of total acids, total sugars, dry matter, and vitamin C. In genotype a2 vitamin C content is highest at b2 (9.57 mg per 100g), showing a 4.18% increase over the control (b1, 9.26 mg per 100g). Conversely, a1 reaches its peak at b1 9.32 mg per 100g, with a decrease at b2 (9.09 mg per 100g). The differing phenotypic responses between genotypes under increasing biostimulant levels, such as the contrasting sugar accumulation patterns in genotype a1 and a2 align with the established idea that humic substances influence metabolism in a genotype-specific manner. With increasing concentrations of the biostimulant additive, the content of total sugars and dry matter increased significantly ($P \leq 0.05$) within the a1 genotype, which is characterized by a high acid content. Excluding concentration b1 (control, 0), the maximum values of statistically significant parameters were obtained at the highest biostimulant concentration (b4), while concentration b3 resulted in the minimum values, regardless of the tomato genotype. However, the application of the maximum biostimulant concentration (b4) did not produce a product with the highest values for all analyzed parameters. The a1b3 product is the highest quality product according to the analyzed parameters. The a2 cultivar produced a higher-quality product compared to the a1 cultivar without the use of biostimulant (b1). Increasing the concentration and adding the maximum biostimulant concentration do not necessarily result in a product with the highest values for the analyzed parameters. Our results are consistent with PADEM and OCAL (1999), who showed that a single application of humic acid during the plant growth cycle was sufficient to increase vitamin C content in tomato fruits grown for processing industry. Ascorbic acid, also known as vitamin C, is a non-enzymatic antioxidant that provides beneficial effects for the human body. According to MALACRIDA *et al.* (2006), higher ascorbic acid content in tomatoes improves postharvest fruit quality. ALENAZI *et al.* (2020) found that ascorbic acid enhances plant tolerance to biotic and abiotic stress. Thus, genotypes with high ascorbic acid content are particularly important for breeding programs and the fresh produce market. In this study, total acids content differed significantly among the studied genotypes. The application of the maximum concentrations of biostimulant (b4) did not result in a product with the highest values for the analyzed parameters. The a1b3 product was the highest quality product according to the analyzed parameters. The a2 genotype produced a higher-quality product compared to the a1 genotype without the use of biostimulant (b1). Our results are in agreement with LIMA *et al.* (2011), who reported that the total acids in tomato fruits increased with higher doses of humic acid application, though remained in the range of 0.3-0.5% citric acid. These results suggest that application of humic acid may have stimulatory effects on tomato plants, improving their efficiency in nutrients uptake, especially phosphorus and potassium which in turn enhances fruit quality. SHAHMALEKI *et al.* (2014) demonstrated that foliar application of humic acid improved fresh firmness, antioxidant activity, vitamin C, total phenolic, and total acid content in tomato fruits of 'Izabella' genotype. Similar results were obtained by KAZEMI *et al.* (2014). They were found that application with humic acid increase TSS content, vitamin C and fruit lycopene content in tomato. Testing on cucumber yielded similar results for vitamin C content (GOVEDARICA – LUČIĆ

et al., 2024) and TSS content (ALMADHAGI, 2019), on cabbage vitamin C content (RODICA *et al.*, 2017).

There were no significant changes in the levels of oxalic, citric and malic acids when applying humic acid, in both genotype. These acids are present in small amounts as intermediate products in metabolic processes of the Krebs cycle. Citric acid is the most dominant organic acid in tomatoes. Along with citric acid, malic acid is the most primary organic acid contributing to the taste of tomatoes. Some authors suggest that biostimulants improve stress tolerance by increasing the production of antioxidants (ERTANI *et al.*, 2011). At all stages, citric acid is the dominant organic acid in tomatoes; however, the malic acid content may be significant in unripe tomatoes. Additionally, the ratio of malic to citric acid can vary greatly between different tomato cultivars. After ripening, the citric acid content decreases (ANDELINI *et al.*, 2023). These results suggest that application of HA may exhibit stimulatory effects on tomato plants thereby improving their efficiency to uptake major nutrients, especially P and K from the soil that in turn improves the quality of tomato fruits.

The highest sugar content was found in genotype a1 of treatment b4, and this was statistically significant ($P \leq 0.05$) compared to genotype a2 and to other applied concentrations of humic acid. Total sugar content in fruits is considered an indicator for determining food quality and is an important energy source for humans and animals (COMERFORD *et al.*, 2021). The total sugar content analysis provides information on nutrition, standard of identity, water retention, flavours, desirable texture, and the stability of food products (BEMILLER, 2018). Total acids and total sugar content in tomato fruit are among the most important properties not only for quality but also for taste. Similar results were reported by FRANÇA *et al.* (2024), who found that humic acid improved photosynthetic activity in tomatoes. The ratio of sugars and organic acids is key to the sweetness and sourness of tomatoes. High total and total sugars content is required for a favourable taste. Similar results were obtained by ZODAPE *et al.* (2011) with the foliar application of *Kappaphycus alvarezii* sap (seaweed) in tomatoes. There was an increase of more than 20% in the levels of ascorbic acid, acidity and total soluble solids, as well as in the levels of N, P, K, Mn and Zn compared with the control treatment.

A scatter plot was created for the first two principal components (F1 and F2) from the PCA data matrix, explaining 70.47% of the variance in the analyzed data (F1 = 36.12% and F2 = 34.35%). (Figure 1). Fruit length (20.5%), vitamin C content (14.7%), yield (13.9%), and fruit mass (13.7%) contribute most to component F1, while oxalic acid content (23.9%), total acids (16.2%), and total sugars (14.1%) contribute the most to component F2. The statistically significant responses of the analyzed parameters depend more on changes in the concentration of biostimulants than on the genotype. The positioning of individual samples in the PCA plot indicates distinct experimental results. For example, samples a1b2 and a2b3 are characterized by high total acid values, with sample a1b3 primarily showing high oxalic acid content. Sample a2b1 is associated with high dry matter content, while sample a1b4 is distinguished by its vitamin C content. Additionally, sample a2b2 is characterized by higher sugar content, a2b1 by fruit length, and a1b3 by fruit length, diameter, yield, and mass, whereas samples a2b2, a2b4, and a1b1 show higher concentrations of vitamin C.

Table 3. Influence of tomato cultivars and humic acid (HA) application on fruits quality traits during the 2022

	a1				a2			
	b1	b2	b3	b4	b1	b2	b3	b4
Vitamin C mg 100g ⁻¹	9,32 ± 0,10 e	9,09 ± 0,02 b, c	8,89 ± 0,04 a	9,14 ± 0,02 c, d	9,26 ± 0,12 d, e	9,57 ± 0,03 f	8,97 ± 0,02 a, b	9,29 ± 0,01 d, e
Dry matter %	5,68 ± 0,02 b	6,14 ± 0,02 d	6,14 ± 0,01 d	6,35 ± 0,01 e	6,71 ± 0,02 f	5,59 ± 0,01 a	5,66 ± 0,02 b	5,94 ± 0,01 c
Total sugars g100g ⁻¹	4,98 ± 0,06 a, b	5,10 ± 0,02 c	5,47 ± 0,02 d	5,79 ± 0,01 f	5,02 ± 0,03 b, c	5,62 ± 0,03 e	4,92 ± 0,04 a	5,43 ± 0,02 d
Total acids g100g ⁻¹	5,96 ± 0,08 c	6,11 ± 0,05 d	6,09 ± 0,02 d	5,74 ± 0,04 b	5,92 ± 0,04 c	5,53 ± 0,04 a	6,20 ± 0,03 d	5,89 ± 0,01 c
Oxalic acid g100g ⁻¹	0,27 ± 0,01 a, b	0,27 ± 0,02 a, b	0,26 ± 0,01 a, b	0,26 ± 0,01 a, b	0,27 ± 0,01 a, b	0,24 ± 0,02 a	0,28 ± 0,01 b	0,26 ± 0,01 a, b
Citric acid g100g ⁻¹	0,40 ± 0,01 a	0,42 ± 0,01 a	0,41 ± 0,02 a	0,39 ± 0,01 a	0,40 ± 0,01 a	0,39 ± 0,02 a	0,37 ± 0,08 a	0,40 ± 0,01 a
Malic acid g100g ⁻¹	0,39 ± 0,01 a	0,41 ± 0,02 a	0,42 ± 0,01 a	0,42 ± 0,06 a	0,41 ± 0,01 a	0,38 ± 0,01 a	0,42 ± 0,01 a	0,40 ± 0,01 a

Different letters indicate significant difference at P < 0.05 level.

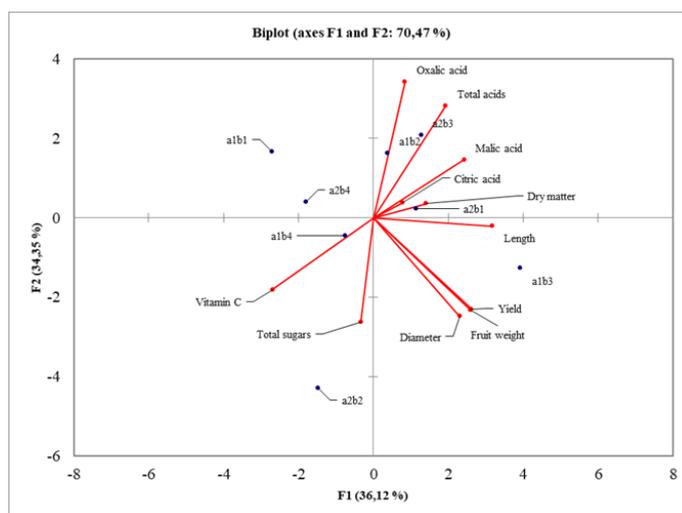


Figure 1. PCA (Biplot diagram) for the parameters of the independent variables (tomato sort and biostimulator) and the responses of the vitamin C, dry matter, total sugars, total and individual acids, fruit weight, length, diameter and yield

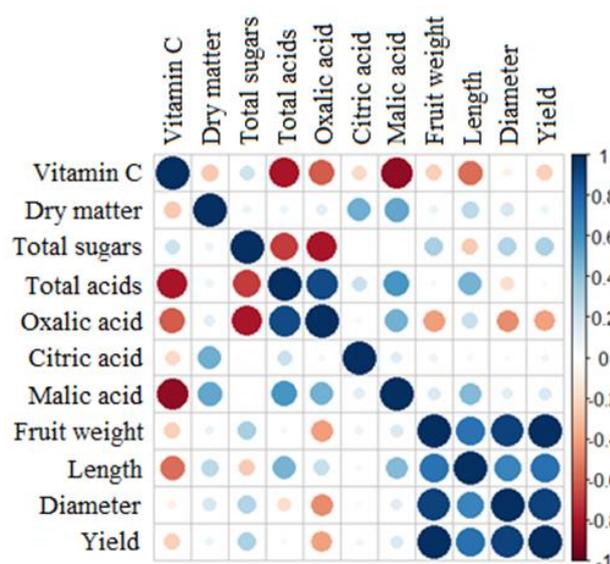


Figure 2. Color correlation diagram between the parameters of the independent variables (tomato sort and biostimulator) and the responses of the vitamin C, dry matter, total sugars, total and individual acids, fruit weight, length, diameter and yield.

The correlation coefficients between the analyzed parameters are visually represented by differences in circle size, shading intensity, and color, with blue indicating a positive correlation and red representing a negative correlation. A high negative correlation coefficient was observed between vitamin C and total acids ($r = -0.82$), vitamin C and malic acids ($r = -0.88$), total sugars and total acids ($r = -0.69$), and total sugars and oxalic acid ($r = -0.82$). One possible theoretical explanation of this result is that the ascorbic acid content in tomato fruit increases until the beginning of ripening and then begins to decrease due to increased ascorbate oxidase activity (YAHIA *et al.*, 2001). A high positive correlation coefficient was observed between fruit mass and yield ($r = 0.93$) and between fruit mass and diameter ($r = 0.74$). As expected, a positive correlation coefficient was observed between total and individual analyzed acids ($r = 0.58 - 0.89$), except with the citric acid ($r = 0.22$). In this process, the ascorbic acid content decreases generating other acids at the same time. Thus, the results of the correlation analysis between ascorbic acid and total acids content in the literature vary. This is suggested to be influenced, among other factors, by the period of measurement and the environmental conditions in which the plants grow (TODEVSKA *et al.*, 2023).

CONCLUSION

Our results indicate that soil drenching with different concentrations of humic acid increased the efficiency of both genotypes in producing quality fruits under protected environment. The

application of different concentrations of biostimulators did not statistically significantly affect fruit weight, diameter, and length, regardless of tomato genotype. A high dose of biostimulator b4 did not improve the tested quality parameters in tested genotypes. As the concentration of the biostimulator additive, the total sugars content statistically significantly increased in the Rally F1 genotype. The occurrence of a negative correlation between total acids and ascorbic acid in tomato fruit should be investigated in further studies. When analyzing the results, it is necessary to consider the characteristics of the genotype for the tested parameters, as well as its resistance to water deficiency for a certain periods and high temperatures in the greenhouse. Differences in temperature and soil water content between June and July may be among the causes of these results. PCA analysis showed that the statistically significant responses of the analyzed parameters depend more on changes in the concentration of biostimulants than on the genotype. Therefore, further research is needed to fine-tune the application of those formulations of humic acid that have beneficial effects in order to suggest an application protocol that may improve tomato fruit quality under water limitation condition, high temperatures and extend the research to other genotypes

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UTICAJ PRIMENE HUMIČNE KISELINE NA SORTE PARADAJZA U USLOVIMA PLASTENIKA

¹Mirjana JOVOVIĆ, ¹Verica MILOVIĆ, ²Zoranka MALEŠEVIĆ, ³Marko PETKOVIĆ

¹Poljoprivredni fakultet Univerziteta u Istočnom Sarajevu, Bosna i Hercegovina

²Akademija strukovnih studija Šumadija, Aranđelovac, Srbija,

³Agronomski fakultet Univerziteta u Kragujevcu, Srbija

Izvod

Rakcije dva hibrida paradajza (*Lycopersicon esculentum* L) Ralli F1 i Pink Rock F1 na različite doze (0, 0,5, 1,0 i 1,5 g L⁻¹) primjene huminske kiseline (HA) u zemljištu su procijenjene u pogledu svojstava prinosa i kvaliteta plodova, u uslovima plastenika. Naši rezultati ukazuju da je natapanje zemljišta različitim koncentracijama huminske kiseline uticalo na povećanje efikasnosti oba kultivara za proizvodnju kvalitetnih plodova u zaštićenom okruženju. Primjena različitih koncentracija biostimulansa nije imala statistički značajan uticaj na masu, dužinu, prečnik i prinos ploda, kao ni na sadržaj limunske i jabučne kiseline, bez obzira na sortu paradajza. Nasuprot tome, primjena različitih koncentracija biostimulansa uticala je na sadržaj ukupnih kiselina, ukupnih šećera, suve materije i vitamina C. Proizvod a1b3 je najkvalitetniji proizvod prema analiziranim parametrima. Kultivar a2 dao je kvalitetniji proizvod u odnosu na kultivar a1, bez upotrebe biostimulansa (b1). Uočen je visok negativni koeficijent korelacije između vitamina C i ukupnih kiselina ($r = -0,82$), vitamina C i jabučne kiseline ($r = -0,88$), ukupnih šećera i ukupnih kiselina ($r = -0,69$), i ukupnih šećera i oksalne kiseline ($r = -0,82$). PCA analiza je pokazala da statistički značajni odgovori analiziranih parametara više zavise od promjene koncentracije biostimulansa nego od kultivara

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