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## THE INFLUENCE OF THE APPLICATION OF MODERN TECHNOLOGIES ON THE PRODUCTION AND MORPHOLOGICAL CHARACTERISTICS OF TWO TOMATO HYBRIDS

**Vojin Cvijanović**

Institute for Science Application in Agriculture, Serbia, vcvijanovic@ipn.bg.ac.rs

**Marija Bajagić**

Faculty of Agriculture, University of Bijeljina, Bosnia and Herzegovina, marijabajagic@yahoo.com

**Mladen Petrović**

Institute for Science Application in Agriculture, Serbia, mpetrovic@ipn.bg.ac.rs

**Miloš Stanković**

Faculty of Management and Economics, Serbia, milostanko@yahoo.com

**Gorica Cvijanović**

Faculty of Agriculture, University of Bijeljina, Bosnia and Herzegovina, cvijagor@yahoo.com

**Abstract:** Agriculture, as an important economic branch, aims to provide a sufficient amount of healthy and safe food. The greatest economic importance has over 30 species in various advanced production systems, integrated or organic production, for fresh consumption and for the needs of the processing industry. The presence of organic products in large market chains indicates the market potential of such products. The need for this type of production directly affected the same demand of end users. One of the most important vegetable species is the tomato. Tomato is one of the most used vegetables in the world. Today, due to its energetic, nutritious and medicinal properties, it is the most represented vegetable species in the human diet. We have witnessed that the excessive, uncontrolled, often unprofessional use of synthetic means for protection and fertilization in food production has threatened its safety and quality. The yield and quality of tomatoes are significantly affected by the use of organic fertilizers. The need for a reduced negative impact on the basic elements of the environment led to intensive development of sustainable agriculture concepts. The production in the protected area of certain plant species has increased significantly, so the production in the protected area occupies a significant place. In order to protect people and the environment, organic and integral production systems are of increasing importance. The modern approach to tomato production involves the application of organic and integral production methods, which implies the limitation or complete elimination of synthetic agents. In recent years, in the protected space in the production of tomatoes, modern high plastics are increasingly represented, with foil of the latest generation, which enables very successful growing of tomatoes in integral and organic production. Tomatoes and tomato products occupy a special place in human nutrition and can be considered as functional food. The aim of the research is to examine the variability of the vegetative growth of tomatoes (the number of flower branches formed, the number of fruits per flower branch during the growing season and tomato yield). In the experiment, two types of tomatoes (grapolo and beef) were used, that is, four different hybrids in two production systems (organic and integrated). The experiment was set up in a protected area according to a random block system in four replications.

**Keywords:** organic and integral production, healthy and safe food, protected area, tomatoes.

### 1. INTRODUCTION

Vegetable growing represents the most intensive branch of plant production with high economic effects. In particular, the profit from vegetable production is greatly increased by growing plants in protected areas, which implies the continuous growth of this method of cultivation. The production of vegetables in Serbia is expanding, and the areas under vegetable production are increasing year by year due to the growing demand both on the domestic and on the world market. Tomatoes belong to one of the most represented vegetable plants on a global scale, and belong to the most profitable vegetable crops. In the structure of vegetable production in our country, tomato is among the most represented species, especially in protected areas where its cultivation dominates, with a share of about 70% (Zdravković et al., 2012). In modern food production and consumption, it occupies an important place. It is known that, in addition to the use of fresh fruit, many products are made from tomatoes in the processing industry, such as: juice, puree, ketchup, skin, soup, etc., which leads to the fact that in the world. Many authors have concluded that tomatoes are rich in vitamins C, E and B, copper and iron, and minerals such as potassium, sodium, magnesium and calcium (Setiarti et al., 2022.). Minerals are micronutrients necessary for the growth, maintenance, and proper functioning of the human body (Dramicanin et al., 2021). Increasing consumer demand for quality and nutritionally valuable products can influence the increase in tomato production in the organic system, using

biological preparations that can contribute to increased yields, protection from pathogens and improvement of fruit quality (Cvijanović et al., 2021). The production of this vegetable is mostly influenced by the yield and price, which tend to constantly increase in the Republic of Serbia (Petrović et al., 2021). Tomato production has a seasonal character and its price varies depending on the period of the year, yet it is possible to increase its yield by using modern technologies (Petrović et al., 2022). The concept of integrated and organic agricultural production includes: cultivation of resistant varieties and hybrids according to various biotic and abiotic factors; application of agrotechnical measures, application of physical-mechanical measures (mulching, soil covering) that change the microclimate and create conditions for preventing the development of pathogens, as well as the application of biological measures, i.e. natural predators of insects and diseases. This type of production includes the cultivation of resistant varieties and hybrids, the integrated application of cultivation, the use of physical and mechanical measures, such as organic mulching to maintain soil fertility and induced (acquired) systemic plant resistance, as well as the use of biological measures, i.e. natural predators and biopesticides (Momirović et al., 2021). Due to the negative impact of agricultural production on the basic elements of the environment (water, soil, air and biodiversity), the concepts of sustainable agriculture began to develop intensively, which foresee significant changes in the technology of growing crops that contribute to a better establishment of the ecological balance and stability of natural resources in the agroecosystem (Momirović et al., 2015). In accordance with the requirements for health-safe products without residues of harmful substances in fruits, there is an increasing need for the production of tomatoes in integral and organic production systems (Cvijanovic et al., 2023).

## 2. MATERIAL AND METHODS

The research was carried out during one growing season in 2021, in controlled microclimate conditions, in order to examine the impact of integrated and organic growing systems on productivity, the number of tomatoes per flower truss and the number of flower trusses in a protected area. The research was conducted on an experimental plot of the company "Zeleni hit", in "13. maj", in the area in the vicinity of Zemun Polje. The experiment was set up in an indoor facility, of the total area of 320 m<sup>2</sup> (8 m by 40 m), ridge height of 5 m, support height 2.6 m, which enabled continuous support to a larger number of flower trusses and implied descending of the plants.

The experimental parts of the research was designed as two-factorial experiment:

- Factor A: growing system
  - o integrated
  - o organic;
- Factor B: chosen tomato genotypes, a total of 4 hybrids, two of each of the prevailing types of tomatoes
  - o Grapolo (hybrids: Avalantino and Dirk)
  - o Beef (hybrids: Rally and Velocity)

For both systems, the basic fertilization was carried out in the amount of 120-140 kg ha<sup>-1</sup> N; 100-110 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub>; 90-120 kg ha<sup>-1</sup> K<sub>2</sub>O and 35-40 kg ha<sup>-1</sup> MgO. Prior to seeding, the soil was prepared by using a standard technology: using organic and congenital mineral fertilizers for integrated farming and using only certified and approved organic and mineral fertilizers listed as the approved products for plant nutrition and protection to be used in organic farming ( <http://www.uzb.minpolj.gov.rs> ).

In both systems, the researchers used bio pesticide agents, useful microorganisms, and predators, as well as pheromone traps and systems of mass trapping to protect crops from pests and diseases. All that was done to harvest the final product without pesticide residues, which was confirmed by certified laboratories. When it comes to weed management, in the integrated farming system the researchers used silver polyethylene mulch, and in organic system a layer of organic matter for covering, which enables high thermal stability, as well as conservation of soil moisture and accessible nutrients in the soil.

At the end of the growing season, in the stage of technological maturity of the plants, samples of 10 plants were marked and taken using a random sampling method with all 4 repetitions and all variants for the analysis of the following properties: the number of formed flower trusses, the number of fruits per flower branches during the growing season and tomato yield.

The results were processed by analysis of variance for a two-factor experiment, and the statistical significance of the differences was determined by the LSD test at 5% and 1% (Statistics program "Statistica 10.0"). The results are presented in tables.

## 3. RESULTS AND DISCUSSION

Modern systems have made it possible to grow tomatoes in an integrated concept on a larger number of flower sticks, and this innovative approach has had equal success in organic agriculture, achieving high productivity and sustainability. It is known that the formation of flowers is affected by light intensity, temperature and nutrients. It is

an important transition from vegetative growth to reproductive growth, and is also a stage in the formation of plant yields (Blackman, 2017).

According to many researchers, plant growth stimulators have a significant influence on the intensity of flower branch formation (Rameau et al., 2015). Table 1 shows the processing result of the determined number of flower branches. Based on the analysis of variance, the number of flowers was not affected by the production system (factor A), nor was the interaction between the production system and the hybrid (A x B), while the genotypic differences of the hybrids had a highly significant effect on the number of flower branches formed (factor B).

Based on the research, we can conclude that the average number of flower branches formed was 6,80. In the organic system of production, the number of formed flower branches was higher by 2,98% compared to the integral system. Hybrids (factor B) had a statistically significant effect on the number of flower branches formed. The highest number of flowering branches was formed by the Avalantino hybrid (12,63). The number of flower branches formed in this hybrid was statistically significantly higher than in all other tested hybrids. Hybrid Velocity had the lowest number of flower branches (3,11). Zdravkoivć et al., (2012) examined six hybrids originating from six inbred lines and found a significant effect of certain genes on the formation of generative organs and the number of fruits per flower branch. According to research (Pou et al., 2021), using organic mulch significantly affects the temperature and amount of water in the soil, as well as SO<sub>2</sub> emissions, which favors the growth and yield of crops.

*Table 1. The number of tomato flowering branches in two production systems and two different types of hybrids during the 2021 growing season.*

Production	Grapolo		Beef		Average
	Avalantino	Dirk	Rally	Velocity	
Organic	24,00	24,50	16,00	15,50	20,00
Integrated	24,00	26,50	15,00	16,50	20,50
	<b>24,00</b>	<b>24,75</b>	<b>15,00</b>	<b>15,50</b>	
				<b>Average</b>	<b>20,25</b>
	<b>A<sup>nz</sup></b>	<b>B<sup>**</sup></b>	<b>A x B<sup>nz</sup></b>		
<b>F – test</b>	<b>4,84</b>	<b>48,83</b>	<b>1,27</b>		
<b>LSD 5%</b>	<b>1,53</b>	<b>2,25</b>	<b>3,18</b>		
<b>LSD 1%</b>	<b>2,32</b>	<b>3,08</b>	<b>4,35</b>		

Based on the variance analysis, the number of formed fruits per flower branch was not affected by the production system (factor A), nor was the interaction between the production system and the hybrid (A x B), while the genotypic differences of the hybrids had a highly significant effect on the number of formed flower branches (factor B). Based on the research, we can conclude that the average number of fruits per flowering branch is 20,25. In the organic system of production, the number of fruits per flowering branch was (20,00), which is 2.5% lower than in the integral system (20,50).

Hybrids (factor B) had a statistically significant effect on the number of formed fruits per flower branch. The largest number of flower branches was formed by the Dirk hybrid (24,75). The number of formed fruits per flower branch in this hybrid was statistically significantly higher than the Rally and Velocity hybrids. Hybrid Rally had the lowest number of flower branches (15,00). Similar research results were obtained by Kapoulas et al., (2011).

*Table 2. The number of fruits per flowering branch in two production systems and two different types of hybrids during the 2021 growing season*

Production	Grapolo		Beef		Average
	Avalantino	Dirk	Rally	Velocity	
Organic	12,90	8,65	3,13	2,95	6,90
Integrated	12,35	7,85	3,35	3,28	6,70
<b>Average</b>	<b>12,63</b>	<b>8,25</b>	<b>3,24</b>	<b>3,11</b>	
				<b>Average</b>	<b>6,80</b>
	<b>A<sup>nz</sup></b>	<b>B<sup>**</sup></b>	<b>A x B<sup>nz</sup></b>		
<b>F – test</b>	<b>1,69</b>	<b>304,13</b>	<b>1,15</b>		
<b>LSD 5%</b>	<b>0,38</b>	<b>0,78</b>	<b>1,10</b>		
<b>LSD 1%</b>	<b>0,57</b>	<b>1,06</b>	<b>1,50</b>		

Based on the variance analysis, the production system (factor A), hybrids (factor B), as well as the interaction relationship between the production system and hybrids (A x B) had a statistically significant effect.

The estimated total yield per plant during the growing season was (4,75 kg). In the organic production system (factor A), the total average yield for all hybrids during the growing season was (5,22 kg), which was 9,89% higher than in the integral production system (4,30 kg).

Hybrids (B) showed great variability. The Avalantino hybrid had the highest average total yield (5,18 kg). The determined yield is statistically highly significant compared to the yield of other hybrids. The interaction of production and hybrid (A x B), it is observed that the Avalantino hybrid had the highest average yield in the organic system (5,97 kg), while in the integral system the highest yield was the Rally hybrid (4,59 kg). The hybrid Rally (4,37 kg) had the lowest average yield in the organic system, while the hybrid Dirk (4,15 kg) had the lowest yield in the integral system. In the research of Tüzen et al., (2021) on the influence of black polyethylene mulch film in the production of tomatoes, it was concluded that the morphological characteristics and yield of tomato fruits can be significantly improved. According to Popović et al. (2015) tomato yield is also dependent on the floor.

**Table 3. Tomato yield in two production systems and two different types of hybrids during the 2021 growing season.**

Production	Grapolo		Beef		Average
	Avalantino	Dirk	Rally	Velocity	
Organic	5,97	5,16	4,37	5,36	5,22
Integrated	4,39	4,12	4,59	4,09	4,30
<b>Average</b>	<b>5,18</b>	<b>4,64</b>	<b>4,48</b>	<b>4,72</b>	
				<b>Average</b>	<b>4,75</b>
	<b>A**</b>	<b>B**</b>	<b>A x B**</b>		
<b>F – test</b>	<b>19,86</b>	<b>10,21</b>	<b>17,59</b>		
<b>LSD 5%</b>	<b>0,50</b>	<b>0,28</b>	<b>0,40</b>		
<b>LSD 1%</b>	<b>0,76</b>	<b>0,38</b>	<b>0,54</b>		

#### 4. CONCLUSION

Based on the obtained results, it can be concluded that the obtained differences are justified, because the hybrids used in the research differ in genotype. There is also a difference within the type of tomato. It was found that the production of tomatoes in the organic production system led to an increased number of formed fruits per flower branch and yield, thanks to top-quality certified fertilizers and biostimulants, which was later reflected in the overall economic benefit when comparing these two systems of agricultural production.

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