Scientific Papers. Series B, Horticulture. Vol. LXX, No. 1, 2026
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

PRODUCTIVITY ELEMENTS, YIELD, AND QUALITY INDICES IN TOMATOES AS A RESULT OF 'GENOTYPE×FERTILIZER' INTERACTION

Alexandra BECHERESCU[1], Gheorghița HOZA[2], Mihai San George BUNA[1], Florin SALA[1, 3]

[1]University of Life Sciences "King Mihai I" from Timisoara, Timișoara,
119 Calea Aradului, 300645, Timisoara, Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Mărăşti Blvd, District 1, Bucharest, Romania
[3]Agricultural Research and Development Station Lovrin, 307250, Lovrin, Timiş, Romania

Corresponding author email: florin_sala@usvt.ro

Abstract

The study evaluated some productivity parameters and quality indices in tomatoes in relation to fertilization. The tomato hybrid 'Polfast F1' was cultivated in relation to Naturamin WSP fertilizer (V1) and Crop Max (V2), and the tomato variety 'San Marzano' in relation to Naturamin WSP (V3) and Crop Max (V4). The 'San Marzano' variety showed an advantage for the number of clusters (PCN) and the number of fruits per plant (PFN). The 'Polfast F1' hybrid showed an advantage for average fruit weight (AFW). In terms of yield (Y/plt) the V4 variant showed an advantage, with statistically significant differences ($p<0.05$). In terms of quality indices, variant V1 showed an advantage for vitamin C (VitC), $p<0.05$, and variant V4 showed an advantage for the calcium (Ca) content, $p<0.01$, and the lycopene (LYCO) content, $p<0.05$. Multivariate analysis (PCA) explained the positioning of the productivity parameters and the fruit quality indices in relation to the principal components, with positive effects in PC1 (PCN, PFN, LYCO) and in PC2 (Ca) and negative effects in PC1 (VitC, AFW).

Key words: *fertilizers, PCA, productivity elements, quality indices, tomatoes, yield.*

INTRODUCTION

Tomatoes are important in human nutrition due to their complex nutritional profile, given by the content of nutrients and specific phytochemical compounds with an antioxidant role (e.g. vitamins, minerals, essential amino acids, monounsaturated fatty acids, phytosterols, and lycopene), with a specific role in human health (Ali et al., 2020; Sattar et al., 2024).

In order to show the importance of tomatoes, various formulations have been made, which highlighted the important position of tomatoes in the structure of vegetable crops (Schwarz et al., 2014), fruit quality and benefits for human health (Bozo et al., 2019), ecological plasticity (Diouf et al., 2020), suitability for different cropping systems (Sattar et al., 2024), importance for different industries (Sattar et al., 2024), versatility and dominance in consumer preferences (Li et al., 2025).

Tomato cultivation faces several challenges related to the cropping system, soil conditions, nutrient imbalances, microbial activity, allelopathic interactions, and crop management practices, all of which may influence plant growth, productivity, and fruit quality (Li et al., 2025; Singh et al., 2025).

Pretreatments of tomato seeds (e.g. shikimic acid) generated positive effects on the agronomic parameters of tomato plants and fruits, and on the content of phytochemical compounds in fruits (Al-Amri, 2013). The advantages of growing tomatoes on nutrient solutions were communicated through higher yields and superior quality indices, compared with the soil cultivation system (Bozo et al., 2019).

Soilless tomato cultivation systems are considered a promising and intensive, sustainable approach with a number of advantages, especially in relation to water and nutrient management (Aydi et al., 2023).

Plant morphological parameters, productivity elements, and quality indices in cherry tomatoes were studied under greenhouse cultivation conditions, and favorable effects were recorded in relation to longer day length (Arshad et al., 2023). Under greenhouse conditions, proper

water and fertilizer management is necessary to optimize tomato yield and quality (Yu et al., 2023). Tomatoes can be cultivated, for productive purposes or for research, in soil, in different substrates (established recipes or accessible mixtures from local resources), or on nutrient solutions. They have the ability to capitalize on growth environments with specific responses (Schwarz et al., 2014).

Growing substrates that contained/integrated shredded corn plant residues favored fruiting in tomatoes and positively influenced dimensional parameters of the fruits, firmness, and total soluble solids content in tomato fruits (Tzortzakis & Economakis, 2008). Alternative growing media were studied compared with commercial media, with the aim of reducing the costs of growing cherry tomatoes (Silva et al., 2017). The study authors identified different variants of alternative substrates made from local components (e.g., compost, soil) with comparable results in plant vigor and yield, or better results, compared with the commercial substrates tested (Silva et al., 2017). Comparative analysis of different growing substrates showed that including a mixture of fermented tomato waste, along with peat and vermiculite, positively influenced vegetable seedlings and seedlings (e.g. chili peppers, greenhouse cucumbers, greenhouse zucchini, and tomatoes) used in the test (Abdel-Razzak et al., 2019).

The water and nutrient retention properties of some vegetable growing media have been improved by components such as vermiculite, perlite, or biochar (Vaughn et al., 2021). Biocarbon-infused growing media (infused with inorganic and organic fertilizers) differentially influenced germination, seedling growth, and transplanting of tomato seedlings (Vaughn et al., 2021).

Certain substrates established for such "soilless" systems (e.g. coconut fiber) raise economic and logistical issues, and various substrates of local origin have been analyzed (Aydi et al., 2023), which, moreover, integrate well into the concept of circular economy.

The use of renewable substrates, or substrates based on renewable components, is a current concern for replacing dedicated substrates in vegetable cultivation (Wang et al., 2024). Seedling growth parameters and water regime in growing media showed that alternative ingredients (e.g. fermented corn residues) to commercial media led to positive results in greenhouse tomato cultivation (Wang et al., 2024).

Tomato plants performance and yield were evaluated in relation to different conventional growing media, and with new ingredients (e.g. white champignon mushroom substrate - as a peat substitute), in different proportions (da Silva Alves et al., 2024). Based on the recorded results, the authors formed the proportion in which the newly tested component, substrate from champignon mushrooms, should be included in the mixture for tomato substrates (da Silva Alves et al., 2024).

In studies on the utilization of fermented organic residues, growing substrates that included biochar improved tomato yields in urban agriculture experiments (de Celis et al., 2025). Fermented organic materials (e.g. food scraps, wood chips) have been used alongside peat, in different proportions, to create growing media for tomatoes, with positive results in plant emergence rate, morphological and physiological parameters, and nutrient content (Hamilton et al., 2025).

Concerns regarding yield, production quality and potential post-harvest losses in tomato cultivation have been identified within communities of “small farmers” under open and protected cultivation conditions (Molelekoa et al., 2025). The development index of tomato plants was positively influenced in relation to organic fertilizers (Mineva, 2025).

Yield variation in tomatoes was recorded in relation to different distances between rows and between plants per row (considered factors of crop geometry) under “poly-house structures” cultivation conditions (Singh et al., 2025). According to the authors, a spatial geometry of the type “60 × 40 cm” led to significantly larger polar and equatorial dimensions of fruits ($p<0.05$), compared to other geometric arrangements of plants, as well as to improved energy efficiency in tomato cultivation (Singh et al., 2025).

In the context of interest in capitalizing on local resources, the circular economy, the sustainability of vegetable cultivation in protected areas, and accessible solutions for “small farmers”, the present study comparatively evaluated two tomato genotypes in relation to fertilizers in a solar growing system in nutrient bags, on a growing substrate predominantly made of local components.

MATERIALS AND METHODS

The study was conducted in the area of Ticvaniu Mic, Caras-Severin County, Romania, during the 2023-2024 (Figure 1). The experiment was conducted in a protected, tunnel-type solar space.

The biological material was represented by two tomato genotypes: the hybrid 'Polfast F1' and the variety 'San Marzano' (Figure 2).



Figure 1. Study location, Ticvaniu Mic ATU, Caras-Severin County, Romania (Google Maps)



Figure 2. Cultivated tomato genotypes; 'Polfast F1' - left; 'San Marzano' - right

The plants were obtained by sowing in alveolar trays (OZ-KA VAKUM), in a professional peat substrate (Zelota Zeme; 80% blond peat, 20% black peat), with a fine granulation, up to 7 mm. Sowing was done on April 10, 2024. During the seedling production period, the temperature was maintained at 22-25°C during the day and at 17-20°C at night. On May 12, the seedlings were transplanted into EPE 28 trays. The substrate was represented by peat for transplanting (Thomaflor; 60% blond peat, 40% black peat) and perlite, in a volumetric proportion of 85% peat and 10% perlite. For plant protection, treatments with Bioprotekt and Previcur Energy (0.2%) were applied. On June 6, the seedlings were planted in vegetation bags (volume 45 L). The growing substrate in the vegetation bags was a homogeneous mixture of alluvial soil (60%), fermented manure (30%), and peat (10%).

Two fertilizer products were applied: Naturamin WSP (0.1%) and Crop Max (0.2%). The experimental variants resulted: V1 ('Polfast F1' + Naturamin WSP), V2 ('Polfast F1' + Crop Max), V3 ('San Marzano' + Naturamin WSP), V4 ('San Marzano' + Crop Max).

Productivity elements were evaluated, Plant clusters number (PCN), average fruit weight (AFW, g), plant fruits number (PFN), yield per plant (Y/plt), yield per hectare (Y/ha), vitamin C content (VitC, mg/100 g), calcium content (Ca, ppm), lycopene content (LYCO, mg/100 g).

Fruit samples were taken randomly from each experimental variant and replication. Productivity elements (PCN, PFN) were determined by counting, on plants, experimental variants and replications. Fruit weight (AFW, g) was determined by weighing with a technical balance. The content of vitamin C (VitC, mg/100 g), calcium (Ca, ppm) and Lycopene (LYCO, mg/100 g) was determined within the Interdisciplinary Research Platform, ULS "King Mihai I" from Timisoara, by accredited methods (Iodometric - Vitamin C, mg/100 g; AAS spectrometry - Ca, ppm; UV-VIS spectrophotometry - Lycopene, mg/100 g).

To assess the reliability of the data and the presence of variance, the ANOVA test was applied with Alpha = 0.05. Correlation analysis (Pearson's R) was applied to assess the interdependence of the elements of productivity, yield, and quality indices. Comparative analysis (t Test) was applied to evaluate the level of confidence of the differences between the values of the variants and the experimental mean for each determined parameter. The PAST software (Hammer et al., 2001), and the calculation module in EXCEL were used for the statistical analysis of the data and the generation of graphs. Established statistical parameters were used to determine the confidence of the results.

RESULTS AND DISCUSSIONS

Under experimental conditions, the interaction of the two tomato genotypes ('Polfast F1', 'San Marzano'), with the applied fertilization (Naturamin WSP, Crop Max), resulted in specific values of productivity, yield, and quality index parameters (Table 1).

Table 1. Productivity elements and quality indices in tomatoes, average values across experimental variants

Trial	PCN	AFW	PFN	$Y_{(plt)}$	$Y_{(ha)}$	Vit C	Ca	LYCO
	(No)	(g)	(No)	(kg/plt)	(t/ha)	(mg/100 g)	(ppm)	(mg/100 g)
V1	3.50	105.00	14.50	1.53	22.95	17.800	88.149	18.870
V2	3.83	117.00	14.80	1.73	25.95	13.580	95.146	19.100
V3	5.00	93.00	22.80	2.13	31.80	9.850	77.357	21.700
V4	5.00	103.00	24.60	2.55	38.25	11.730	125.897	22.430
SE	±0.25	±1.72	±2.99	±0.14	±2.14	±1.05	±5.67	±0.59

Plant cluster number (PCN) ranged from 3.50±0.25 (V1) to 5.00±0.25 (V3, and V4). AFW ranged from 93.00±1.72 g (V3) to 117.00±1.72 g (V2). The PFN parameter recorded values between 14.50±2.99 (V1) and 24.60±2.99 (V4). The yield per plant (Y/plt) recorded values between 1.53±0.14 kg/plt (V1) and 2.55±0.14 kg/plt (V4), and the yield per hectare (Y/ha) recorded values between 22.95±2.14 t/ha (V1) and 38.25±2.14 t/ha (V4). In the case of quality indices, the vitamin C (Vit C) content recorded values between 9,850±1.05 mg/100 g (V3) and 17,800±1.05 mg/100 g (V1). The calcium (Ca) content varied between 77,357±5.67 ppm (V3) and 125,897±5.67 ppm (V4). The lycopene content (LYCO) recorded values ranging from 18,870±0.59 mg/100 g (V1) to 22,430±0.59 mg/100 g (V4). The ANOVA test (Alpha = 0.05) confirmed the statistical reliability of the experimental data, and the presence of variance in the data set ($F > Fcrit$; $p < 0.001$).

According to the coefficient of variation values, moderate variability was recorded for the PFN parameter ($CV_{PFN} = 23.76$) and for the Vit C parameter ($CV_{VitC} = 21.07$). Low variability was recorded for the other parameters, namely $CV_{PCN} = 15.54$, $CV_{AFW} = 7.57$, $CV_{Y/plt} = 19.11$, $CV_{Y/ha} = 19.08$, $CV_{Ca} = 15.53$, $CV_{LYCO} = 7.58$.

High variability has been reported in tomato fruits as a result of polymorphism (Schwarz et al., 2014). Tomato has been used as a “model plant” for biochemical, cellular, molecular, genetic, physiological, and fruit development studies (Schwarz et al., 2014).

The interdependence between morphological parameters, yield, and quality indices was evaluated through correlation analysis (Table 2). The PCN parameter showed a positive correlation of very strong intensity with PFN (r = 0.986***), and with the lycopene content, LYCO (r = 0.986***). The PCN parameter showed a positive correlation of strong intensity with the yield per plant and per unit area, Y/plt (r = 0.947**), Y/ha (r = 0.944**). The PCN parameter showed a strong negative correlation with vitamin C, VitC (r = -0.931**). The PFN parameter showed a very strong positive correlation with yield (r = 0.968***, in the case of Y/plt; r = 0.966***, in the case of Y/ha) and with lycopene (r = 0.999). The PFN parameter showed a strong negative correlation with Vit C (r = -0.859), and the PFN parameter showed a moderate negative correlation with AFW (r = -0.766). Yield per plant, Y/plt showed a positive correlation of very strong intensity with Y/ha (r = 0.999***) and with LYCO (r = 0.976). It showed a negative correlation of strong intensity with Vit C (r = -0.826). Yield per unit area, Y/ha showed a positive, very strong correlation

with LYCO (r = 0.974***) and a negative, strong correlation with VitC (r = -0.922). Vitamin C content, Vit C, showed a negative correlation with LYCO (r = -0.862).

Table 2. Correlation table

Variable	Statistical parameters	PCN	PFN	AFW	$Y_{(plt)}$	$Y_{(ha)}$	VitC	Ca	LYCO
PCN	Pearson's r	—							
	p-value	—							
PFN	Pearson's r	0.986***	—						
	p-value	< .001	—						
AFW	Pearson's r	-0.751	-0.766*	—					
	p-value	0.051	0.045	—					
$Y_{(plt)}$	Pearson's r	0.947**	0.968***	-0.585	—				
	p-value	0.001	< .001	0.167	—				
$Y_{(ha)}$	Pearson's r	0.944**	0.966***	-0.579	0.999***	—			
	p-value	0.001	< .001	0.173	< .001	—			
VitC	Pearson's r	-0.931**	-0.859*	0.601	-0.826*	-0.822*	—		
	p-value	0.002	0.013	0.153	0.022	0.023	—		
Ca	Pearson's r	0.348	0.439	0.126	0.630	0.637	-0.169	—	
	p-value	0.444	0.324	0.787	0.130	0.124	0.717	—	
LYCO	Pearson's r	0.986***	0.999***	-0.745	0.976***	0.974***	-0.862*	0.461	—
	p-value	< .001	< .001	0.055	< .001	< .001	0.013	0.298	—

Note: "*" symbol of significance: *significance for p<0.05; **significance for p<0.01; ***significance for p<0.001

A positive correlation of high undertensity was recorded between total yield and the the height of tomato plants under greenhouse conditions (r = 0.91 for the Grando variety, and r = 0.89 for the Vermilenza variety) under organic fertilization conditions (Mineva, 2025).

The comparative analysis was performed between the experimental variants for the parameters considered.

In the case of the number of clusters per plant (PCN), the average value calculated at the experiment level was = 4.33. Compared to the average value, variant V1 recorded a value lower than the average, within statistical safety conditions (p<0.05). In the case of the other variants, the differences did not present statistical safety. The average value of the PCN parameter at the level of the hybrid 'Polfast F1' (variants V1, V2) was 3.67, and the average value of the PCN parameter at the level of the variety 'San Marzano' (variants V3, V4) was 5.00.

In the case of the number of fruits per plant (PFN), the average value calculated at the experiment level was $\overline{PFN}$ = 19.18. Compared to the average value, variant V4 recorded a value higher than the average, in conditions of statistical safety (p<0.05). In the case of the other variants, the differences did not present statistical safety. The average value of the PFN parameter at the level of the hybrid 'Polfast F1' (variants V1, V2) was 14.65, and the average value of the PFN parameter at the level of the variety 'San Marzano' (variants V3, V4) was 23.70.

In the case of the average fruit weight (AFW), the average value calculated at the experiment level was $\overline{AFW}$ = 104.50 g. Compared to the average value, variant V2 recorded a value higher than the average under conditions of statistical safety (p<0.05), and variant V3 recorded a value lower than the average under conditions of statistical safety (p<0.05). In the case of the other variants, the differences did not present statistical certainty (Table 3). The average value of fruit weight at the level of the hybrid 'Polfast F1' (variants V1, V2) was 111.00 g, and the average value of yield at the level of the variety 'San Marzano' (variants V3, V4) was 98.00 g (Figure 3).

Table 3. Results of comparative analysis for tomato fruit weight

Statistical parameters	V1	V2	V3	V4
Given mean	105.00	117.00	93.00	103.00
Sample mean	104.50			
95% conf. interval	(95.406 113.59)	(95.406 113.59)	(95.406 113.59)	(95.406 113.59)
Difference	0.50	12.50	11.50	1.50
95% conf. interval	(-8.5944 9.5944)	(3.4056 21.594)	(2.4056 20.594)	(-7.5944 10.594)
t	-0.1413	-3.5332	3.2505	0.4240
p (same mean)	0.8931	0.0167	0.0227	0.6892
Significance	ns	*	o	ns

Table 4. Results of comparative analysis for yield per plant

Statistical parameters	V1	V2	V3	V4
Given mean	1.530	1.730	2.130	2.550
Sample mean	1.985			
95% conf. interval	(1.5487 2.4213)	(1.5487 2.4213)	(1.5487 2.4213)	(1.5487 2.4213)
Difference	0.455	0.255	0.145	0.565
95% conf. interval	(0.018669 0.89133)	(-0.18133 0.69133)	(-0.29133 0.58133)	(0.12867 1.0013)
t	2.6806	1.5023	-0.8543	-3.3286
p (same mean)	0.0438	0.1933	0.4320	0.0208
Significance	o	ns	ns	*

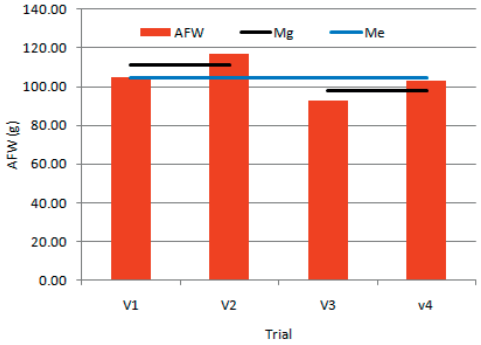

Figure 3. Average weight of tomato fruits in relation to the experimental variants; Mg – mean of genotype; V1, V2 – 'Polfast F1' ; V3, V4 – 'San Marzano'; Me – mean of experiment

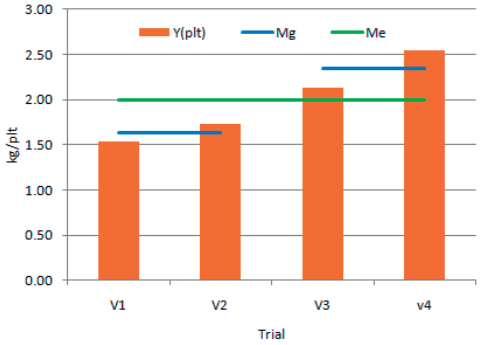

Figure 4. Tomato yield per plant, in relation to experimental variants; Mg – mean of genotype; V1, V2 – 'Polfast F1' ; V3, V4 – 'San Marzano'; Me – mean of experiment

Positive variations, in quantitative and qualitative terms, were recorded in tomato fruits under the influence of treatments with microorganisms (Dragomir et al., 2025).

In the case of yield per plant (Y/plt), the average value calculated at the experiment level was =1.985 kg (Table 4). Compared to the mean value, variant V4 recorded a value higher than the mean under statistical safety conditions ($p<0.05$), and variant V1 recorded a value lower than the mean under statistical safety conditions ($p<0.05$). In the case of the other variants, the differences did not show statistical safety (Table 4). The average yield value for the 'Polfast F1' hybrid (variants V1, V2) was 1.630 kg/plt, and the average yield value for the 'San Marzano' variety (variants V3, V4) was 2.340 kg/plt (Figure 4).

In the case of vitamin C (Vit C) content, the average value calculated at the experiment level was $\overline{VitC}$ = 13.24 mg/100 g (Table 5).

Table 5. Results of comparative analysis for vitamin C content

Statistical parameters	V1	V2	V3	V4
Given mean	17.80	13.58	9.85	11.73
Sample mean	13.24			
95% conf. interval	(10.033 16.447)	(10.033 16.447)	(10.033 16.447)	(10.033 16.447)
Difference	4.56	0.34	3.39	1.51
95% conf. interval	(1.3532 7.7668)	(-2.8668 3.5468)	(0.18324 6.5968)	(-1.6968 4.7168)
t	-3.6554	-0.2726	2.7175	1.2104
p (same mean)	0.0147	0.7961	0.0419	0.2802
Significance	*	Ns	o	ns

Compared to the average value, variant V1 recorded a value higher than the average under conditions of statistical safety ($p<0.05$), and in the case of variant V3, a value lower than the average was recorded under conditions of statistical safety ($p<0.05$). In the case of the other variants, the differences did not show statistical significance (Table 5). The average value of the vitamin C content in the hybrid 'Polfast F1' (variants V1, V2) was 15.69 mg/100g, and the average value of the vitamin C content in the variety 'San Marzano' (variants V3, V4) was 10.79 mg/100 g (Figure 5).

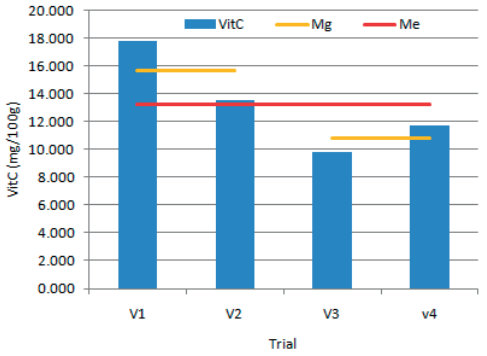

Figure 5. Vitamin C content in tomatoes, in relation to experimental variants; Mg – mean of genotype; V1, V2 – 'Polfast F1'; V3, V4 – 'San Marzano'; Me – mean of experiment

In the case of calcium (Ca) content, the average value calculated at the experiment level was $\overline{Ca}$ = 96.638 ppm (Table 6).

Table 6. Results of the comparative analysis for Ca content in tomato fruits

Statistical parameters	V1	V2	V3	V4
Given mean	88.149	95.146	77.357	125.897
Sample mean	96.638			
95% conf. Interval	(79.382 113.89)	(79.382 113.89)	(79.382 113.89)	(79.382 113.89)
Difference	8.489	1.492	19.281	29.259
95% conf. Interval	(-8.7672 25.746)	(-15.764 18.749)	(2.0248 36.538)	(12.002 46.515)
t	1.2646	0.2223	2.8722	-4.3585
p (same mean)	0.2618	0.8329	0.0349	0.0073
Significance	ns	ns	o	**

Compared to the calculated average value, variant V3 recorded a value below the average under conditions of statistical safety ($p<0.05$), and variant V4 recorded a value above the average, with the difference under conditions of statistical safety ($p<0.01$). In the case of variants V1 and V2, the differences did not show statistical significance (Table 6). The average value of Ca content in the hybrid 'Polfast F1' (variants V1, V2) was 91.65 ppm, and the average value of Ca content in the variety 'San Marzano' (variants V3, V4) was 101.63 ppm (Figure 6).

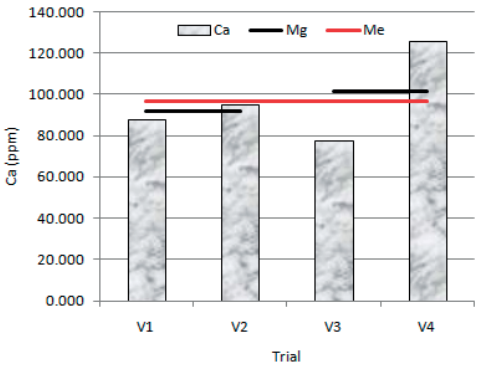

Figure 6. The Ca content of tomatoes, in relation to the experimental variants; Mg – mean of genotype; V1, V2 – 'Polfast F1'; V3, V4 – 'San Marzano'; Me – mean of experiment

In the case of lycopene content (LYCO), the average value calculated at the experiment level was $\overline{LYCO}$ = 20.527 mg/100 g (Table 7).

Table 7. Results of the comparative analysis for lycopene content in tomato fruits

Statistical parameters	V1	V2	V3	V4
Given mean	18.870	19.100	21.700	22.430
Sample mean	20.527			
95% conf. interval	(18.738 22.315)	(18.738 22.315)	(18.738 22.315)	(18.738 22.315)
Difference	1.657	1.427	1.173	1.903
95% conf. interval	(-0.13185 3.4452)	(-0.36185 3.2152)	(-0.61518 2.9618)	(0.11482 3.6918)
t	2.3811	2.0505	-1.6864	-2.7356
p (same mean)	0.0631	0.0956	0.1525	0.0410
Significance	ns	ns	ns	*

Compared with the calculated average value, variant V4 had a lycopene content above the average, with a statistically significant difference ($p<0.05$). In the case of the other variants, the differences did not show statistical

significance (Table 7). The average value of lycopene content in the 'Polfast F1' hybrid (variants V1, V2) was 18,985 mg/100 g, and the average value of lycopene content in the 'San Marzano' variety (variants V3, V4) was 22,065 mg/100 g (Figure 7).

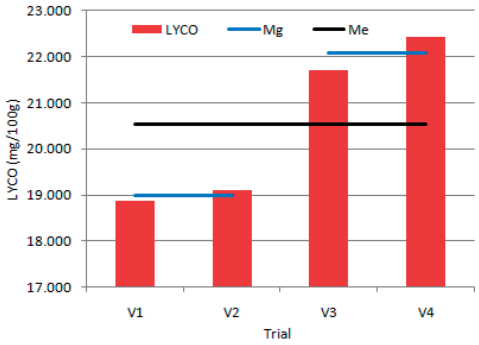

Figure 7. Lycopene content in tomatoes, in relation to experimental variants; Mg – mean of genotype; V1, V2 – 'Polfast F1'; V3, V4 – 'San Marzano'; Me – mean of experiment

Lycopene is a dietary carotenoid present in tomatoes, with an important role in human health (Ali et al., 2020). The increase in lycopene content, with values of up to 26.64% in tomato fruits, was recorded under the influence of treatments with biostimulating substances (Bălan et al., 2024). The variation in the content of phytochemical compounds in tomatoes was analyzed in relation to environmental factors, and the role of temperature in the formation of lycopene and beta-carotene content was recorded (ElShamey et al., 2025).

The impact of the experimental variants on the values of productivity parameters, yield, and quality indices in tomatoes was evaluated (Figure 8). Variant V1 showed a negative effect (with statistical certainty) on the PCN parameter, yield (Y/plt, Y/ha) and a positive impact on vitamin C content. Variant V2 showed a positive effect (with statistical certainty) on fruit weight (AFW), and effects without statistical significance on the other elements evaluated. The Crop Max product improved the performance of the 'Polfast F1' hybrid compared to the Naturamin WSP product. Variant V3 showed a negative effect (with statistical certainty) on the AFW parameter, vitamin C (VitC) content, and calcium (Ca) content in tomato fruits. On the other parameters evaluated, the effect was without statistical certainty. Variant V4 generated the most positive effects (with statistical certainty) in tomatoes, as an expression of the interaction of the 'San Marzano' variety with the Crop Max fertilizer (Figure 8).

	Polifast F1		San Marzano	
	Naturamin WSP	Crop Max	Naturamin WSP	Crop Max
	V1	V2	V3	V4
PCN	o	ns	ns	ns
PFN	ns	ns	ns	*
AFW	ns	*	o	ns
Y/plt	o	ns	ns	*
Y/ha	o	ns	ns	*
VitC	*	ns	o	ns
Ca	ns	ns	o	**
LYCO	ns	ns	ns	*

Figure 8. Synthetic diagram of the effect generated by the experimental variants on tomatoes

Advantages of some types of local substrates for tomatoes have been recorded, with positive effects on physiological indices, morphological parameters of plants, productivity, and fruit quality elements (Aydi et al., 2023). The variation in tomato fruit production and quality was analyzed in relation to climatic parameters under greenhouse cultivation conditions, on a "coconut-containing growbag (Jiffy growbag)" (Arshad et al., 2023). Mathematical models have described quality indicators in tomatoes under greenhouse conditions in relation to the water regime and variable fertilization rates (Yu et al., 2023).

In the present study, the growing substrate made mainly from local resources, alluvial soil (60%), mranita (30%), and improved with peat (10%), created good conditions for the growth of tomato plants ('Polfacf F1', 'San Marzano') in a tunnel-type greenhouse. From the interaction with the fertilizer products, the tomato genotypes generated differentiated values of the evaluated

parameters, in relation to their specific biological potential.

CONCLUSIONS

The cultivation conditions in a tunnel-type greenhouse, in container bags (volume of 45 L), with a homogeneous growth substrate consisting of alluvial soil (60%), fermented manure (30%) and peat (10%), ensured uniform growing conditions for the tomato plants.

The two tomato genotypes, the 'Polfac F1' hybrid and the 'San Marzano' variety, benefited differentially from treatments with Naturamin WSP and Crop Max.

The 'San Marzano' showed advantages for the number of clusters per plant (PCN) and for the number of fruits per plant (PFN). The interaction between the 'San Marzano' variety and the product Crop Max (V4) led to positive, statistically significant differences for the parameter PFN ($p<0.05$).

For average fruit weight (AFW), the 'Polfac F1' hybrid presented advantages, and the interaction between 'Polfac F1' and the Crop Max fertilizer (V2) generated positive differences compared to the experimental average, with statistical certainty ($p<0.05$).

For yield per plant (Y/plt) and associated yield per hectare (Y/ha), the 'San Marzano' variety presented advantages, and the interaction between 'San Marzano' and Crop Max generated positive differences compared to the experiment average ($p<0.05$).

For vitamin C content (Vit C, mg/100 g), the 'Polfac F1' genotype presented advantages, and the interaction between 'Polfac F1' and Naturamin WSP generated values above the average of the experiment ($p<0.05$).

For calcium content (Ca, ppm) and lycopene content (LYCO, mg/100 g) the 'San Marzano' genotype presented advantages, and the interaction between 'San Marzano' and Crop Max generated values above the average of the experiment ($p<0.01$ for Ca; $p<0.05$ for LYCO).

The Crop Max fertilizer product, in combination with both genotypes, generated the most advantages for fruit parameters, yield, and quality indices, except for average fruit weight (AFW) and vitamin C content (Vit C) where the Naturamin WSP product showed better performance.

Overall, the 'San Marzano' variety, in combination with Crop Max, generated the most advantages for the fruit parameters, yield, and quality indices evaluated in tomatoes under the study conditions.

REFERENCES

Abdel-Razzak, H., Alkoaik, F., Rashwan, M., Fulleros, R., & Ibrahim, M. (2019). Tomato waste compost as an alternative substrate to peat moss for the production of vegetable seedlings. *Journal of Plant Nutrition*, *42*(3), 287-295.

Al-Amri, S. M. (2013). Improved growth, productivity and quality of tomato (*Solanum lycopersicum* L.) plants through application of shikimic acid. *Saudi Journal of Biological Sciences, 20*(4), 339-45.

Ali, M. Y., Sina, A. A., Khandker, S. S., Neesa, L., Tanvir, E. M., Kabir, A., Khalil, M. I., & Gan, S. H. (2020). Nutritional composition and bioactive compounds in tomatoes and their impact on human health and disease: A review. *Foods, 10*(1), 45.

Arshad, A., Jerca, I. O., Chan, S., Cîmpeanu, S. M., Teodorescu, R., I., Țiu, J., Bădulescu, L., & Drăghici, E. M. (2023). Study regarding the influence of some climatic parameters from the greenhouse on the tomato production and fruit quality. *Scientific Papers. Series B, Horticulture, LXVII*(2), 295-306.

Aydi, S., Aydi, S. S., Marsit, A., Abed, N. E., Rahmani, R., Bouajila, J., Merah, O., & Abdelly, C. (2023). Optimizing alternative substrate for tomato production in arid zone: Lesson from growth, water relations, chlorophyll fluorescence, and photosynthesis. *Plants, 12*(7), 1457.

Bălan, D., Luță, G., Stanca, M., Jerca, O., Jurcoane, Ș., Gaidău, C., Niculescu, M., Sancakli, A., & Uzuner Demir, A. (2024). Effect of biostimulant treatment on the antioxidant activity in tomato fruit. *Scientific Papers. Series B, Horticulture, LXVIII*(2), 393-400.

Bozo, T., T., Mpambani, B., Mbenga, A., & Mhlontlo, S. (2019). Comparative studies on yield and quality response of soil and soilless grown tomatoes: The case study of Masiphathisane community project and Bathurst Experimental Farm. *South African Journal of Agricultural Extension , 47*(4), 75-85.

da Silva Alves, L., Tolardo, G., Caitano, C., E. C., Vieira Júnior, W., G., Gomes Freitas, P., N., & Cunha Zied, D. (2024). Use of spent mushroom substrate for cherry tomato seedlings: A potential alternative to peat in horticulture. *Biological Agriculture & Horticulture, 40*(2), 127-140.

de Celis, M., de Sosa, L. L., Picca, G., González-Polo, N., Ruano, C., G., Beneduce, L., Zaccone, C., & Panettieri, M. (2025). Biochar-based organic substrates enhance tomato growth by promoting specific microbial communities in rooftop farming. *Environmental Microbiome, 20*(1), 82.

Diouf, I., Derivot, L., Koussevitzky, S., Carretero, Y., Bitton, F., Moreau, L., & Causse, M. (2020). Genetic basis of phenotypic plasticity and genotype × environment interactions in a multi-parental tomato

population. *Journal of Experimental Botany, 71*(18), 5365-5376.

Dragomir, C., -L., Hoza, G., Becherescu, A., Paraschiv, M., Nicola, C., Frîncu, M., Bădulescu, L., & Hoza, D. (2025). The influence of microorganisms on the quantitative and qualitative characteristics of tomato fruits. *Scientific Papers. Series B, Horticulture, LXIX*(1), 433-443.

ElShamey, E., Zeng, Y., Ding, Y., & Yang, J. (2025). Fitochimicale funcționale din tomate: biosinteză, reglare genică și implicații asupra sănătății umane. *Frontiers in Plant Science, 16*, 1662388.

Google Maps, https://www.google.com/maps (Accessed on 19 January, 2026).

Hamilton, A., N., Bertucci, M., B., Gibson, K., E., Savin, M. C., Kirkpatrick, D., & Woody-Pumford, R. (2025). Assessing Food Waste Compost as a Substrate Amendment for Tomato and Watermelon Seedlings. *HortTechnology, 35*(2), 125-134.

Hammer, Ø., Harper, D., A. T., & Ryan, P. D. (2001). PAST: Paleontological Statistics software package for education and data analysis. *Palaeontologia Electronica, 4*(1), 1-9.

Li, Y., Zhang, R., Zhang, C., Li, Q., Nie, L., Wang, C., & Wang, X. -X. (2025). Integrative approaches to nutrient management in tomato cultivation for improved sustainability and productivity. *Frontiers in Plant Science, 16*, 1626136.

Mineva, R. (2025). Influence of organic fertilizers on the morphological development and productivity in greenhouse tomato. *Scientific Papers. Series B, Horticultura. LXIX*(2), 508-515.

Molelekoa, T., Karoney, E., M., Siyoum, N., Gokul, J., K., & Korsten, L. (2025). Quality and quantity losses of tomatoes grown by small-scale farmers under different production systems. *Horticulturae, 11*(8), 884.

Sattar, S., Iqbal, A., Parveen, A., Fatima, E., Samdani, A., Fatima, H., Iqbal, M., S., & Wajid, M. (2024). """Tomatoes unveiled: A comprehensive exploration from cultivation to culinary and nutritional significance. *Qeios, CC-BY*, 4.0, 1-14.

Schwarz, D., Thompson, A., J., & Kläring, H. P. (2014). Guidelines to use tomato in experiments with a controlled environment. *Frontiers in Plant Science, 5*, 625.

Silva, J. da, Teixeira, J. dos S., Silva, M. T. da, Santos, D. F. dos, Júnior, A. B. da S., Carvalho, A. P. V. de, & Costa, K. D., da S. (2017). Alternative substrates for production of cherry tomato seedlings. *Journal of Experimental Agriculture International, 18*(4), 1-7.

Singh, S., Singh, P., Singh, G., & Sandhu, A.S. (2025). Crop productivity and energy indices of tomato (*Solanum lycopersicum*) production under naturally ventilated poly-house structures in North-Western India. *Energy, 314*, 134239.

Tzortzakis, N., G., & Economakis, C. D. (2008). Impacts of the substrate medium on tomato yield and fruit quality in soilless cultivation. *Horticultural Science, 35*(2), 83-89.

Vaughn, S., F., Byars, J., A., Jackson, M., A., Peterson, S., C., & Eller, F. J. (2021). Tomato seed germination and transplant growth in a commercial potting substrate amended with nutrient-preconditioned Eastern red cedar (*Juniperus virginiana* L.) wood biochar. *Scientia Horticulturae, 280*, 109947.

Wang, Y., Zhang, X., Du, X., Zhang Z., & He, Z. (2024). Effects of different straw breeding substrates on the growth of tomato seedlings and transcriptome analysis. *Scientific Reports, 14*, 22181.

Yu, X., Zhang, J., Zhang, Y., Ma, L., Jiao, X., Zhao, M., & Li, J. (2023). Identification of optimal irrigation and fertilizer rates to balance yield, water and fertilizer productivity, and fruit quality in greenhouse tomatoes using TOPSIS. *Scientia Horticulturae, 311*, 111829.