

## **THE INFLUENCE OF GRAFTING AND BIOSTIMULATORS ON PHYSICAL AND SENSORIAL TRAITS OF GREENHOUSE TOMATO FRUIT (*Lycopersicon esculentum* Mill.) IN FIELD PRODUCTION**

Janina Gajc-Wolska, Jadwiga Radzanowska, Mariola Łyszowska  
Warsaw University of Life Sciences

**Abstract.** Four tomato cultivars Macarena F<sub>1</sub>, Faustine F<sub>1</sub>, Cathy F<sub>1</sub> and Fanny F<sub>1</sub> were used in the study. Transplants were grown in a greenhouse. Seeds were sown at the end of March. The plants were grafted on Maxifort F<sub>1</sub> rootstock on April 5, 6 and 21 in the years 2006, 2007, 2008 without the use of biostimulators. In the case of the other combinations each year the following treatments with biostimulators were performed: watering with Goteo 0.1% solution (twice – 4 and 2 weeks before planting and three times after planting at three-week intervals), spraying with BM 86 0.1% solution (four times every three weeks starting at the blooming of the first cluster). In the control combination plants were untreated with biostimulators and were not grafted. Physical properties were determined and sensory analysis of tomato fruit was performed. The results showed that there was no significant influence of the applied preparations on the a\*/b\* value of fruits which depended mostly on the cultivars. The highest fruit firmness was obtained with BM preparation and in Faustine F<sub>1</sub> and Cathy F<sub>1</sub> cultivars. There was no significant influence of the preparations on sensory quality of fruits. Variability in sensory quality of fruits rather depended on the analyzed cultivars than on the investigated combination.

**Key words:** biostimulators, tomato fruit, fruit firmness, fruit colour, sensory analysis

### **INTRODUCTION**

The quality of food products is mainly described by sensory characteristics (appearance, texture, taste and smell), chemical composition, physical traits, mechanical properties, functionality, and defects [Baryłko-Pikielna et al. 1996]. In fresh tomato fruit two quality attributes that are most important to buyers and consumers are texture and skin colour [Tijskens and Evelo 1994]. The degree of fruit firmness was used as an indication of fruit quality [Burton 1982], and firmness may be the final index by which the con-

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Corresponding author – Janina Gajc-Wolska, Department of Vegetable and Medicinal Plants, Warsaw University of Life Sciences, 159 Nowoursynowska Street 02-776 Warszawa, Poland, e-mail: janina\_gajc\_wolska@sggw.pl

sumers decide to purchase a given batch of tomatoes [Gormley and Egan 1978]. Tomato color is another important quality factor for the consumer. Changes in firmness were highly correlated with the surface appearance characteristics of tomatoes [Yang and Chinnan 1988] which was related to colour, shape and sense of feel firmness at the time of purchasing. In order to attain eating quality, it is important to include all important sensory characteristics. Beside all flavor characteristics it involves all the above: appearance, texture, and changes in fruit texture which take place at the retail and consumer level [Booth 1990].

## MATERIAL AND METHODS

The following tomato cultivars were used in the experiments: Macarena F<sub>1</sub> and Faustine F<sub>1</sub> from Syngenta Seeds Company, Cathy F<sub>1</sub> and Fanny F<sub>1</sub> from Seminis Seeds Company and biostimulators Goteo and BM 86 from Arysta Life Sciences Company. Goteo and BM 86 are derived from seaweed homogenate and contain inorganic nutrients: Goteo phosphorus and potassium and BM 86 nitrogen, boron, molybdenum and magnesium. The experiment was arranged in a two-factor split-plot design with four replications during three years, i.e. 2006–2008 on the experimental field of the Department of Vegetable and Medicinal Plants at Wilanów. Transplants were grown in the greenhouse. Seeds were sown at the end of March. The plants were grafted on Maxifort F<sub>1</sub> rootstock on April 5, 6 and 21 in the years 2006, 2007, 2008 without the use of biostimulators. In the case of other combinations each year the following treatments with biostimulators were used: watering with Goteo 0.1% solution (twice – 4 and 2 weeks before planting and three times after planting with a three-week intervals), spraying with BM 86 0.1% solution (four times every three weeks started at the blooming of the first cluster). In the control combination plants were not treated with biostimulators and were not grafted. Other agricultural practices were the same in the control combination as in the examined objects. Plants were planted in the field at 70×100 cm spacing – 20 plants per plot. Average temperatures and rainfall sum were recorded (tab. 1). Plants were grown in deep medium-heavy alluvial soil with a 1.9–2.3% content of organic matter. Owing to good texture, the air-water conditions of the soil were satisfactory for plant production and during the period of water shortage plants were T-Tape irrigated. N, P, K, Mg content of the soil was kept at the optimum level with fertilizers applied to equal the average of 120 kg N ha<sup>-1</sup> (60 kg N side dressing), 50 kg P ha<sup>-1</sup>, and 180 kg K ha<sup>-1</sup>. The harvest of fruit lasted from the end of July in 2006 and 2008 or the beginning of August in 2007 until the middle of September. Physical properties were determined and sensory analysis of the tomato fruit was performed.

Fruit colour was determined in the CIE L\*a\*b\* system using a trichromatic colorimeter Hunter MiniScan MS-4500L (viewing area 25 mm).

L\* – lightness – values from 0 – blackness to 100 – whiteness,

a\* – the share of red (with positive values) or green (with negative values),

b\* – the share of yellow (with negative values).

When measuring the hue of colour was determined from the a\*/b\* ratio.

Table 1. Average temperatures and the sum of rainfall for May-September in the years 2006–2008

Tabela 1. Średnie miesięczne temperatury i sumy opadów od maja do września w latach 2006–2008

Months Miesiące	Temperatures – Temperatury, °C			Rainfall – Opady, mm		
	2006	2007	2008	2006	2007	2008
May Maj	13.7	16.0	14.1	61.0	74.1	36.8
June Czerwiec	18.0	19.4	19.3	22.6	85.4	24.5
July Lipiec	22.6	19.3	19.7	80.9	89.1	97.8
August Sierpień	17.8	19.4	19.2	179.8	42.0	89.0
September Wrzesień	15.1	13.8	13.0	14.4	79.1	53.7

Fruit firmness – the measurements were taken using Instron 4303 apparatus. Firmness was defined as a value of force necessary for puncturing fruit skin with a 5 mm cylindrical probe. Measurements were taken with the crosshead 500 N cm<sup>-2</sup> moving at the speed of 200 mm min<sup>-1</sup>. The results were expressed in N cm<sup>-2</sup>.

Sensory analysis was made by the scaling method. The trained panel of 10 persons evaluated tomato fruit samples according to their tough of skin, flesh texture, juiciness of flesh, tomato smell, strange smell, taste (sweet, sour, typical tomato, strange) and overall quality.

Statistical analysis was elaborated using two-way analysis of variance. Detailed comparison of means was performed by the Tukey's test at the significance level of  $\alpha = 0.05$ .

## RESULTS AND DISCUSSION

The results of tomato fruit colour measurement showed that the value of the parameter L\* – light skin – was not significantly different between the combinations as well as cultivars (tab. 2). In the analyzed fruit cultivars significant differences in regard to the value the a\* (red colour) were observed. The higher values for the parameter a\* were characteristic for the fruits of Faustine F<sub>1</sub>, Cathy F<sub>1</sub> and Fanny F<sub>1</sub> cultivars than for the fruits of Macarena F<sub>1</sub> cultivar (tab. 2).

There were no statistically significant differences in value b\* (yellow colour) in the fruits of all combination as well as cultivars (tab. 2). The ratio of the red to yellow colour (a\*/b\*) describes the hue of colour, which is an important criterion in the evaluation of fruit. In the stipulated scale the hue can take the values from  $\leq 1.0$  to  $\geq 2.2$  which means poor and very good marks respectively [Kader and Morris 1978a, 1978b]. The a\*/b\* value in fruits was on the same level in all combinations. Among the cultivars the higher hue (a\*/b\*) of fruits was obtained in Faustine F<sub>1</sub>, Cathy F<sub>1</sub> and Fanny F<sub>1</sub> in comparison to Macarena F<sub>1</sub> cultivar (tab. 2).

Table 2. The physical traits of tomato fruits (2006–2008)  
Tabela 2. Cechy fizyczne owoców pomidora (2006–2008)

Treatments – Kombinacja	Cultivar – Odmiana				Mean Średnia	
	Macarena F <sub>1</sub>	Faustine F <sub>1</sub>	Cathy F <sub>1</sub>	Fanny F <sub>1</sub>		
L*	grafting szczepienie	42.68 a**	42.41 a	41.31 a	40.68 a	41.77 a
	Goteo	42.60 a	41.10 a	40.77 a	41.73 a	41.55 a
	BM 86	43.13 a	41.32 a	40.87 a	41.15 a	41.61 a
	control – kontrola	42.11 a	40.62 a	41.35 a	39.67 b	40.93 a
	mean – średnia	42.63 a	41.36 a	41.07 a	40.80 a	
a*	grafting szczepienie	24.81 b	27.90 a	26.18 a	28.16 a	26.76 a
	Goteo	24.95 b	28.38 a	28.91 a	27.60 a	27.46 a
	BM 86	22.56 b	26.98 a	27.89 a	27.20 a	26.15 a
	control – kontrola	21.79 b	28.19 a	27.17 a	27.93 a	26.27 a
	mean – średnia	23.52 b	27.86 a	27.53 a	27.72 a	
b*	grafting szczepienie	27.73 a	28.25 a	27.22 a	25.88 a	27.27 a
	Goteo	27.35 a	27.87 a	27.51 a	27.72 a	27.61 a
	BM 86	27.20 a	27.22 a	26.76 a	28.16 a	27.33 a
	control – kontrola	25.97 a	26.08 a	27.57 a	26.17 a	26.44 a
	mean – średnia	27.06 a	27.35 a	27.26 a	26.98 a	
a*/b*	grafting szczepienie	0.89	0.98	0.96	1.08	0.97
	Goteo	0.91	1.01	1.05	0.99	0.99
	BM 86	0.82	0.99	1.04	0.96	0.95
	control – kontrola	0.83	1.08	0.98	1.06	0.98
	mean – średnia	0.88	1.01	1.00	1.02	
Firmness Jędrność Nm <sup>-2</sup>	grafting szczepienie	12.8 a	12.5 a	11.3 ab	10.4 b	11.7 b
	Goteo	9.6 c	13.0 a	13.4 a	11.9 b	11.9 b
	BM 86	10.9 c	14.7 b	21.2 a	12.7 b	14.8 a
	control – kontrola	10.4 c	12.3 ab	13.3 a	11.5 b	11.8 b
	mean – średnia	10.9 b	13.1 a	14.8 a	11.6 b	

\*\*means followed by the same letters are not significantly different at  $\alpha = 0.05$  – średnie oznaczone tymi samymi literami są nieistotne statystycznie przy  $\alpha = 0,05$

It is confirmed by the results of Batu [2004]. According to the author fruit colour is one of the quality factors of fresh tomatoes in consumer preference. The a\*/b\* value for the light red stage that is commonly marketable is between 0.60 and 0.95. In the case of red stage the a\*/b\* value varies from 0.95 to 1.21. It seems that the a\*/b\* value mostly depends on the cultivars rather than other factors.

Fruit firmness is also a very important factor similarly as colour. Significant differences in firmness values were observed for combinations. The highest firmness of fruits was obtained in the combination with BM biostimulator as compared to other combinations. It was observed that the higher measurement of firmness was characteristic of fruits of Faustine F<sub>1</sub> and Fanny F<sub>1</sub> and the lower of Macarena F<sub>1</sub> and Cathy F<sub>1</sub> cultivars (tab. 2). On the basis of objectives, firmness evaluation revealed that the minimum acceptable level or marketability score of tomato firmness at which an individual tomato fruit could be accepted for sale at a retail level is about 14.5 and 14.6 N cm<sup>-1</sup> [Batu

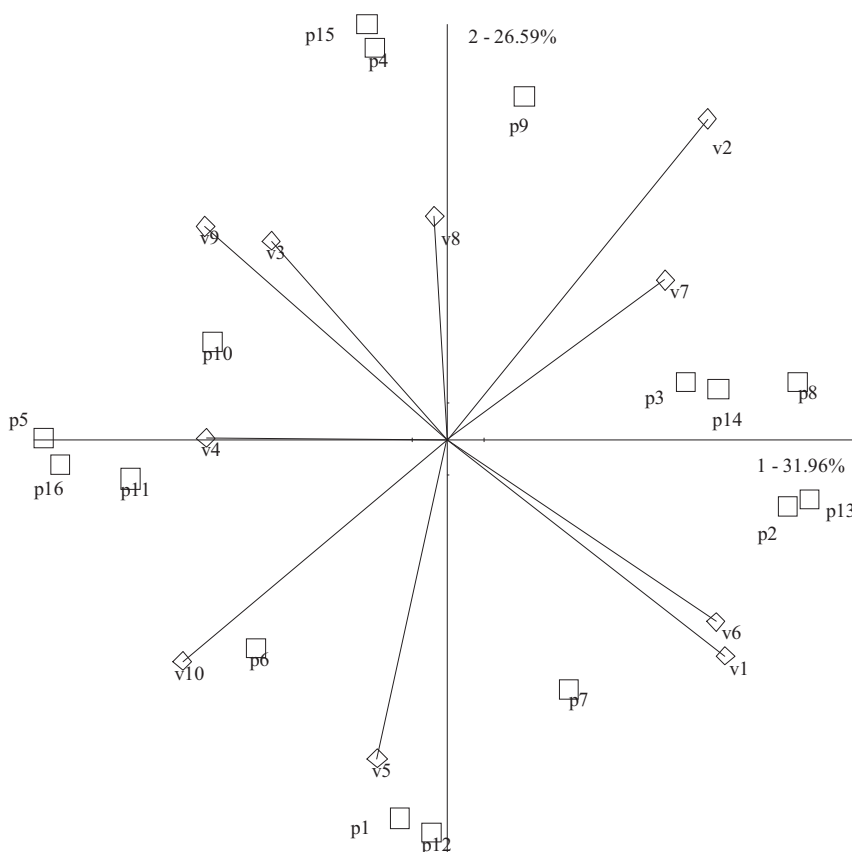


Fig. 1. PCA projection of similarities differences and of sensory quality of fruit tomato (2006–2008); the cultivars of tomato (points marks numbers) p1 – Makarena F<sub>1</sub> grafting, p2 – Fanny F<sub>1</sub> grafting, p3 – Faustine F<sub>1</sub> grafting, p4 – Cathy F<sub>1</sub> grafting, p5 – Fanny F<sub>1</sub> control, p6 – Makarena F<sub>1</sub> control, p7 – Makarena F<sub>1</sub> Goteo, p8 – Cathy F<sub>1</sub> Goteo, p9 – Faustine F<sub>1</sub> Goteo, p10 – Fanny F<sub>1</sub> Goteo, p11 – Fautine F<sub>1</sub> control, p12 – Cathy F<sub>1</sub> control, p13 – Makarena F<sub>1</sub> BM, p14 – Fanny F<sub>1</sub> BM, p15 – Faustine F<sub>1</sub> BM, p16 – Cathy F<sub>1</sub> BM; attributes evaluated (vectors marks numbers) v1 – tomato smell, v2 – strange smell, v3 – tough of skin, v4 – flesh texture, v5 – juiciness of flesh, v6 – tomato taste, v7 – sour taste, v8 – sweet taste, v9 – strange taste, v10 – overall quality

Ryc. 1. Projekcja PCA podobieństw i różnic w jakości sensorycznej owoców pomidora (2006–2008); odmiany pomidora (punkty oznaczone cyframi) p1 – Makarena F<sub>1</sub> szczepione, p2 – Fanny F<sub>1</sub> szczepione, p3 – Faustine F<sub>1</sub> szczepione, p4 – Cathy F<sub>1</sub> szczepione, p5 – Fanny F<sub>1</sub> kontrola, p6 – Makarena F<sub>1</sub> kontrola, p7 – Makarena F<sub>1</sub> Goteo, p8 – Cathy F<sub>1</sub> Goteo, p9 – Faustine F<sub>1</sub> Goteo, p10 – Fanny F<sub>1</sub> Goteo, p11 – Fautine F<sub>1</sub> kontrola, p12 – Cathy F<sub>1</sub> kontrola, p13 – Makarena F<sub>1</sub> BM, p14 – Fanny F<sub>1</sub> BM, p15 – Faustine F<sub>1</sub> BM, p16 – Cathy F<sub>1</sub> BM; oceniane wyróżniki (wektory oznaczone cyframi); v1 – zapach pomidorowy, v2 – zapach obcy, v3 – twardość skórki, v4 – struktura mięszsu, v5 – soczystość mięszsu, v6 – smak pomidorowy, v7 – smak kwaśny, v8 – smak słodki, v9 – smak obcy, v10 – ocena ogólna

1998]. The result showed that only the fruit obtained from the combination with BM bio-stimulator and Cathy F<sub>1</sub> cultivar fruits achieved the level of acceptability for sale (tab. 2).

The results of the profile assessment of tomato fruits are shown in figure 1 in a form of “quality map”, in the space created by the first two main components PC 1 and PC 2, which shows 58.55% of the variability in the sensory quality of the analysed cultivars. The location of the analyzed samples of fruits from different combinations on the chart proves their variability in regard to analysed taste, smell and texture attributes. The highest notes of overall quality were obtained in fruits of Macarena F<sub>1</sub> cv. from the control combination. The high marks of tomato smell and taste were observed in fruits of Macarena F<sub>1</sub> cv. from the combinations with Goteo and BM 86 and Fanny F<sub>1</sub> cv. from grafting combination. The fruit samples of Faustine F<sub>1</sub> cv. from the BM 86 combination and Cathy F<sub>1</sub> cv. from grafting combination received the highest notes for sweet taste. The highest marks for flash juiciness were obtained for fruits of Macarena F<sub>1</sub> cv. from grafting combination and Cathy F<sub>1</sub> cv. from the control combination. Fruits of Faustine F<sub>1</sub> cv. from the control combination, Cathy F<sub>1</sub> cv. from BM 86 combination, Fanny F<sub>1</sub> cv. from the control combination and Fanny F<sub>1</sub> cv. from Goteo combination were characterized by the highest mark for flesh texture. However, fruits of Fanny F<sub>1</sub> cv. from Goteo combination also received the highest notes for strange taste, and hardness of skin. The high marks of strange smell were obtained in fruits of Faustine F<sub>1</sub> cv. from Goteo combination and sour taste in fruits of Fanny F<sub>1</sub> cv. from BM 86 combination and Faustine F<sub>1</sub> cv. from grafting combination. This chart shows that the positive and negative attributes mostly depended on genetic potential of the cultivars rather than on other factors, which agrees with the results by Krumbein et al. [2004].

## CONCLUSIONS

1. There was no significant influence of applied preparations on the a\*/b\* value of fruits which was mostly cultivar dependent.
2. The highest firmness of fruits was obtained with BM preparation and in Faustine F<sub>1</sub> and Cathy F<sub>1</sub> cultivars which indicates that those fruits are better acceptable for sale at retail level.
3. There was no significant influence of the preparation on the sensory quality of fruits. Variability in sensory quality of fruits rather depended on the analyzed cultivars than on the investigated combination.

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## WPLYW SZCZEPIENIA I BIOSTYMULATORÓW NA CECHY FIZYCZNE I SENSORYCZNE OWOCÓW POMIDORA (*Lycopersicon esculentum* Mill.) W UPRAWIE POLOWEJ

**Streszczenie.** Do badań wzięto cztery odmiany pomidora wysokorosnącego: Macarena F<sub>1</sub>, Faustine F<sub>1</sub>, Cathy F<sub>1</sub> i Fanny F<sub>1</sub>. Rozsadę przygotowywano w szklarni. Nasiona wysiano w końcu marca. Rośliny szczepiono na podkładce vegetatywnej Maxifort F<sub>1</sub> w następujących terminach: 5, 6 kwietnia 2006 r., 2007 r. i 21 kwietnia 2008 r. Rośliny szczepione nie były traktowane biostymulatorami. W pozostałych kombinacjach w każdym roku uprawy wprowadzono biostymulatory: Goteo 0,1% dwukrotne podlewanie 4 i 2 tygodnie przed posadzeniem rozsady i trzykrotne w odstępach trzytygodniowych po posadzeniu roślin. BM 86 0,1% czterokrotne opryskiwanie co trzy tygodnie począwszy od kwitnienia pierwszego grona. W kombinacji kontrolnej nie stosowano biostymulatorów i nie szczepiono roślin. Badano cechy fizyczne oraz wykonano analizę sensoryczną owoców pomidora. Nie odnotowano istotnego wpływu preparatów na barwę owoców, która głównie zależała od odmiany. Najwyższą jędrność owoców uzyskano w kombinacji z preparatem BM 86 oraz dla odmiany Faustine F<sub>1</sub> i Cathy F<sub>1</sub>. Nie stwierdzono istotnego wpływu preparatów na jakość sensoryczną owoców. Różnice jakie wystąpiły w ocenie sensorycznej zależały głównie od odmiany, a nie od badanej kombinacji.

**Słowa kluczowe:** biostymulatory, owoce pomidora, jędrność owoców, barwa owoców, analiza sensoryczna

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