ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol., Hortorum Cultus 8(3) 2009, 37-43*

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

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Abstract. Four tomato cultivars Macarena F_1, Faustine F_1, Cathy F_1 and Fanny F_1 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_1 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_1 and Cathy F_1 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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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_1 and Faustine F_1 from Syngenta Seeds Company, Cathy F_1 and Fanny F_1 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_1 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^{-1} (60 kg N side dressing), 50 kg P ha^{-1}, and 180 kg K ha^{-1}. 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 Wrzesien	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^{-2} moving at the speed of 200 $mm \cdot min^{-1}$. The results were expressed in N cm^{-2}.

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_1, Cathy F_1 and Fanny F_1 cultivars than for the fruits of Macarena F_1 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 ≤ 1.0 to ≥ 2.2 which means poor and very good marks respectively [Kader and Morris 1978a, 1978b]. The a*/b* value in fruits was on the some level in all combinations. Among the cultivars the higher hue (a*/b*) of fruits was obtained in Faustine F_1, Cathy F_1 and Fanny F_1 in comparison to Macarena F_1 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_1	Faustine F_1	Cathy F_1	Fanny F_1	
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^{-2}	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_1 and Fanny F_1 and the lower of Macarena F_1 and Cathy F_1 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^{-1} [Batu

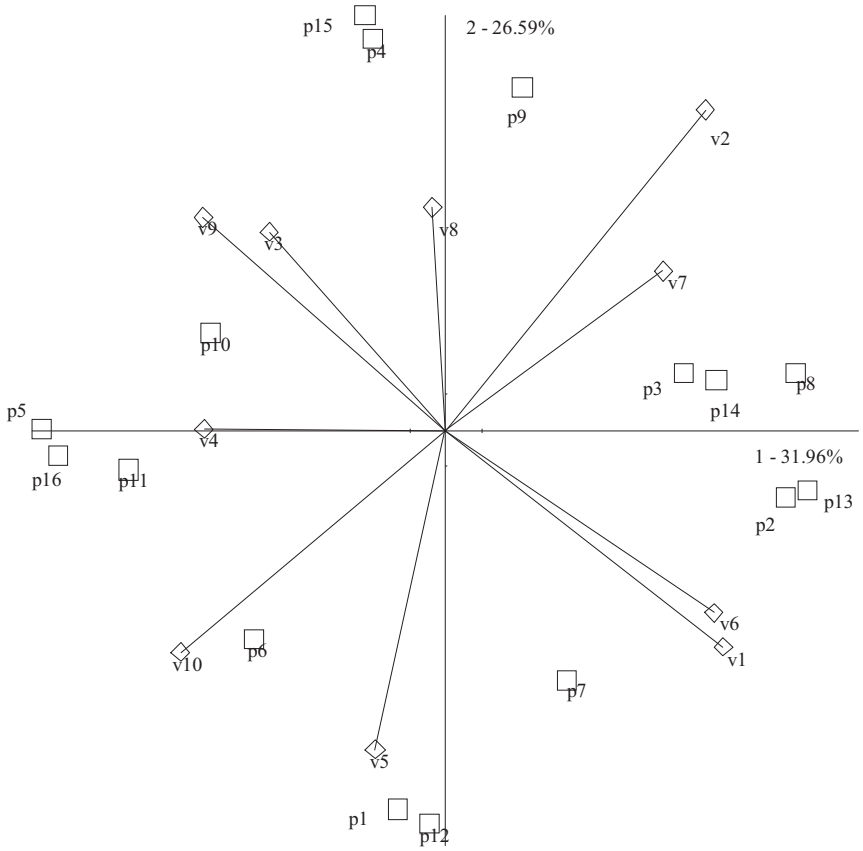

Fig. 1. PCA projection of similarities differences and of sensory quality of fruit tomato (2006–2008); the cultivars of tomato (points marks numbers) p1 – Makarena F_1 grafting, p2 – Fanny F_1 grafting, p3 – Faustine F_1 grafting, p4 – Cathy F_1 grafting, p5 – Fanny F_1 control, p6 – Makarena F_1 control, p7 – Makarena F_1 Goteo, p8 – Cathy F_1 Goteo, p9 – Faustine F_1 Goteo, p10 – Fanny F_1 Goteo, p11 – Fautine F_1 control, p12 – Cathy F_1 control, p13 – Makarena F_1 BM, p14 – Fanny F_1 BM, p15 – Faustine F_1 BM, p16 – Cathy F_1 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_1 szczepione, p2 – Fanny F_1 szczepione, p3 – Faustine F_1 szczepione, p4 – Cathy F_1 szczepione, p5 – Fanny F_1 kontrola, p6 – Makarena F_1 kontrola, p7 – Makarena F_1 Goteo, p8 – Cathy F_1 Goteo, p9 – Faustine F_1 Goteo, p10 – Fanny F_1 Goteo, p11 – Fautine F_1 kontrola, p12 – Cathy F_1 kontrola, p13 – Makarena F_1 BM, p14 – Fanny F_1 BM, p15 – Faustine F_1 BM, p16 – Cathy F_1 BM; oceniane wyróżniki (wektory oznaczone cyframi); v1 – zapach pomidorowy, v2 – zapach obcy, v3 – twardość skórki, v4 – struktura miąższu, v5 – soczystość miąższu, 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 biostimulator and Cathy F_1 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_1 cv. from the control combination. The high marks of tomato smell and taste were observed in fruits of Macarena F_1 cv. from the combinations with Goteo and BM 86 and Fanny F_1 cv. from grafting combination. The fruit samples of Faustine F_1 cv. from the BM 86 combination and Cathy F_1 cv. from grafting combination received the highest notes for sweet taste. The highest marks for flash juiciness were obtained for fruits of Macarena F_1 cv. from grafting combination and Cathy F_1 cv. from the control combination. Fruits of Faustine F_1 cv. from the control combination, Cathy F_1 cv. from BM 86 combination, Fanny F_1 cv. from the control combination and Fanny F_1 cv. from Goteo combination were characterized by the highest mark for flesh texture. However, fruits of Fanny F_1 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_1 cv. from Goteo combination and sour taste in fruits of Fanny F_1 cv. from BM 86 combination and Faustine F_1 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_1 and Cathy F_1 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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WPŁYW 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_1, Faustine F_1, Cathy F_1 i Fanny F_1. Rozsadę przygotowywano w szklarni. Nasiona wysiano w końcu marca. Rośliny szczepiono na podkładce wegetatywnej Maxifort F_1 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_1 i Cathy F_1. 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

This work was supported by Rector of Warsaw University of Life Sciences, Poland Grant No. 504-1004260015.

Accepted for print – Zaakceptowano do druku: 19.11.2009