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THE INFLUENCE OF GRAFTING AND BIOSTIMULATORS ON THE YIELD AND FRUIT QUALITY OF GREENHOUSE TOMATO CV. (*LYCOPERSICON ESCULENTUM* MILL.) GROWN IN THE FIELD

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Summary

Four tomato cultivars Macarena F_1, Faustine F_1, Cathy F_1 and Fanny F_1 were used in the study. Seeds were sown at the end of March and transplants were grown in a greenhouse. The plants were grafted on Maxifort F_1 rootstock on April 5, 6 and 21 in the years 2006, 2007, 2008 respectively 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 first cluster). In the control combination plants were neither-nor grafted or treated with biostimulators. Plants were planted in the field at 70 x 100 cm spacing - 20 plants per plot. For the ripe fruits analyses the following parameters were determined: dry matter, total sugars, vitamin C, carotenoids and macroelements: N, P, K, Ca.

A higher total and marketable yield was obtained after grafting and Goteo treatments. There was a significant influence of grafting and the application of the biostimulators on the content of dry matter and total sugars, however, the highest content of vitamin C and carotenoids were obtained in the control. There was a slight increase of the content of nitrates and calcium in the fruit in the case of grafting and Goteo biostimulator watering treatments, whereas the highest content of potassium in the fruit was obtained in plants treated with BM 86 and phosphorus in the fruits from control combination plants.

key words: tomato fruit, chemical composition, biostimulators, rootstock

INTRODUCTION

An early development stage is an important cultivar feature in tomato cultivation as it determines the beginning of fruit ripening. In tomato plants, a high variability between individual development stages was observed

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(Atherton & Harris 1986). Many factors such as temperature, water deficiency, fertilization and biostimulators applied, affect the vegetative development (Rylski 1985, Buczkowska 1992, Gajc-Wolska *et al*. 2007). Plant grafting is a widely used means of plant propagation and growth control that is of considerable importance in the adaptation of interesting cultivars in the appropriate areas (Pina & Errea 2005). The main objective of grafting is to obtain cultivars with a higher fruit production and quality (Lee 1994). However, grafting was carried out to reduce infections of soil-borne diseases caused by pathogens (Biles *et al*. 1989, Pavlou & Vakalounakis 2005) and to increase low-temperature resistance as well (Ruiz *et al*. 1997, Pudelski 1998, Wysocka-Owczarek 2001, Santa-Cruz *et al*. 2002, Fernandez-Garcia et al. 2002). The rootstock can also greatly influence plant growth, yield, and fruit quality. Fruit size of tomato and melon cultivars grafted onto rootstocks having vigorous root system are significantly increased as compared to those from intact plants. The effects of rootstocks on fruit quality is often determinant. However, it varies greatly with the scion cultivar (Trionfetti *et al*. 2002). A similar effect to rootstocks was obtained by using liquid products derived from seaweed. The application of seaweed products (biostimulators) has beneficial effects on plants (Metting *et al*. 1990). Biostimulators are recommended to increase the effectiveness and efficiency of traditional soil fertilization. The efficacy of biostimulators was evaluated in many field trials with vegetable crops, however only some researchers reported statistically significant positive effects on the crop yield and crop quality (Blunden & Wildgoose 1977, Abetz 1980, Abetz & Young 1983, Verkleij 1992).

The aim of this study was to evaluate the influence of rootstock and biostimulators (Goemar Goteo, BM 86) on the yield and chemical composition of fruits of greenhouse cv. of tomato grown in the field.

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. Biostimulators Goteo and BM 86 were supplied by Arysta Life Sciences Company. Goteo and BM 86 derived from seaweed homogenate and they 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 an experimental field of the Department of Vegetable and Medicinal Plants at Wilanów. Average temperatures and rainfall sum were recorded (Table 1). Plants were grown on deep medium-heavy alluvial soil with 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 optimum level with fertilizers applied to equal the average of 120 kg $N \cdot ha^{-1}$ (60 kg N side dressing), 50 kg $P \cdot ha^{-1}$, and 180 kg $K \cdot ha^{-1}$.

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

Months	Temperatures (ºC)			Rainfall (mm)		
	2006	2007	2008	2006	2007	2008
May	13.7	16.0	14.1	61.0	74.1	36.8
June	18.0	19.4	19.3	22.6	85.4	24.5
July	22.6	19.3	19.7	80.9	89.1	97.8
August	17.8	19.4	19.2	179.8	42.0	89.0
September	15.1	13.8	13.0	14.4	79.1	53.7

Seeds were sown at the end of March and transplants were grown in the greenhouse. The plants were grafted on Maxifort F_1 rootstock on April 5, 6 and 21 in the years 2006, 2007, 2008 respectively without the use of biostimulators. In the case of the other combinations each year the following treatments of 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 neither-nor grafted or treated with biostimulators. Others agricultural practices were the same in the control combination as in the examined objects. Plants were planted into the field at 70 x 100 cm spacing - 20 plants per plot. 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. The fruit quality evaluation consisted of dry matter determination at 104ºC, total sugars was measured with the Luffa-Schoorla method, vitamin C content using the Tilmans' method (Charłampowicz 1966), carotenoids were determined by the flow method with the wave length of 450 nm and the contents of basic macrocomponents: NO_3 by the flow method with the wave length of 560 nm, P was determined by the spectrophotometric method with the wave length of 460 nm, K, Ca by the flame method using the flame photometer.

In each year the statistical analysis was elaborated using two-way analysis of variance, and after that the data was evaluated using the synthesis analysis of variance. Detailed comparison of means was performed by the Tukey's test at the significance level of α=0.05

RESULTS AND DISCUSSION

The observations in the present work indicate, that grafting affected the time of developmental stage of the cultivars studied. A slightly higher number of leaves up to the first cluster was reported on the grafted plants as compared to other treatments. Similar results of the influence of grafting on development of the plants was obtained in some other studies conducted with tomato (van der Knijff *et al*. 2004,Venema *et al*. 2008)

The grafting and biostimulators treatments influenced the biomass of plant shoots and roots. The highest biomass of shoot and root were obtained after using the vegetative rootstock and Goteo biostimulator. The

results of studies carried out by Zijlstra *et al*. (1987) and Gajc-Wolska *et al*. (2007) confirmed influence of grafting and Goteo biostimulator on the biomass of plant.

In the present work the results indicate, that a higher total yield was obtained in grafted plans and treated with Goteo biostimulator as compared to other treatments. The marketable yield of fruit was statistically signifycantly differentiated by grafting, Goteo application and the cultivars used. Grafting and Goteo treatment resulted in a higher yield as compared to the control or BM 86 biostimulator treatment. Among the investigated cultivars the highest marketable yield was obtained in the cultivars Macarena F_1 and Faustine F_1 (Table 2), it is also confirmed earlier by Klein and Perry (1982), and Lee (1994). According to the authors climatic conditions including light and temperature and the rootstock can also have a strong influence on the yield and chemical composition as well as fruit quality.

Table 2. The total and marketable yield of tomato fruit (mean for 2006-2008)

Treatments	Cultivar				Mean
	Macarena F_1	Faustine F_1	Cathy F_1	Fanny F_1	
Total yield ($kg \cdot m^{-2}$)					
Grafting	6.9	6.7	7.9	6.8	7.1 a
Goteo	7.3	7.3	6.2	5.2	6.5 ab
BM 86	6.9	5.5	5.3	5.9	5.9 b
Control	5.2	6.3	5.2	5.6	5.6 b
Mean	6.6 a*	6.5 a	6.2 a	5.8 a	
Marketable yield ($kg \cdot m^{-2}$)					
Grafting	4.9	5.9	6.3	5.4	5.6 a
Goteo	6.3	6.4	5.1	4.6	5.6 a
BM 86	5.8	4.7	3.8	5.2	4.8 b
Control	4.4	4.9	4.2	4.7	4.5 b
Mean	5.3 a*	5.4 a	4.8 b	4.9 b	

*means followed by the same letters are not significantly different at α=0.05

The highest dry matter content of fruit was obtained for Goteo, BM 86, and the control treatments as compared to the grafting treatment. The highest dry matter content in fruits was noted in Faustine F_1 and Cathy F_1 as compared to Macarena F_1 and Fanny F_1. The content of total sugars was higher in fruits from the grafting treatment, Goteo application, and control treatments. Among the cultivars compared the highest content of total sugars was obtained in cultivars Macarena F_1 and Faustine F_1.The highest vitamin C content in fruits was obtained in the control as compared to other treatments. In fruits of Fanny F_1 cultivar the highest content of vitamin C was obtained as compared to other cultivars. Similar trends were visible in relation to carotenoids. Fruits collected from the control treatment had a higher carotenoids content, but among the cultivars studied the highest content of carotenoids was found in fruits of cultivar

Cathy F_1 (Table 3). This observation is in agreement with results obtained by Howard *et al*. (1999) and Gajc-Wolska *et al*. (2007). Those authors noted higher content of dry matter, total sugars and vitamin C content in the fruit from grafting treatment and Goteo application.

Table 3. Nutrition value of tomato fruits (mean for 2006-2008)

Treatmens	Cultivar				Mean
	Macarena F_1	Faustine F_1	Cathy F_1	Fanny F_1	
Dry matter (%)					
Grafting	4.26	4.96	5.42	4.50	4.78 b
Goteo	4.57	5.38	5.46	4.84	5.06 a
BM 86	4.59	5.21	5.43	4.85	5.02 a
Control	4.72	5.47	5.60	4.95	5.18 a
Mean	4.53 b*	5.25 a	5.47 a	4.78 b	
Total sugars (%)					
Grafting	3.84	4.12	3.74	2.57	3.56 a
Goteo	4.30	2.82	2.72	2.22	3.01 a
BM 86	3.52	3.21	2.30	2.47	2.87 b
Control	2.76	4.21	2.27	3.20	3.11 a
Mean	3.60 a*	3.59 a	2.75 b	2.61 b	
Vitamin C ($mg \cdot 100g^{-1}$)					
Grafting	24.0	25.8	27.9	30.3	27.0 b
Goteo	25.3	27.4	30.4	28.4	27.8 b
BM 86	26.3	33.3	26.8	27.2	28.4 b
Control	32.5	25.7	30.0	36.6	31.2 a
Mean	27.0 b*	28.0 b	28.7 b	30.6 a	
Carotenoids ($mg \cdot 100g^{-1}$)					
Grafting	9.97	10.57	10.96	10.20	10.42 b
Goteo	9.49	10.49	10.10	10.14	10.05 b
BM 86	9.63	10.23	11.19	10.62	10.41 b
Control	10.92	10.89	12.19	11.28	11.32 a
Mean	10.00 b*	10.54 b	11.11 a	10.56 b	

* Note: see Table 2

In the present study the results indicate, that a higher content of nitrates and calcium was noted in the fruits of grafting and Goteo treatments (Table 4). Ruitz *et al*. (1997) observed, that the use of different rootstock genotypes caused little change in the leaf content of macronutrients such as N and Ca. A higher content of phosphorus was obtained in the fruit from the control, the lowest in the grafting treatment. The highest content of phosphorus was noted in the fruits of Macarena F_1 and Faustine F_1. The content of potassium was the highest in the fruit from BM 86 treatment as compared to other treatments (Table 4).

Table 4. The content of macrocomponents in tomato fruits (mean for 2006-2008)

Treatments	Cultivar				Mean
	Macarena F_1	Faustine F_1	Cathy F_1	Fanny F_1	
	Nitrates (mg·100g^{-1})				
Grafting	6.18	5.07	5.70	7.64	6.14 a
Goteo	6.19	5.88	6.01	5.92	6.00 a
BM 86	5.89	5.98	6.00	6.04	5.97 b
Control	3.14	4.93	6.01	6.09	5.04 b
Mean	5.35 b*	5.46 b	5.93 b	6.42 a	
	Phosphorus (mg·100g^{-1})				
Grafting	13.5	16.0	12.0	15.5	14.2 c
Goteo	24.0	32.0	19.5	13.5	22.5 b
BM 86	20.5	36.5	17.5	32.5	26.7 b
Control	56.5	26.0	36.5	18.5	34.3 a
Mean	28.6 a*	27.6 a	21.3 b	20.0 b	
	Potassium (mg·100g^{-1})				
Grafting	276	286	282	281	281 b
Goteo	274	291	294	297	289 b
BM 86	306	312	300	283	300 a
Control	275	309	299	274	289 b
Mean	282 a*	299 a	293 a	283 a	
	Calcium (mg·100g^{-1})				
Grafting	19.5	22.5	21.0	22.0	21.2 a
Goteo	23.5	21.5	25.5	24.0	23.6 a
BM 86	18.5	19.5	19.0	21.5	19.6 b
Control	18.5	19.0	19.0	18.5	18.7 b
Mean	20.0 a*	20.6 a	21.1 a	21.5 a	

*Note: see Table 2

CONCLUSIONS

1. Grafting treatment and watering with Goteo biostimulator enhanced the biomass of plant.
2. The highest total and marketable yield after grafting treatment and watering with Goteo treatment proved a high efficiency of these treatments.
3. There was a significant influence of grafting and the applications of biostimulators on the content of dry matter and total sugars, however the highest content of vitamin C and carotenoids were obtained in the control.
4. There was a slight increase in the content of nitrates and calcium in fruit in the grafting and watering with Goteo treatments.
5. The highest content of potassium was obtained in fruit from plants treated with BM 86 and phosphorrus in fruits from the control plants.

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WPŁYW SZCZEPIENIA I BIOSTYMULATORÓW NA PLONOWANIE I JAKOŚĆ OWOCÓW POMIDORA SZKLARNIOWEGO (*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, wysiewając nasiona w końcu marca. Rośliny szczepiono na podkładce wegetatywnej Maxifort F_1 w następujących terminach: 5, 6 kwiecień 2006 r., 2007 r. i 21 kwiecień 2008r. Rośliny szczepione nie były traktowane biostymulatorami. W pozostałych kombinacjach w każdym roku uprawy stosowano biostymulatory: Goteo 0,1% dwukrotne podlewanie 4 i 2 tygodnie przed posadzeniem rozsady i trzykrotne w odstępach trzy tygodniowych 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. Pomidory sadzono w rozstawie 70 x 100 cm, 20 roślin na poletku. Dojrzałe owoce poddano analizie chemicznej na zawartość: suchej masy, cukrów ogółem, witaminy C, karotenoidów, makroelementów NO_3, P, K, Ca.

Wyższym plonem ogólnym i handlowym charakteryzowały się rośliny szczepione na podkładce wegetatywnej i podlewane preparatem Goteo. Stwierdzono istotne różnice w zawartości suchej masy i cukrów ogółem w owocach pochodzących ze wszystkich kombinacji, natomiast najwyższą zawartością witaminy C i karotenoidów charakteryzowały się owoce z kombinacji kontrolnej. Nieznacznie wyższą zawartość azotanów stwierdzono w owocach pochodzących z roślin szczepionych i podlewanych preparatem Goteo, natomiast najwyższą zawartością potasu charakteryzowały się owoce z obiektów, gdzie stosowano preparat BM 86, a fosforu w owocach z kombinacji kontrolnej.