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THE IMPACT OF DIFFERENT METHODS USED FOR IMPROVING FLOWER BIND UPON THE YIELD OF SOME TOMATO HYBRIDS CULTIVATED ON MINERAL WOOL SUBSTRATE IN INDUSTRIAL GREENHOUSES

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Abstract

Obtaining high and superior qualitative tomato yields, in conditions of forced culture system, being economically profitable, depends on modernizing the culture technology. In classical Venlo industrial greenhouses, modernization is possible till the technical limit allowed by their construction type. Among the technological links that can be modernized, and to which we refer in this study, are the following: cultivation of performant hybrids with high quantitative and qualitative potential (Noralee F1 and Marissa F1); fertilization during vegetation with modern chemicals, completely soluble (Yara and Haifa Chemicals), applied using drip irrigation system; using mineral wool as culture substrate (Grodan) and applying new and efficient methods for improving flower bind (pollination with bumblebees - Biobest or Natupol). This article presents the impact of all these modernized technological links upon the quantitative and qualitative tomatoes yields. Tomato-Stim determined large tomato yields, but the best results upon the yield quantity and quality were obtained from those tomato plants where natural pollination was improved by the use of bumblebees. Most of the results showed that the quality of the obtained yields (namely Extra+Ist quality) finds itself in a reversed proportionality with the production quantity per hectare. The influence of both graduation of the fertigation systems are substantiated in the very close quantitative production and from a statistic point of view were not covered, as there were no significant production differences. Results lead us to recommend the cultivation of Noralee F1 hybrid, the use of any of the fertilizers Yara and Haifa Chemicals via fertigation and the use of bumblebees (Biobest or Natupol) to improve the tomato flower binding and to obtain superior quality fruits.

Key words: *bumblebees fertigation, quality.*

INTRODUCTION

Modernizing the culture technology for vegetable cultivated in a protected or forced system, consists in improving some technological links (improving flower bind degree, using modern fertilizers, performant hybrids etc.) so that the effect would be and efficient yield, considering its productivity, quality and economic efficiency (Horgoş A. et al., 2002).

Today, tomatoes is widely cultivated throughout the world and adapted into many cultivars (Olmstead and Palmer, 1997).

The replacement of soil, as natural culture substrate, in greenhouses with an artificial culture substrate, in this case *mineral wool*, represents an important technological link in the modernization process as it determines the improvement of other technological links, which are irrigation and fertilization at the same time by using the drip-irrigation system (fertigation). (Horgoş A. et al., 2005).

Bumblebees are important pollinators for tomato crops. Foragers are capable of assessing the pollen reward of the flowers, the first flower visit is the most effective concerning pollen removal and, consequently, pollination, and small foragers are as efficient in pollinating tomato flowers as are big ones. In line with some earlier studies (Buchmann and Cane 1989; Harder, 1990; Shelly et al., 2000) provide clear evidence that bees are indeed

capable of perceiving the amount of pollen obtained while visiting a flower (Nunes-Silva Patricia et al., 2013).
The cultivated plant is autogamous. However, one of the features of the genus is the poricidal opening of its anthers, which requires the agitation of the flowers by wind and/or the presence of pollinators that vibrate their indirect flight muscles for the release of pollen grains, even in cultivated varieties of tomatoes and especially in the still air of greenhouses (Kevan et al., 1991; Morandin et al., 2001b). Teppner (2005), while conducting studies on tomato plants in central Europe, observed that bees, such as *Bombus* and *Lasioglossum*, can be good pollinators of the flowers by vibrating their anthers easily.
Pollination is an important component of crop production for many cultivated plants. Through pollination research focused on crop plants, agricultural practices become better designed to efficiently produce high quality crops (Morse A., 2009).
In conclusion, the combined influence of technological works listed above, in correlation with the micro-climate factors from industrial heated greenhouses; assure high yields, qualitatively superior, which determine the profitability of tomato cultures.

MATERIALS AND METHODS

Researches on the impact of different methods for improving flower binding in tomato hybrids culture with undetermined growth, on mineral wool, were developed in classic Venlo industrial greenhouses from Agro-Codlea Company (placed in the Western part of Romania, in Arad County). The experiment was developed upon two Dutch hybrids with undetermined growth: Noralee F1 (generative hybrid) new hybrid belonging to Enza Zaden company and Marissa F1, belonging to Royal Sluis company, which is vigorous and high performances regarding fructification and fruits' quality.
The hybrids were observed regarding their productive and qualitative potential under the impact of two fertigation systems (with two completely soluble modern chemical fertilizers-Yara and Haifa Chemicals) and also by using different methods for improving flower bind (fecundation).
The culture was established in spring, the beginning of March (the 2nd - 3rd of March 2015), when the seedling had 65 days and it was planted to density of 24,288 plants/ha. The experiment is considered to be poly-factorial, having the following factors:
Factor A - Hybrids with undetermined growth cultivated on mineral wool: a_1 - Noralee F_1; a_2 - Marissa F_1.
Factor B - Fertigation system: b_1 - Fertigation with completely soluble chemicals: Yara (Yara Mila Cropcare; Yara Mila Ferticare I-III; Yara Mila Folicare B; Folicare Zn; Folicare Cu; KNO_3 Krista; Ca $(NO_3)_2$, Calcinit; K_3PO_4);b_2 - Fertigation with completely soluble chemicals: Haifa-Chemicals (Multicote 4, Multicote 4 with microelements - ME, magnesium nitrate, complex soluble fertilizers N-P-K, mono-potassium phosphate - MPK).
Factor C - Improvement of flower bind (fecundation): c_1 - Control, no stimulants, natural pollination; c_2 - Sprayings with Tomato-Stim stimulant (artificial stimulation); c_3 - Mechanical methods (shaking plants, minting the plant supporting wires, producing air streams by using the pulverizer); c_4 - Using bumblebees (Biobest, Natupol) to improve natural pollination.
The culture technology was distinctive by three modern works: the use of artificial culture substrate (mineral wool used as "matress"), the drip irrigation system (Netafim-Israel installation type) and the fertilization done with completely soluble chemicals using the drip irrigation installation (fertigation process).
The researches were done in order to determine the efficacy of tomato culture when cultivating hybrids with undetermined growth, with high productive potential, cultivated on artificial substrate in conditions of modern technology, which is still limited by the Velno classical greenhouse.

RESULTS AND DISCUSSIONS

The experimental results presented in tables 1 and 2 and figure 1 are the expression of the interactions between the three experimental factors, materialized in the different production and quality levels, related to the variability of production elements (average number of fruits per plant and average weight of one tomato fruit). The number of fruits per plant is clearly

influenced by the method used for improving flower binding (factor C), the values being of 118.4% (c_3 - Mechanical methods) and 140.6% (c_2 - Sprayings with Tomato-Stim stimulant) compared to the control c_1 - No stimulants, natural pollination (100%). The same rule applies to the average weight of fruits, the maximum value being obtained under the impact of c_3 (Mechanical methods - plants' shaking, minting the plant supporting wires, producing air streams with the pulverizer) and c_4 (Using bumblebees for natural pollination), compared to the other two methods, c_1 (No stimulants, natural pollination) and c_2 (Sprayings with Tomato-Stim stimulant).

The hierarchy levels of production are in direct proportionality rule with the number of fruits per plant and the average weight of a fruit.

Production quality levels, in terms of its quantitative proportionality, do not follow the same route under the direct influence of all graduations of factor C (Method of improving the binding of flowers). There is a deviation under the impact of c_2 (Sprayings with Tomato-Stim stimulant - artificial stimulation), where at a production point almost equal to the one obtained under the impact of c_4 (Using bumblebees for natural pollination) the difference is not significant (-1.5 t/ha), while the extra and first quality production represent 72.5% of the total, which is with 13.8% less than under the impact of c_4 (Using bumblebees for natural pollination), where the share is 86.3%.

Under the impact of factor B's graduations (fertigation system), the production elements and the obtained quantities are almost equal (the differences varying between 0.8-2.8 t/ha, respectively 0.6-2.0%). Considering production's quality (extra and first quality), the difference between b_1 (Yara) and b_2 (Haifa Chemicals) is significant, in the limits of 2.8% (c_1) and 5.4% (c_2).

Factor A (the hybrid) contributes to the differentiation of production levels, at the same time quantitative and qualitative), in interaction with both factor B and C and their graduations. Hybrid Noralee F1 has a medium production level of 124.9 t/ha and a maximum of 145.2 t/ha in $a_1b_1c_4$ (Noralee F1-Yara-Bumblebee pollination), being followed by 140.5 t/ha in $a_1b_1c_2$ (Noralee F1-Yara-Tomato-Stim) and 139.8 t/ha in $a_1b_2c_4$ (Noralee F1-Haifa Chemicals - Bumblebee pollination). Considering its qualitative production, the extra and first quality yield shares of the total yield are relatively close, being 82.0% in a_1 - Noralee F_1 and 80.2% in a_2 - Marissa F_1.

Variations percentage share of extra and first quality production have values between 84.4% in a_1b_1 (Noralee F1-Yara), 79.5% in a_1b_2 (Noralee F1-Haifa Chemicals) and 82.4% in a_2b_1 (Marissa F1-Yara), 78.0% in a_2b_2 (Marissa F1-Haifa Chemicals).

Preceding with the analysis of the summary the 3rd table regarding the experimental result we arrive to the following:

-In all the graduations of factor C (method of flower binding improvement), the production achieved under the influence of b1-Yara is on an average higher than under the influence of b2-Haifa Chemicals, the difference being rather very small (1.6 t/ha, namely 1.3%); the highest difference being registered in C4 (the natural pollination via bumblebees), these being 5.4 t/ha, namely 4.0% (c4b1a1 = 145.2 t/ha→106.9% and c4b2a1 = 139.8 t/ha→102.9%);

-Compared to M_{X1} $[c_5 = (c_1 + \cdots + c_4)/4]$ = 120.0 t/ha→100.0%), the production from b_1 (Yara) is 120.8 t/ha→100.7%, and for b_2 (Haifa Chemicals) is 119.2 t/ha→99.3%, a difference of 1.6 t/ha→1.4% being very low; the difference is similar also in the case of M_{X2} $[c_6 = (c_5 - c_1)/3]$ →100.0%, meaning 1.7 t/ha →1.3%;

- The highest productions are obtained under the influence of graduation c_2 (Tomato-Stim), 134.3 t/ha → 153.3% compared to $c_1 - M_t$ and under c_4 (bumblebees pollination), 135.8 t/ha → 155.0% compared to c_1–M_t;

- The production quality of the tomatoes under the influence of c_2 (Tomato-Stim) is lower though, percentage wise down to 72.5% (97.4 t/ha E+Ist quality) from a total production of 134.3 t/ha, compared to the best quality of the same, namely the one from c_4 (bumblebees pollination), of 86.3% (117.2 t/ha E+Ist quality) of a total of 135.8 t/ha;

- The production quality obtained (Extra+Ist quality) finds itself in a reversed proportionality with the production quantity per hectare;

- Out of the four methods of flower binding, from a quantity point of view as well as quality of tomato production, the method of using Biobest or Natupol bumblebees takes first place (c_4), where the average production per hectare as well as the quality had maximum worth compared to the other graduations.

Table 1. Experimental results on cultivating undetermined growth tomato hybrids in industrial greenhouses on mineral wool substrate, Ist cycle - 2015

Factor C (Improvement of flower bind)	Factor B (Fertigation system)	Factor A (The hybrid)	Average no. of fruits/plant		Average weight/ fruit (g/piece)	Average production				
						kg/plant	t/ha	% than c_1	of which extra and Ist quality production	
			piece/ pl	%					t/ha	%
c_1- Control, no stimulants, natural pollination	b_1-Yara	a_1 - Noralee F_1	32.6	100.0	114.7	3.738	90.8	103.7	76.0	83,7
		a_2 - Marissa F_1	31.5	100.0	111.9	3.524	85.6	97.7	70.0	81,8
		Average a for c_1xb_1	*32.1*	*100.0*	*113.3*	*3.631*	*88.2*	*100.7*	*73.0*	*82,8*
	b_2-Haifa chemicals	a_1 - Noralee F_1	32.5	100.0	114.3	3.714	90.2	103.0	73.2	81,2
		a_2 - Marissa F_1	31.2	100.0	110.6	3.450	83.8	95.7	67.1	80,1
		Average a for c_1xb_2	*31.9*	*100.0*	*112.5*	*3.582*	*87.0*	*99.3*	*70.2*	*80,7*
	Average value of factor B for c_1		***32,0***	***100.0***	***112.9***	***3.607***	***87.6***	***100.0***	***71.6***	***81.7***
c_2- Sprayings with Tomato-Stim stimulant (artificial stimulation)	b_1-Yara	a_1 - Noralee F_1	46.9	143.9	123.3	5.785	140.5	104.6	106.9	76,1
		a_2 - Marissa F_1	43.7	138.7	121.4	5.307	128.9	95.8	95.6	74,2
		Average a for c_2xb_1	*45.3*	*141.1*	*122.4*	*5.546*	*134.7*	*100.3*	*101.3*	*75,2*
	b_2-Haifa chemicals	a_1 - Noralee F_1	45.9	141.2	122.7	5.632	136.8	101.9	97.3	70,9
		a_2 - Marissa F_1	43.5	139.4	124.0	5.394	131.0	97.5	90.0	68,7
		Average a for c_2xb_2	*44.7*	*140.1*	*123.4*	*5.513*	*133.9*	*99.7*	*93.5*	*69,8*
	Average value of factor B for c_2		***45,0***	***140.6***	***122.9***	***5.529***	***134.3***	***100.0***	***97.4***	***72.5***
c_3- Mechanical methods (shaking plants, minting the plant supporting wires, producing air streams)	b_1-Yara	a_1 - Noralee F_1	39.8	122.0	139.1	5.536	129.6	106.1	114.2	88,1
		a_2 - Marissa F_1	37.0	117.5	129.3	4.784	116.2	95.2	100.2	86,2
		Average a for c_3xb_1	*38.4*	*119.6*	*134.2*	*5.060*	*122.9*	*100.7*	*107.2*	*87,2*
	b_2-Haifa chemicals	a_1 - Noralee F_1	38.2	117.5	136.5	5.216	126.7	103.8	104.3	82,3
		a_2 - Marissa F_1	36.4	116.7	131.1	4.772	115.9	94.9	94.3	81,4
		Average a for c_3xb_2	*37.3*	*116.9*	*133.8*	*4.994*	*121.3*	*99.3*	*99.3*	*81,9*
	Average value of factor B for c_3		***37,9***	***118.4***	***134.0***	***5.027***	***122.1***	***100.0***	***103.3***	***84.6***
c_4- Natural pollination using bumblebees (Biobest)	b_1-Yara	a_1 - Noralee F_1	42.9	131.6	139.3	5.978	145.2	106.9	129.9	89,5
		a_2 - Marissa F_1	40.4	128.3	131.7	5.319	129.2	95.1	113.4	87,8
		Average a for c_4xb_1	*41.7*	*129.9*	*135.5*	*5.649*	*137.2*	*101.0*	*121.7*	*88,7*
	b_2-Haifa chemicals	a_1 - Noralee F_1	41.7	128.3	138.0	5.756	139.8	102.9	118.0	84,4
		a_2 - Marissa F_1	40.6	130.1	130.8	5.311	129.0	95.0	107.1	83,0
		Average a for c_4xb_2	*41.2*	*129.1*	*134.4*	*5.533*	*134.4*	*99.0*	*112.6*	*83,8*
	Average value of factor B for c_4		***41,5***	***129.7***	***135.0***	***5.591***	***135.8***	***100.0***	***117.2***	***86.3***

Culture density: 24,288 plants/ha

Table 2. Experimental results on cultivating undetermined growth tomato hybrids in industrial greenhouses on mineral wool substrate, Ist cycle - 2015

Factor A (The hybrid)	Factor B (Fertigation system)	Factor C (Improvement of flower bind)	Average no. of fruits/plant		Average weight/ fruit (g/piece)	Average production				
						kg/plant	t/ha	% than c_1	of which extra and Ist quality production	
			piece/ pl	%					t/ha	%
a_1 - Noralee F_1	b_1-Yara	c_1 - Control - natural pollination	32.6	81.5	114.7	3.738	90.8	100.0	76.0	83,7
		c_2 - Stimulation with Tomato-Stim	46.9	117.3	123.3	5.785	140.5	154.7	106.9	76,1
		c_3 - Mechanical pollination	39.8	99.5	139.1	5.536	129.6	142.7	114.2	88,1
		c_4 - Bumblebee pollination - Biobest	42.9	107.3	139.3	5.978	145.2	159.9	129.9	89,5
		Average of factor C for a_1xb_1	*40.5*	*101.3*	*129.1*	*5.209*	*126.5*	*139.3*	*106.8*	*84,4*
	b_2-Haifa chemicals	c_1 - Control - natural pollination	32.5	81.3	114.3	3.714	90.2	100.0	73.2	81,2
		c_2 - Stimulation with Tomato-Stim	45.9	114.8	122.7	5.632	136.8	151.7	97.0	70,9
		c_3 - Mechanical pollination	38.2	95.5	136.5	5.216	126.7	140.5	104.3	82,3
		c_4 - Bumblebee pollination - Biobest	41.7	104.3	138.0	5.756	139.8	155.0	118.0	84,4
		Average of factor C for a_1xb_2	*39.5*	*98.8*	*127.9*	*5.080*	*123.4*	*136.8*	*98.1*	*79,5*
	Average of factor B for a_1		***40.0***	***100.0***	***128.5***	***5.144***	***124.9***	*	***102.5***	***82.0***
a_2 - Marissa F_1	b_1-Yara	c_1 - Control - natural pollination	31.5	82.7	111.9	3.524	85.6	100.0	70.0	81,8
		c_2 - Stimulation with Tomato-Stim	43.7	114.7	121.4	5.307	128.9	150.6	95.6	74,2
		c_3 - Mechanical pollination	37.0	97.1	129.3	4.784	116.2	135.7	100.2	86,2
		c_4 - Bumblebee pollination - Biobest	40.4	106.0	131.7	5.319	129.2	150.9	113.4	87,8
		Average of factor C for a_2xb_1	*38.2*	*100.3*	*123.6*	*4.735*	*115.0*	*134.3*	*94.8*	*82,4*
	b_2-Haifa chemicals	c_1 - Control - natural pollination	31.2	81.9	110.6	3.450	83.8	100.0	67.1	*80,1*
		c_2 - Stimulation with Tomato-Stim	43.5	114.2	124.0	5.394	131.0	156.3	90.0	68,7
		c_3 - Mechanical pollination	36.4	95.5	131.1	4.772	115.9	138.3	94.3	81,4
		c_4 - Bumblebee pollination - Biobest	40.6	106.6	130.8	5.311	129.0	153.9	107.1	83,0
		Average of factor C for a_2xb_2	*37.9*	*99.5*	*124.1*	*4.731*	*114.9*	*137.1*	*89.6*	78,0
	Average of factor B for a_2		***38.1***	***100.0***	***123.9***	***4.733***	***114.9***	*	***92.2***	*80.2*

Culture density: 24,288 plants/ha.

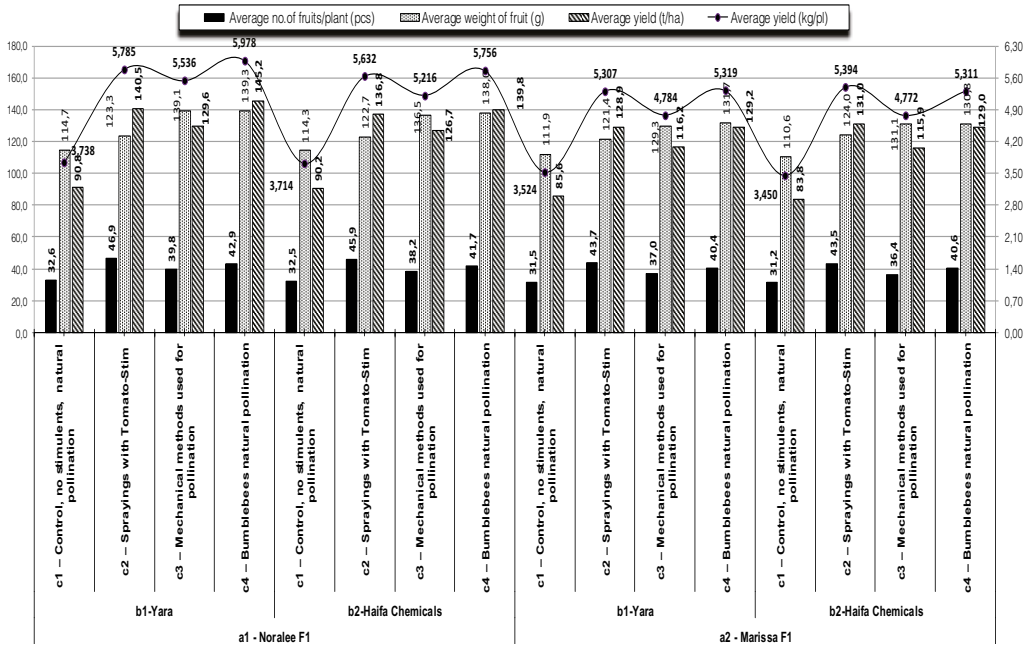

Figure 1. Experimental results on cultivating undetermined growth tomato hybrids in industrial greenhouses on mineral wool substrate, I[st] cycle - 2015

Table 3. Synthesis of experimental results on the non-determined growth tomato hybrids cultivated in warm greenhouses with modernized technological works

Factor experimental			Average production for:																	
			Factor A				Factor B							Factor C						
C	B	A	t/ha	% than c_{1-5}	E+I[st] quality		t/ha	% than $c_{1-5}b_1$	% $c_{1-5}b_{1-2}$ than Mx_1b_{1-2}	E+I[st] quality				t/ha	% than c_1	%c_{1-5} than Mx_1	E+I[st] quality				
					t/ha	%				t/ha	%	% than b_1	% than c_1b_{1-2}				t/ha	%	% than c_1	% than Mx_1	% than Mx_2
c_1		a_1	90.8	103.7	76.0	83.7														
	b_1	a_2	85.6	97.7	70.0	81.8	88.2	100.0	73.0	73.0	82.8	100.0	100.0							
		c_1xb_1	*88.2*	*100.7*	*73.0*	*82.8*														
		a_1	90.2	103.0	73.2	81.2														
	b_2	a_2	83.8	95.7	67.1	80.1	87.0	98.6	73.0	70.2	80.7	96.2	100.0	87.6	100.0	73.0	71.6	81.7	100.0	73.5	67.6
		c_1xb_2	*87.0*	*99.3*	*70.2*	*80.7*														
B average for a_1			***87.6***	***100.0***	***71.6***	***81.7***	***87.6***	***99.3***	***73.0***	***71.6***	***81.7***	***98.1***	***100.0***								
c_2		a_1	140.5	104.6	106.9	76.1														
	b_1	a_2	128.9	95.8	95.6	74.2	134.7	100.0	111.5	101.3	75.2	100.0	138.8							
		c_2xb_1	*134.7*	*100.3*	*101.3*	*75.2*														
		a_1	136.8	101.9	97.0	70.9														
	b_2	a_2	131.0	97.5	90.0	68.7	133.9	99.4	112.3	93.5	69.8	92.3	133.2	134.3	153.3	111.9	97.4	72.5	136.0	100.0	92.0
		c_2xb_2	*133.9*	*99.7*	*93.5*	*69.8*														
B average for a_2			***134.3***	***100.0***	***97.4***	***72.5***	***134.3***	***99.7***	***111.9***	***97.4***	***72.5***	***96.2***	***136.0***								
c_3		a_1	129.6	106.1	114.2	88.1														
	b_1	a_2	116.2	95.2	100.2	86.2	122.9	100.0	101.7	107.2	87.2	100.0	146.8							
		c_3xb_1	*122.9*	*100.7*	*107.2*	*87.2*														
		a_1	126.7	103.8	104.3	82.3														
	b_2	a_2	115.9	94.9	94.3	81.4	121.3	98.7	101.8	99.3	81.9	92.6	141.5	122.1	139.4	101.8	103.3	84.6	144.3	106.1	97.5
		c_3xb_2	*121.3*	*99.3*	*99.3*	*81.9*														

Factor experimental			Average production for:																		
			Factor A				Factor B							Factor C							
C	B	A	t/ha	% than c_{1-5}	E+Ist quality		t/ha	% than $c_{1-5}b_1$	% $c_{1-5}b_{1-2}$ than Mx_1b_{1-2}	E+Ist quality				t/ha	% than c_1	%c_{1-5} than Mx_1	E+Ist quality				
					t/ha	%				t/ha	%	% than b_1	% than c_1b_{1-2}				t/ha	%	% than c_1	% than Mx_1	% than Mx_2
B average for a_3			***122.1***	***100.0***	***103.3***	***84.6***	***122.1***	***99.3***	***101.7***	***103.3***	***84.6***	***96.4***	***144.3***								
c_4	b_1	a_1	145.2	106.9	129.9	89.5	137.2	100.0	113.6	121.7	88.7	100.0	166.7	135.8	155.0	113.2	117.2	86.3	163.7	120.3	110.7
		a_2	129.2	95.1	113.4	87.8															
		c_4xb_1	*137.2*	*101.0*	*121.7*	*88.7*															
	b_2	a_1	139.8	102.9	118.0	84.4	134.4	97.9	112.8	112.6	83.8	92.5	160.4								
		a_2	129.0	95.0	107.1	83.0															
		c_4xb_2	*134.4*	*99.0*	*112.6*	*83.8*															
B average for a_4			***135.8***	***100.0***	***117.2***	***86.3***	***135.8***	***99.0***	***113.2***	***117.2***	***86.6***	***96.3***	***163.7***								
c_5 (Mx1)	***b_1***	a_1	126.5	105.4	106.8	84.4	120.8	100.0	100.0	100.8	81.1	100.0	138.1	120.0	137.0	100.0	97.4	81.2	136.0	100.0	91.8
		a_2	115.0	95.8	94.8	82.4															
	b_1		120.8	100.7	100.8	83.4															
	b_2	a_1	123.4	102.8	98.1	79.5	119.2	98.7	100.0	93.9	79.6	93.2	133.8								
		a_2	114.9	95.7	89.6	78.0															
	b_2		119.2	99.3	93.9	78.8															
	a_1		125.0	104.2	102.5	82.0	*	*	*	*	*	*	*								
	a_2		115.0	95.8	92.2	80.2	*	*	*	*	*	*	*								
Mx_1			***120.0***	***100.0***	***97.4***	***81.2***	120.0	99.3	100.0	96.5	80.4	95.7	134.8								
c_6 (Mx2	***b_1***	*	*	*	*	*	131.6	100.0	100.7	110.1	83.7	100.0	150.8	130.7	149.2	108.9	105.9	81.0	147.9	108.7	100.0
	b_2	*	*	*	*	*	129.9	98.7	99.4	101.8	78.4	92.5	145.0								
	*	a_1	136.4	104.4	111.7	81.9	*	*	*	*	*	*	*								
		a_2	125.0	95.6	100.1	80.1	*	*	*	*	*	*	*								
Mx_2			***130,7***	***100,0***	***105.9***	***81.0***	***130.7***	***99.3***	***100.0***	***105.9***	***81.0***	***96.2***	***150.0***								

In table 4 there are presented the statistical results of production differences significances under the impact of the interaction between the experimental factors.

Table 4. Unilateral and interaction impact of experimental factors upon the production of some non-determined growth tomato hybrids, cultivated on mineral substrate in industrial greenhouses

Variant	Average production (t/ha)		Relative production (%)	Difference (±t/ha)	Significance
1. Unilateral impact of the hybrid upon tomato production					
a2-a1	114.95	124.95	91.99	-10.00	000
DL 5% = 1.60		DL 1% = 2.42		DL 0.1%= 3.89	
2. Unilateral impact of the fertigation system upon tomato production					
b2-b1	119.15	120.75	98.68	-1.60	-
DL 5% = 2.69		DL 1% = 3.71		DL 0.1% = 5.11	
3. Unilateral impact of the flower bind improvement method upon tomato production					
c2-c1	134.30	87.60	153.31	46.70	***
c3-c1	122.10	87.60	139.38	34.50	***
c4-c1	135.80	87.60	155.02	48.20	***
c5-c1	119.96	87.60	136.94	32.36	***
c3-c2	122.10	134.30	90.92	-12.20	000
c4-c2	135.80	134.30	101.12	1.50	-
c5-c2	119.96	134.30	89.32	-14.34	000
c4-c2	135.80	134.30	101.12	1.50	-
c5-c3	119.96	122.10	98.25	-2.14	-
c5-c4	119.96	135.80	88.33	-15.84	000
DL 5% = 2.60		DL 1% = 3.52		DL 0.1% = 4.71	

Variant	Average production (t/ha)		Relative production (%)	Difference (±t/ha)	Significance
4. Interaction impact between different hybrids and the same or different fertigation systems upon tomato production					
a2b1-a1b1	114.97	126.53	90.87	-11.55	000
a2b2-a1b2	114.93	123.38	93.15	-8.45	000
a2b2-a1b1	114.93	126.53	90.83	-11.60	000
DL 5% = 3.13			DL 1% = 4.41	DL 0.1% = 6.32	
5. Interaction impact between the same hybrid and different fertigation systems upon tomato production					
a1b2- a1b1	123.38	126.53	97.51	-3.15	-
a2b2- a2b1	114.93	114.97	99.96	-0.05	-
DL 5% = 3.81			DL 1% = 5.24	DL 0.1% = 7.22	
6. Interaction impact between the same hybrid and different flower bind improvement methods upon tomato production					
a1c2- a1c1	138.65	90.50	153.20	48.15	***
a1c3- a1c1	128.15	90.50	141.60	37.65	***
a1c4- a1c1	142.50	90.50	157.46	52.00	***
a1c5- a1c1	124.97	90.50	138.08	34.47	***
a1c3- a1c2	128.15	138.65	92.43	-10.50	000
a1c4- a1c2	142.50	138.65	102.78	3.85	*
a1c5- a1c2	124.97	138.65	90.13	-13.68	000
a1c4- a1c3	142.50	128.15	111.20	14.35	***
a1c5- a1c3	124.97	128.15	97.52	-3.18	-
a1c5- a1c4	124.97	142.50	87.70	-17.53	000
a2c2- a2c1	129.95	84.70	153.42	45.25	***
a2c3- a2c1	116.05	84.70	137.01	31.35	***
a2c4- a2c1	129.10	84.70	152.42	44.40	***
a2c5- a2c1	114.95	84.70	135.71	30.25	***
a2c3- a2c2	116.05	129.95	89.30	-13.90	000
a2c4- a2c2	129.10	129.95	99.35	-0.85	-
a2c5- a2c2	114.95	129.95	88.46	-15.00	000
a2c4- a2c3	129.10	116.05	111.25	13.05	***
a2c5- a2c3	114.95	116.05	99.05	-1.10	-
a2c5- a2c4	114.95	129.10	89.04	-14.15	000
DL 5% = 3.68			DL 1% = 4.98	DL 0.1% = 6.66	
7. Interaction impact between the same fertigation system and different flower bind improvement methods upon tomato production					
b1c2- b1c1	134.70	88.20	152.72	46.50	***
b1c3- b1c1	122.90	88.20	139.34	34.70	***
b1c4- b1c1	137.20	88.20	155.56	49.00	***
b1c5- b1c1	120.75	88.20	136.90	32.55	***
b1c3- b1c2	122.90	134.70	91.24	-11.80	000
b1c4- b1c2	137.20	134.70	101.86	2.50	-
b1c5- b1c2	120.75	134.70	89.64	-13.95	000
b1c4- b1c3	137.20	122.90	111.64	14.30	***
b1c5- b1c3	120.75	122.90	98.25	-2.15	-
b1c5- b1c4	120.75	137.20	88.01	-16.45	000
b2c2- b2c1	133.90	87.00	153.91	46.90	***
b2c3- b2c1	121.30	87.00	139.43	34.30	***
b2c4- b2c1	134.40	87.00	154.48	47.40	***
b2c5- b2c1	119.17	87.00	136.97	32.17	***
b2c3- b2c2	121.30	133.90	90.59	-12.60	000
b2c4- b2c2	134.40	133.90	100.37	0.50	-
b2c5- b2c2	119.17	133.90	89.00	-14.73	00
b2c4- b2c3	134.40	121.30	110.80	13.10	***
b2c5- b2c3	119.17	121.30	98.24	-2.13	-

Variant	Average production (t/ha)		Relative production (%)	Difference (±t/ha)	Significance
b2c5- b2c4	119.17	134.40	88.67	-15.23	000
DL 5% = 3.68			DL 1% = 4.98	DL 0.1% = 6.66	
8. Interaction impact between different fertigation systems and the same or different flower bind improvement methods upon tomato production					
b2c1- b1c1	87.00	88.20	98.64	-1.20	-
b2c2- b1c2	133.90	134.70	99.41	-0.80	-
b2c3- b1c3	121.30	122.90	98.70	-1.60	-
b2c4- b1c4	134.40	137.20	97.96	-2.80	-
b2c5- b1c5	119.17	120.75	98.69	-1.58	-
b2c2- b1c1	133.90	88.20	151.81	45.70	***
DL 5% = 4.25			DL 1% = 5.80	DL 0.1% = 7.84	
9. Interaction impact between different hybrids and the same or different flower bind improvement methods upon tomato production					
a2c1- a1c1	84.70	90.50	93.59	-5.80	00
a2c2- a1c2	129.95	138.65	93.73	-8.70	000
a2c3- a1c3	116.05	128.15	90.56	-12.10	000
a2c4- a1c4	129.10	142.50	90.60	-13.40	000
a2c5- a1c5	114.95	124.97	91.98	-10.02	000
a2c2- a1c1	129.95	90.50	143.59	39.45	***
DL 5% = 3.65			DL 1% = 5.04	DL 0.1% = 6.99	
10. Interaction impact between the same hybrid and the same fertigation system and different flower bind improvement methods upon tomato production					
a1b1c2- a1b1c1	140.50	90.80	154.74	49.70	***
a1b1c3- a1b1c1	129.60	90.80	142.73	38.80	***
a1b1c4- a1b1c1	145.20	90.80	159.91	54.40	***
a1b1c5- a1b1c1	126.53	90.80	139.35	35.73	***
a1b1c3- a1b1c2	129.60	140.50	92.24	-10.90	000
a1b1c4- a1b1c2	145.20	140.50	103.35	4.70	-
a1b1c5- a1b1c2	126.53	140.50	90.06	-13.97	000
a1b1c4- a1b1c3	145.20	129.60	112.04	15.60	***
a1b1c5- a1b1c3	126.53	129.60	97.63	-3.07	-
a1b1c5- a1b1c4	126.53	145.20	87.14	-18.67	000
a2b2c2- a2b2c1	131.00	83.80	156.32	47.20	***
a2b2c3- a2b2c1	115.90	83.80	138.31	32.10	***
a2b2c4- a2b2c1	129.00	83.80	153.94	45.20	***
a2b2c5- a2b2c1	114.93	83.80	137.15	31.13	***
a2b2c3- a2b2c2	115.90	131.00	88.47	-15.10	000
a2b2c4- a2b2c2	129.00	131.00	98.47	-2.00	-
a2b2c5- a2b2c2	114.93	131.00	87.74	-16.07	000
a2b2c4- a2b2c3	129.00	115.90	111.30	13.10	***
a2b2c5- a2b2c3	114.93	115.90	99.17	-0.97	-
a2b2c5- a2b2c4	114.93	129.00	89.10	-14.07	000
DL 5% = 5.20			DL 1% = 7.05	DL 0.1% = 9.42	
11. Interaction impact between the same hybrid and different fertigation systems and the same flower bind improvement method upon tomato production					
a1b2c1- a1b1c1	90.20	90.80	99.34	-0.60	-
a1b2c5- a1b1c5	123.40	126.53	97.52	-3.13	-
a2b2c2- a2b1c2	131.00	128.90	101.63	2.10	-
a2b2c5- a2b1c5	114.93	114.97	99.97	-0.03	-
DL 5% = 6.01			DL 1% = 8.20	DL 0.1% = 11.09	
12. Interaction impact between different hybrids and the same fertigation system and the same flower bind improvement method upon tomato production					
a2b1c1- a1b1c1	85.60	90.80	94.27	-5.20	-
a2b1c2- a1b1c2	128.90	140.50	91.74	-11.60	000

Variant	Average production (t/ha)		Relative production (%)	Difference (±t/ha)	Significance
a2b1c3- a1b1c3	116.20	129.60	89.66	-13.40	000
a2b1c4- a1b1c4	129.20	145.20	88.98	-16.00	000
a2b1c5- a1b1c5	114.97	126.53	90.86	-11.57	000
a2b2c1- a1b2c1	83.80	90.20	92.90	-6.40	0
a2b2c2- a1b2c2	131.00	136.80	95.76	-5.80	0
a2b2c3- a1b2c3	115.90	126.70	91.48	-10.80	000
a2b2c4- a1b2c4	129.00	139.80	92.27	-10.80	000
a2b2c5- a1b2c5	114.93	123.40	93.14	-8.47	00
DL 5% = 5.60			DL 1% = 7.68	DL 0.1% = 10.50	

Analysing the significance of the production differences from the table the following conclusions emerge:

Point 1 - the unilateral influence of the hybrid on the production - shows that the obtained production from the two hybrids have a statistical assurance, the significance of the production differences between Marissa F1 (a_2) and Noralee F1 (a_1) being considerably negative, meaning that the Noralee F1 (a_1) hybrid has superior production qualities compared to Marissa F1 (a_2), 125 t/ha and respectively 115 t/ha, but quality as well, as the data from table 3 shows;

Point 2 - the unilateral influence of the fertigation system on the production - shows that the productions obtained under the influence of the two fertigation systems do not have a statistical assurance, having no significant production differences, which proves that both fertigation systems can be used because the difference between the two is very low in relation to the average production per hectare (119.2 t/ha respectively 120.8 t/ha);

Point 3 - the unilateral influence of the improved flower binding method on the production - shows that the production obtained under the influence of method c_2 (stimulation with Tomato-Stim), c_3 (mechanical pollination) and c4 (natural pollination via bumble-bees) have statistical assurance, the significance of the production differences compared to c1 (unstimulated and non-pollinated Mt) being essentially positive in all cases, which shows that all used methods are beneficial for the improvement of flower binding compared to the controlled variant; also significance of the difference between c3 (mechanical pollination) and c_2 (stimulation with Tomato-Stim) is essentially negative, which proves that the production has statistical assurance, namely under the influence of c_2 (stimulation with Tomato-Stim) being quantity wise superior but not quality wise (table 3);

Analysing points 4-12 from table 4 we see that based on the bi- or tri-factorial interactions, there is a very big diversity in the significance of the differences in production, that include all degrees of assessment (very significantly positive or negative, distinctively significant positive or negative and significant positive or negative). This proves the intensity of the unilateral influences or the interactions of the experimental factors on the productions obtained from a quantitative angle.

CONCLUSIONS

The productions following the influences of some experimental factors, such as the fertigation system with different types of modern chemical instant fertilizers, administered interacting bi-factorial with the cultivated hybrid, have proved the complexity of the interactions (tri-factorial) with the improved flower binding methods by differentiating them quantitatively and qualitatively in a tomato culture performed on a substrate of mineral cotton.

The diversity of factor C graduation (Improved flower binding method) over the tomatoes production, have determined influences over the quantity as well as quality types, namely the ones which through their natural influence have contributed to a better pollination and fertilization, thus a better flower binding. The same as for Carlos de Melo e Silva Neto et al. (2013) results, our results show that native bees buzz-pollinate tomato flowers, increasing the pollen load on their stigma and consequently fruit production and quality.

Due to the influence of c4 graduation (bumblebees natural pollination) and c2 (Tomato-Stim) the biggest average tomato production within the experiment was of 135.8 t/ha and respectively 134.3 t/ha, but not the best quality in both graduations, as Extra+Ist quality production. This is due to the fact that the pollen dose added to the stigmas of tomato flowers (with the help of bumblebees) lead to a good pollination (meaning a good production increase) and also, if we are to consider the other aspects, an increase in the number of fertilized eggs, which also mean an increase in the production of seeds in the fruits. Related to this, studies developed by Tanksley (2004) and Paran et al. (2007) have shown that the number of seeds in development in tomato fruits influences the activity of the fw 2.2 gene, which is responsible for the production of stimuli for the ovary walls growth and fruit formation (quoted by de Carlos de Melo e Silva Neto et al., 2013).

It has been observed that under the c_2 graduation (Tomato-Stim) the production on second place in quantity size is on the last place regarding the quality Extra+Ist quality production.

The Extra+Ist quality production, from a percentage aspect at its highest was obtained under the c4 graduation (bumblebees natural pollination) - 86.3%, followed chronologically by c_3 (mechanical pollination) - 84.6%. According to Carlos de Melo e Silva Neto et al., 2013, it has been shown that in greenhouses *Melipona quadrifasciata* bees, gains in fruit production reached 15% (Bispo dos Santos et al., 2009), while with *B. impatiens*, gains reached 50% in fruit mass and up to the double in the number of seeds (Morandin et al., 2001a).

The classification from a quality point of view of the production on the first two places, productions under the influence of c_4 (bumblebees natural pollination) and c_3 (mechanical pollination), is based on the natural pollination phenomenon which determines the growth and development on the plant of non-parthenocarpic fruits, with outstanding physical (size, weight and color etc.), chemical and organoleptic (flavor, smell etc.) characteristics.

The influence of both graduation of the fertigation systems (Yara and Haifa Chemicals) are substantiated in the very close quantitative production and from a statistic point of view were not covered, because there were no significant production differences.

Noralee F1 and Marissa F1 hybrids are valuable both due to the quantitative level of production as well as the value of Extra+Ist quality production, these ranging without taking into account c_1 - Mt, throughout the following intervals:

- Noralee F1: 126.7-145.2 t/ha, of which 97.3-129.9 t/ha Extra+Ist quality production, meaning 70.9-89.5%;
- Marissa F1: 115.9-131.0 t/ha, of which 90.0-113.4 t/ha Extra+Ist quality production, meaning 68.7-87.8%.

Based on the conclusions following the performed research, the recommendation is:

- The cultivation of Noralee F1 hybrid;
- The use of both fertilizers Yara and Haifa Chemicals via fertigation;
- The use of mechanical means or bumblebees (Biobest or Natupol) to improve the tomato flower binding and to obtain superior quality fruits.

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