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Influence of foliar fertilizer application on yield in some cherry tomato hybrids

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Abstract Cherry tomatoes variety appears as a novelty in the range of vegetables grown in greenhouses and solariums in our country during the last 15-20 years. An increasing percentage of consumers have accepted them because of their culinary advantages such as: serving as whole fresh fruits at festive meals, during excursions and hiking, without having to divide/cut them as in the case of large fruit tomatoes; easier and elegant marketing in the form of separate fruits or whole buns in plastic casseroles; appreciated organoleptic qualities, such as acidity, sugars, vitamins, dry matter etc. To achieve higher yields that meet the needs of continued growing consumption, it was necessary to improve the culture technology concerning the range of hybrids used in culture and to supplement foliar fertilization with appropriate fertilizers, specific to this method of fertilization. This paper presents the way in which four cherry tomatoes hybrids cultivated in solariums behave in terms of their productive potential by applying different foliar fertilizers.

Key words

variety, assortment, fruit, production, consumption, solariums, fertilizers

Cherry tomatoes are a new variety, which appeared around 15-20 years ago in the range of vegetables cultivated in our country in the forced and protected system of culture. A growing segment of the population has accepted them because of their culinary advantages.

The yields obtained from this tomato variety are lower than those of large fruit varieties because of the average fruit weight, which is very small. As mentioned before, cherry tomatoes fruit weight is around 15-30 g / piece (very small) compared to the fruit's weight of large fruit varieties - 150-220 g / piece, and even higher [7, 8, 9].

The genetic productive potential of these tomato variety is much lower, and the yields are lower than those obtained from large fruit varieties. Studies on cherry tomatoes culture were conducted to improve the quality of production were carried out by Hernández Suárez M.H. et al. [6] and Pinho L. et al. [13].The cultivars type cherry can be grown not only for culinary properties but also for ornamental purposes, this being a "segment" insufficiently valorified nationally and even international. These cultivars are distinguished by the growing season, plant size and most obvious by the size shape and colour of fruits [3].

Foliar fertilization is applied during the vegetation period and its role is to ensure for the plant a good supply of nutritive elements and to prevent nutritional disorders [10]. The nutritional requirements of tomato plants can be met with chemical or organic fertilizers, according to Ferreira et al. [5]. Suitable organic sources of animal origin are cattle, poultry, and goat manure as well as vermicompost. Sand and vermiculite are the most used sources of mineral origin, while styrofoam and phenolic foam are commonly used artificial sources [2, 12].

The use of organic fertilizers to the tomato crop can avoid or reduce the deleterious effects attributed to the use of chemical fertilizer. It is known that applying chemical fertilizer leads to the deterioration fertility of soil, and as well it leads to a reduction in fruit nutrition values and edible qualities [15]. It also reduces the dry matter content of tomatoes [1, 4, 11, 14].

In order to ensure the profitability of the cherry tomato cultivation, it is necessary, first of all, to obtain higher yields that meet the need for continued consumption growth. In this respect, there are needed experimental studies on the productive efficiency of new cherry tomato species, in conditions of growth and development in

polyethylene solariums and in greenhouses, in order to make a selection of these for future inclusion in the cultivation assortment.

The paper presents data obtained of four red cherry tomatoes hybrids, cultivated in solariums, in terms of their productive potential under the impact of foliar spraying with fertilizers.

Material and Method

The main purpose of the research was to determine the way four hybrids of German origin behave in solarium conditions and in the secondary plan to study their productive potential under different conditions of culture technology, by applying foliar fertilizers in addition to the root, organic and mineral fertilization.

The objectives of the researches refer to the study for four cherry tomato hybrids concerning their productive efficiency, cultivated in the polyethylene solarium conditions of growth and development, also to determine their quantitative and qualitative production elements and their productive potential when applying foliar fertilizers besides radicular fertilization.

The experiments were carried out during the year 2017, the experimental field being located on a cambic sloppy chernozem on a private property located in the southern part of Timisoara.

In order to achieve the stated goals and objectives, a bifactorial experience was organized with the following experimental factors:

Factor A – Cherry tomato hybrid: a_1 – Philovita F_1; a_2 – Delicacy F_1; a_3 – Nugget F_1; a_4 – Nectar F_1;

Factor B – Foliar fertilizer: b_1 - not fertilized / unfertilized (Ct - control variant); b_2 – Cropmax; b_3 – Bionat Plus.

During vegetation, observations were made on the number of flowers in a bunch, the number of bound/aborted flowers, the number of fruits per plant, the average fruit weight and the average yield per plant and also per hectare.

The culture was set up with a 60-day seedling on April 15th and the density resulting from the planting scheme was 2.5 plants / m^2.

The culture technology was the one specific to tomato's cultivation in greenhouses and solariums with distinctions specific for the cherry tomatoes cultivation.

Some clarifications on cherry tomatoes' culture technology:

- there was a classical culture technology applied, as the solarium does not have a drip irrigation system, sprinkling irrigation being used;
- foliar fertilizers have been applied, according to manufacturer's instructions, in this way: Cropmax two applications at intervals 10 days in concentration 0.1% and Bionat Plus three applications at intervals 12 days in conc. 0.6% during the vegetation period. The first treatment was applied before flowers were bound on the first fruiting level of the plant;
- fertilization was done by the applying chemical fertilizers on the soil surface, in accordance with the manufacturer's prescriptions (Cropcare to basic fertilization 100 g/m^2 superficially embedded in wet soil);
- flower pollination was done naturally;
- phytosanitary treatments were carried out with pesticides specific for the existing diseases and pests in the culture.

Results and Discussions

Table 1 and the related chart (Graphic 1) present the experimental results of the observed hybrids.

Table 1. Experimental results of cherry tomato hybrids cultivated in solarium

Factor A (The hybrid)	Factor B (Foliar fertilizer)	Plant hight (cm)	No.of florets (bunches/ plant) (piece)	No.flowers bound/floret (%)				No.flowers/plant			Average no.of fruits/ bunch (pc)	Average weight of fruit (g)	Average weight of bunch (g)	No.of fruits/ plant (pc)	Average yield/ plant (kg/ plant)	Average yield	
				pc	Of which:			pc/ plant	Din care:							t/ha	% than b_1
					bound		aborted		bound	aborted							
					pc	%	pc		pc/ plant	pc/ plant							
a_1-Philovita F1	b_1-Ct unfertilized	180.2	6.2	15.8	14.1	89.1	1.7	98.0	87.6	10.4	14.1	16.3	230.3	87.6	1.428	35.7	100.0
	b_2-Crompax	186.7	6.2	16.7	15.4	91.8	1.3	103.5	95.4	8.1	15.4	18.7	287.7	95.4	1.784	44,6	124.9
	b_3-Bionat plus	197.8	6.1	16.6	15.4	92.6	1.2	101.3	94.1	7.2	15.4	19.8	305.6	94.1	1.864	46,6	130.5
a_2-Delicacy F1	b_1-Ct unfertilized	189.1	6.5	15.3	13.6	88.9	1.7	99.5	88.3	11.2	13.6	18.7	254.2	88.3	1.652	41,3	100.0
	b_2-Crompax	190.5	7.0	15.3	14.0	91.8	1.3	107.1	97.7	9.4	14.0	21.2	296.0	97.7	2.072	51,8	125.4
	b_3-Bionat plus	191.7	6.8	15.5	14.4	93.1	1.1	105.4	98.3	7.1	14.4	22.3	322.4	98.3	2.192	54,8	132.7
a_3-Nugget F1	b_1-Ct unfertilized	191.9	5.5	17.9	16.2	90.5	1.7	98.5	89.3	9.2	16.2	18.9	306.9	89.3	1.688	42,2	100.0
	b_2-Crompax	195.4	5.8	18.0	16.6	92.3	1.4	104.4	96.1	8.3	16.6	22.1	366.2	96.1	2.124	53,1	125.8
	b_3-Bionat plus	199.1	5.9	17.7	16.7	94.5	1.0	104.4	98.7	5.7	16.7	22.9	383.1	98.7	2.260	56,5	133.9
a_4-Nectar F1	b_1-Ct unfertilized	183.5	5.9	16.0	14.9	93.1	1.1	94.4	87.7	6.7	14.9	21.7	322.7	87.7	1.904	47,6	100.0
	b_2-Crompax	189.6	6.7	16.2	15.4	95.2	0.8	108.5	103.4	5.1	15.4	23.2	358.2	103.4	2.400	60.0	126.1
	b_3-Bionat plus	191.5	6.6	16.3	15.7	96.4	0.6	107.6	103.8	3.8	15.7	24.7	388.5	103.8	2.564	64,1	134.6
a_5 - Mx	b_1-Ct unfertilized	185.9	6.0	16.3	14.7	90.2	1.6	97.6	88.2	9.4	14.7	18.9	278.5	88.2	1.668	44,7	100.0
	b_2-Crompax	190.5	6.4	16.6	15.4	92.8	1.2	105.9	98.2	7.7	15.4	21.3	327.0	98.2	2.095	52,4	125.7
	b_3-Bionat plus	192.5	6.4	16.5	15.6	94.5	0.9	104.7	98.7	6.0	15.6	22.4	349.9	98.7	2.220	55,5	133.1
Average value of the experiment		**199,6**	*	**16.5**	**15.2**	**92.1**	**1.3**	**102.7**	**95.0**	**7.7**	**15.2**	**20.9**	**318.5**	**95.0**	**1.994**	**49.9**	*

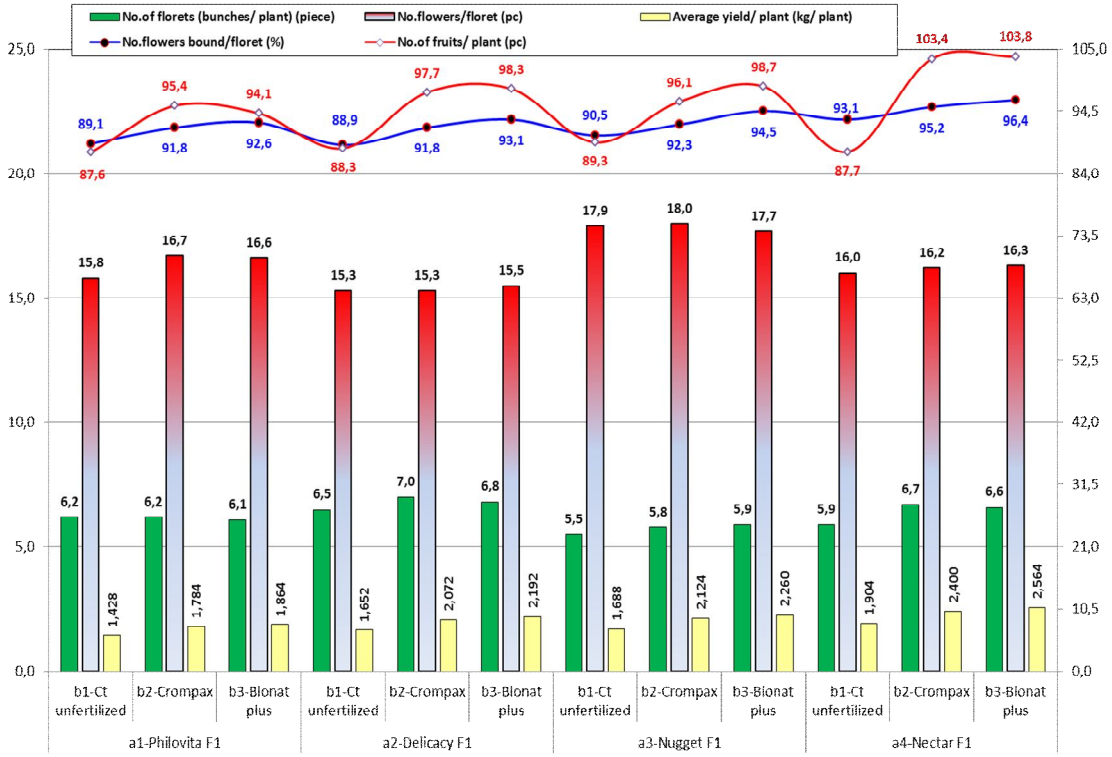
Seeding norm: 25000 plants/ha pc - piece

To ensure a superior level of productive potential, inflorescences' flowers have been naturally pollinated by specific mechanical methods and by using the Tomato-Stim stimulator when microclimate conditions have needed it.

At this time, these methods are used in general in addition to other modern methods in tomato culture technology, in order to ensure that the flower bound closes to 100% and, implicitly, to obtain the highest possible yield of flawless quality.

The method of natural pollination by mechanical means ensures the obtaining of full tomato fruits, the voids being specific for biostimulation with various chemical or biochemical stimuli when the manufacturer's specified concentrations or the temperature and the humidity in the greenhouse microclimate of the day of stimulation are not obeyed as recommended.

The number of bunches per plant on all four hybrids under the impact of factor B is mostly the same, the differences in minus being insignificant or even very small under the impact of graduation b_3 (Bionat Plus).



Graphic 1. Experimental results of cherry tomato hybrids Philovita F_1, Delicacy F_1, Nugget F_1 and Nectar F_1 cultivated in solarium

Flow rate of flower binding was lower under the impact of b_1 gradient (Ct unfertilized) ranging from 88.9-93.1% to a_1b_1 and a_4b_1, respectively, compared to 96.4% for a_4b_3 and 95.2% and 94.6% under the impact of graduation b_2 and b_3. It is concluded that a better binding of flowers occurs when using Cropmax and Bionat Plus foliar fertilizers.

The average number of fruit in a bunch follows the same rule of comparison in the study of the number of bound flowers, being higher under the impact of graduation b_3 (Bionat Plus) for all hybrids, 16.7 pieces/bunch for a_3b_3 (Nugget F_1 - Bionat Plus) and 15.7 pieces/bunch for a_4b_3 (Nectar F_1 - Bionat Plus).

The average weight of a fruit is influenced by the use of the two foliar fertilizers, with insignificant differences (0.8 - 1.5 g/pcs.). The maximum number of fruit per plant is of 103.8 pieces in the a_4b_3 correlation, 98.7 pieces in a_3b_3, compared to 98.3 pieces and 94.1 pieces in the correlations a_2b_3 and a_1b_3 respectively.

Average crop yields per plant and hectare are directly proportional to the average number of fruits per plant and their average weight, shown also by Hoza Gheorghiţa (2010). The largest yields were recorded under the impact of graduation b_3 (Bionat Plus), 64.1 t/ha on Nectar F_1 and 56.5 t/ha at Nugget F_1, the other two being below these levels, meaning 54.8 t/ha for Delicacy F_1 and 46.6 t/ha at Philovita F_1. Noteworthy that under the impact of b_2 - Cropmax, Nectar F_1 yield is higher than the one obtained from Nugget F_1 under the impact of b_3 - Bionat Plus.

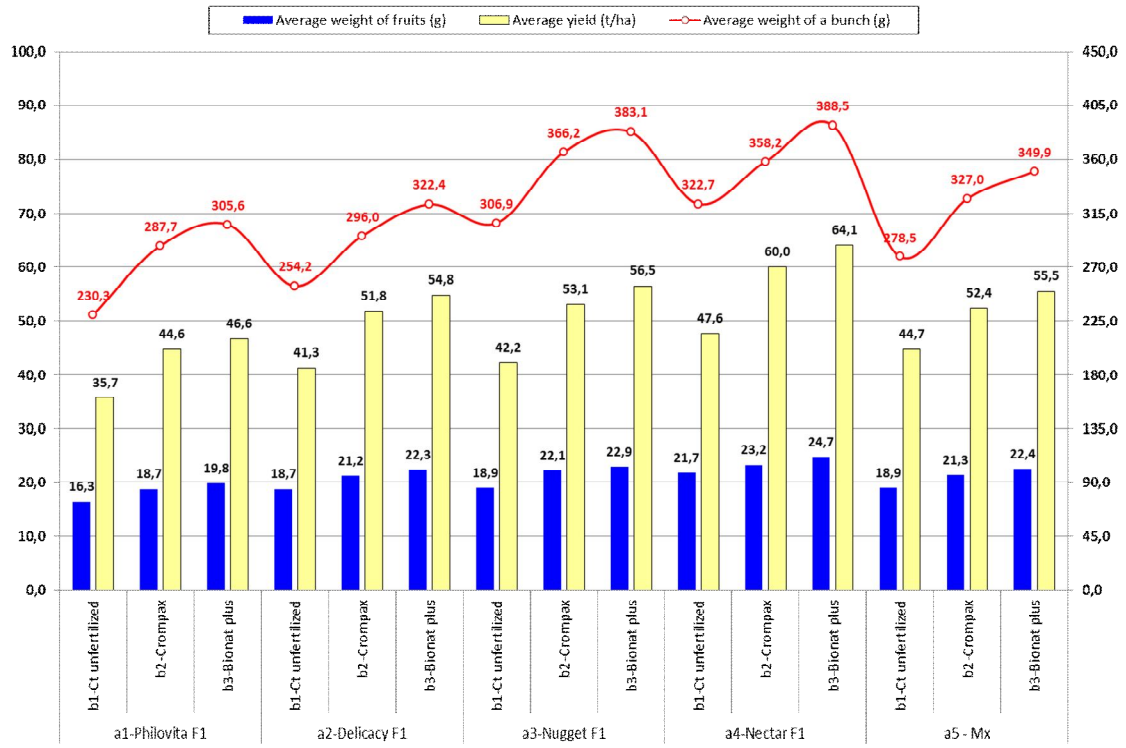
The productive potential of the Nectar F_1 hybrid (57.2 t/ha) is obviously higher than of the other three hybrids (Nugget F_1 - 50.6 t / ha, Delicacy F_1 - 49.3 t / ha and Philovita F_1 - 42.3 t / ha).

Table 2 and the graph in figure 2 show, in addition to the average yield per plant and per hectare, differentiated under the impact of factor B (b_1 - b_3) also the yields obtained under the impact of factor A (a_1 and a_4) - the hybrid. The superiority of Nectar F_1 is found in an average yield of 57.2 t/ha (135.2%) compared to the yields obtained from the other three hybrids: 50.6 t/ha (119.6%) from Nugget F_1, 49.3 t/ha (116.5%) from Delicacy F_1 and 42.3 t/ha (100.0%) from Philovita F_1.

The experimental data were processed according to statistical mathematical rules in order to highlight not only the average values of the production components but also the variation limits and the differences between the hybrids under the impact of some experimental factors.

Table 2. Synthesis of experimental results on cherry tomatoes hybrids Philovita F_1, Delicacy F_1, Nugget F_1 and Nectar F_1 lour cultivated in solariums

Factor A (the hybrid)	Factor B (foliar fertilizer)	No.of florets.	Average no.of	Average weight of	No.of fruits/	Average yield/	Average yield		Production elements for factor A					Average yield for factor A			Fruits' weight
		(bunch/ plant (pc)	fruits/ bunch (pc)	a bunch (g)	plant (pc)	plant (kg/ plant)	t/ha	% than b_1	No.of bunch/ plant (pc)	Average no.of fruits/ bunch (pc)	Average weight of a bunch (g)	No.of fruits/ plant (pc)	Average weight of fruits (g)	t/ha	% than a_1	% than Mx	groups (g) (min-max/ average)
a_1-Philovita F1	b_1-Ct unfertilized	6.2	14.1	230.3	87.6	1.428	35.7	100,0									I
	b_2-Crompax	6.2	15.4	287.7	95.4	1.784	44.6	124,9	6.16	14.96	274.53	92.36	18.26	42.3	100.0	84,8	16.0…20.0
	b_3-Bionat plus	6.1	15.4	305.6	94.1	1.864	46.6	130,5									18.3
a_2-Delicacy F1	b_1-Ct unfertilized	6.5	13.6	254.2	88.3	1.652	41.3	100,0									II
	b_2-Crompax	7.0	14.0	296.0	97.7	2.072	51.8	125,4	6.76	14.00	290.86	94.76	20.73	49.3	116.5	98,8	18.5…22.5
	b_3-Bionat plus	6.8	14.4	322.4	98.3	2.192	54.8	132,7									20.7
a_3-Nugget F1	b_1-Ct unfertilized	5.5	16.2	306.9	89.3	1.688	42.2	100,0									III
	b_2-Crompax	5.8	16.6	366.2	96.1	2.124	53.1	125,8	5.73	16.50	352.06	94.70	21.30	50.6	119.6	101,4	18.5…23.0
	b_3-Bionat plus	5.9	16.7	383.1	98.7	2.260	56.5	133,9									24.3
a_4-Nectar F1	b_1-Ct unfertilized	5.9	14.9	322.7	87.7	1.904	47.6	100,0									IV
	b_2-Crompax	6.7	15.4	358.2	103.4	2.400	60.0	126,1	6.40	15.33	356.46	98.80	23.20	57.2	135.2	114,6	24.5…25.0
	b_3-Bionat plus	6.6	15.7	388.5	103.8	2.564	64.1	134,6									20.9
a_5 - Mx	b_1-Ct unfertilized	6.0	14.7	278.5	88.2	1.668	44.7	100,0									*
	b_2-Crompax	6.4	15.4	327.0	98.2	2.095	52.4	125,7	6.26	15.20	318.50	95.03	20.87	49.9	118.0	100,0	16.0…25.0
	b_3-Bionat plus	6.4	15.6	349.9	98.7	2.220	55.5	133,1									20.9
Average value of the experiment		**6,3**	**15.2**	**318.5**	**95.0**	**1.994**	**49.9**	*	**6,26**	**15.20**	**318.50**	**95.03**	**20.87**	**49.9**	**118.0**	**100.0**	*



Graphic 2. Synthesis of experimental results for cherry tomatoes hybrids Philovita F_1, Delicacy F_1, Nugget F_1 and Nectar F_1 cultivated in solariums

Table 3 is based on the statistical calculations specific to variance analysis methods, and it shows the meanings of yield differences in the comparisons made because of the interdependence between the experimental factors.

Table 3. Statistical calculation of the interaction between the experimental factors on the yield of cherry tomatoes

Variant	Average yield (t/ha)		Relative yield (%)	Difference (± t/ha)	Significance
1. Singular impact of the hybrid upon cherry tomatoes yield					
a2-a1	49.30	42.30	116.55	7.00	**
a3-a1	50.60	42.30	119.62	8.30	**
a4-a1	57.23	42.30	135.30	14.93	***
a3-a2	50.60	49.30	102.64	1.30	-
a4-a2	57.23	49.30	116.09	7.93	**
a4-a3	57.23	50.60	113.11	6.63	**
DL 5% = 3,60			DL 1% = 5,45	DL 0,1% = 8,76	
2. Singular impact of the foliar fertilizer upon cherry tomatoes yield					
b2-b1	52.38	41.70	125.60	10.68	***
b3-b1	55.50	41.70	133.09	13.80	***
b3-b2	55.50	52.38	105.97	3.13	*
DL 5% = 2.46			DL 1% = 3.39	DL 0.1% = 4.67	
3. The interaction impact between different hybrids and the same or different foliar fertilizers upon cherry tomatoes yield					
a2b1-a1b1	41.30	35.70	115.69	5.60	*
a3b1-a1b1	42.20	35.70	118.21	6.50	*
a4b1-a1b1	47.60	35.70	133.33	11.90	***
a3b1-a2b1	42.20	41.30	102.18	0.90	-
a4b1-a2b1	47.60	41.30	115.25	6.30	*
a4b1-a3b1	47.60	42.20	112.80	5.40	*
a2b2-a1b2	51.80	44.60	116.14	7.20	*
a3b2-a1b2	53.10	44.60	119.06	8.50	**
a4b2-a1b2	60.00	44.60	134.53	15.40	***
a3b2-a2b2	53.10	51.80	102.51	1.30	-
a4b2-a2b2	60.00	51.80	115.83	8.20	**
a4b2-a3b2	60.00	53.10	112.99	6.90	*
a2b3-a1b3	54.80	46.60	117.60	8.20	**
a3b3-a1b3	56.50	46.60	121.24	9.90	**
a4b3-a1b3	64.10	46.60	137.55	17.50	***
a3b3-a2b3	56.50	54.80	103.10	1.70	-
a4b3-a2b3	64.10	54.80	116.97	9.30	**
a4b3-a3b3	64.10	56.50	113.45	7.60	**
a2b2-a1b1	51.80	35.70	145.10	16.10	***
a3b3-a1b1	56.50	35.70	158.26	20.80	***
a3b3-a2b2	56.50	51.80	109.07	4.70	-
DL 5% = 5.38			DL 1% = 7.72	DL 0.1% = 11.39	
4. The interaction impact between the same hybrid and different foliar fertilizers upon cherry tomatoes yield					
a1b2 - a1b1	44.60	35.70	124.93	8.90	**
a1b3- a1b1	46.60	35.70	130.53	10.90	***
a1b3- a1b2	46.60	44.60	104.48	2.00	-
a2b2- a2b1	51.80	41.30	125.42	10.50	***
a2b3- a2b1	54.80	41.30	132.69	13.50	***
a2b3- a2b2	54.80	51.80	105.79	3.00	-
a3b2- a3b1	53.10	42.20	125.83	10.90	***
a3b3- a3b1	56.50	42.20	133.89	14.30	***
a3b3- a3b2	56.50	53.10	106.40	3.40	-
a4b2- a4b1	60.00	47.60	126.05	12.40	***
a4b3- a4b1	64.10	47.60	134.66	16.50	***
a4b3- a4b2	64.10	60.00	106.83	4.10	-
DL 5% = 4.92			DL 1% = 6.78	DL 0.1% = 9.33	

From the unilateral analysis of the factors under point 1 it is found that the significance of yield differences in the majority are significant positive.

The significance of the production difference between a_4 -Nectar F_1 and a_1 – Philovita F_1 is very significant positive, and the difference between a_3 – Nugget F_1 and a_2 – Delicacy F_1 has no significance.

It shows that the obtained yields have statistical coverage, highlighting the production of a_4 – Nectar F_1 compared to all the other hybrids.

Out of the analysis in point 2, it is shown that the significance of yield difference between b_2 - Cropmax and b_1 - Ct is very significant positive, and also between b_3 - Bionat Plus and b_1 - Ct unfertilized is the same, very significant positive, which shows that the yields achieved have statistical coverage and that the method of foliar fertilization is nevertheless superior in terms of the yield level achieved, but also for other reasons, such as the higher quality of yields.

From the complex analysis carried out in points 3 and 4, in most of cases, the significance of yield differences is significant, distinct or very significant positive, which shows that the yields obtained under the impact of numerous interactions between the graduations of the experimental factors have statistical coverage.

This demonstrates once again that the results of the interactions between b_2 - Cropmax and b_3 - Bionat Plus graduations with any of the four hybrids have statistical coverage. The final conclusion is that the use of the two foliar fertilizers (Cropmax and Bionat Plus) on any of the experimental hybrids is beneficial compared to the unfertilized Ct.

Conclusions

1. The German origin cherry tomato hybrids - Philovita F_1, Delicacy F_1, Nugget F_1 and Nectar F_1, have an unquestionable biological value, both in terms of the superior level of the productive potential and also of the high- quality features of the production elements.
2. Nectar F_1 hybrid proved to be the most productive, the level of the yields achieved under the impact of graduation b_3 -Bionat Plus being 64.1 t/ha (134.6%) and under the impact of b_2 - Cropmax of 60.0 t/ha (126.1%), compared to 47.6 t/ha (100.0%) under the impact of b_1 - Ct not fertilized.
3. Nugget F_1 hybrid also has a high productive potential, but below the level of Nectar F_1 hybrid. The average obtained yield was of 56.5 t/ha (133.9%) under the impact of b_3 - Bionat Plus and 53.1 t/ha (125.8%) under the impact of b_2 -Cropmax. The average yield of 50.6 t/ha (119.6%) is 15.6% lower than that of Nectar F_1, 57.2 t/ha.
4. The use of foliar fertilizers on all four hybrids determines yield increases ranging from 30.5-34.6% for Bionat Plus, and between 24.9-26.1% for Cropmax fertilizer.
5. The foliar fertilization with Bionat Plus proved to be superior, so that the yields under its impact had statistical coverage.

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