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THE INFLUENCE OF BIOFERTILIZING AND BIOSTIMULATING PRODUCTS ON THE PRODUCTION OF CORNICHON CUCUMBER HYBRIDS CULTIVATED IN HEATED SOLARIUMS

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Abstract

The aim of this study was to determine the influence of foliar fertilizers, applied individually or in combination, on production characteristics and the production of pickled cucumbers grown in solarium, but also the combined effect of the two factors studied. The biological material studied was represented by two cucumber hybrids, SV 9007 and Kybria, and 3 fertilizers, Cropmax, Fury and Auxym. The study was placed according to the experimental technique for bifactorial experiments. The observations highlighted that the Kybria hybrid achieved the highest total production (80.2 t/ha) while the SV-9007 hybrid had the best production of 1st quality fruit, i.e. 65.6 t/ha of the total production of 72.8 t/ha. The fertilizer product with the strongest influence on production and production parameters was Auxym, followed by Furia. However, the combination of the two products (Auxym + Furia) had the greatest influence on production in terms of quantity and quality. The results support the cultivation of cornichon cucumbers, the hybrid SV-9007 F1 and the application of the fertilization products Furia and Auxym in combination, during vegetation

Key words: *hybrid, phasal fertilization, production parameters, solarium culture.*

INTRODUCTION

The beginning of a new crop in the assortment of vegetable crops in Romanian greenhouses occurred in the immediate period of the 1980s, namely the cultivation of cucumbers, which revolutionized the cultivation of cucumbers on the whole (Becherescu et al., 2016). Horgoş et al. (2007) identified at least three main reasons for obtaining productions of this new variety of greenhouse cucumbers in the years '83-'85 (cucumbers with small cornichon-type fruits). These imply, first of all, solving an extremely acute problem at the time, namely the replacement of an unsellable production of cucumbers with long fruits in given periods of time (in the second half of May and June, but especially in cycle II). The second reason implies the increasingly pressuring requirements of the canning industry internally, and especially externally. Thirdly, the urgent need to reduce energy consumption for the second production cycle, on the background of the worsening energy crisis, had severe repercussions on the greenhouse industry, the heat requirements of cornichon crops in the second cycle being much lower or completely absent.

Cornichon cucumber cultures in the last two decades has practically replaced, almost entirely, that of long cucumbers, both in greenhouses, but especially in protected spaces, both heated or unheated. Cornichon cucumber hybrids have a lower genetic yield potential than cucumbers with long or semi-long fruits (Hoza, 2003).

The destination of the cornichon production for pickling by industrial facilities requires the harvesting of much smaller fruits (4-6 cm, 6-9 cm, sometimes 9-12 cm), with the effect of obtaining lower yields from a quantitative point of view (Ciofu et al., 2003).

New cucumber hybrids with very high yield potential have appeared, the value of which depends on the cultivation technology applied (Dinu et al., 2009). The technological links

with major impact on the level of production obtained are those on root and foliar fertilization, as well as phytosanitary protection, and last, but not least, the architecture of plant conducting in vegetation, in terms of pinching shoots and balancing the number of fruit on the plant.
In conclusion, high-performance cultivation technologies and modern cultivation spaces have made cornichon cultivation an extremely profitable crop due primarily to the demand for production obtained mainly for industrialization, but also for fresh consumption, in slightly smaller proportion.

MATERIALS AND METHODS

The research regarding the influence of fertilizers on production and quality has been conducted in heated protected spaces in a traditional area for vegetable crops in the locality of Olari from Arad county, Romania.
The hybrids used in the experiment were SV 9007 F1 from the Seminis company and Kybria F1 from Rijk Zwaan. The crop was established on March 14-15, 2019, at a density of 18,000 pl/ha, and the clearing of the land was made on August 1, 2019.
A two-fold experiment was carried out, which included the following experimental factors:
Factor A - The hybrid
a_1 - SV-9007 F1; a_2 - Kybria F1;
Factor B - Foliar fertilizers applied in vegetation
b_1 - Unfertilized control;
b_2 - Cropmax - foliar fertilizer;
b_3 - Furia - foliar fertilizer and biostimulant;
b_4 - Auxym - natural compound of vegetal extracts;
b_5 - Furia + Auxym
Fertilization and irrigation were carried out through the drip irrigation system (fertigation). The applied technology was specific to cornichon crops from heated protected spaces.
Cornichon cultivation was established in a heated protected space covered with double thermal foil and equipped with a heating source. In the previous autumn, the fertilization was carried out with well-fermented manure (8 kg/m^2), followed by soil mobilization. The soil was partially mulched with black mulch film, thus ensuring weed control. The planting was done using seedlings obtained on the farm, aged 35 days. The maintenance works of the cultivation consisted in trellising the plants using strings and trellis clips, guiding them on strings, and defoliation consisting in removing old or diseased leaves.
Statistical analysis. The statistical significance of the differences between variants was obtained by determining the mean, the standard deviation of the mean and the coefficient of variability. To determine the significance of differences between the factors and their gradations, the processing of statistical data was performed by analyzing the variance and the "t" test for the experiments with two factors in the subdivided graphs (Ciulca, 2006). The significance of differences was expressed both by symbols (*; **; ***; 0; 00; 000) and in letter format. The differences between the variants marked with different letters were considered significant.

RESULTS AND DISCUSSIONS

An important component of production, with a decisive impact on the plant, and consequently on the unit area, is the number of fruits per plant, which can be influenced by the applied cultivation technology. This consists in practicing a proper density in the crop according to the plant habitus, in the correct management of the microclimate in the crop space, in the use of stimulating products with the role of intensifying the plant metabolism, etc (Luchian et al., 2002; Jurian et al., 2003; Tiwari & Sharma 1999; Çakir et al., 2017).
Table 1 shows edifying data on the level of production per hectare, depending on the interaction of the two experimental factors (hybrid and fertilizing products). The production elements that determined the quantitative levels of production are the number of fruits per plant and the average weight of the fruits. The average weight of the fruit displays variation limits, as well as the number of fruits/plant depending on the interaction between the hybrid and the foliar product used for each hybrid.
In SV-9007 F1 the variation limit is very accentuated, of 13.3 fruits/plant and 8.97 g and in Kybria F1 it reaches even higher values, of 14.6 fruits/plant and 9.70 g.

Table 1. Results regarding the influence of fertilizers on the cucumber yield

Experimental factors		No. fruit/plant (piece)	Average weight /fruit (g/piece)	Average yield /plant (kg/plant)	Fruit length (cm)	Average production compared with the factor			
						B		A	
Factor A (Hybrid)	Factor B (Fertilizer)					t/ha	%	t/ha	%
a_1 - SV-9007 F1	b_1 - Unfertilized control	54.1	58.11	3.144	6.2-7.3	56.6	100.0	72.8	100.0
	b_2 - Cropmax	63.2	61.36	3.878	6.4-8.2	69.8	123.3		
	b_3 - Furia	67.4	64.86	4.372	6.9-9.1	78.7	139.0		
	b_4 - Auxym	65.8	65.85	4.333	7.0-9.4	78.0	137.8		
	b_5 - Furia + Auxym	67.0	67.08	4.494	7.1-9.8	80.9	142.9		
a_2 - Kybria F1	b_1 - Unfertilized control	56.0	60.41	3.383	6.4-7.4	60.9	100.0	80.2	110.2
	b_2 - Cropmax	65.8	63.73	4.194	6.7-8.5	75.5	124.0		
	b_3 -Furia	71.2	69.37	4.939	7.1-9.5	88.9	146.0		
	b_4 - Auxym	68.9	69.82	4.811	7.2-9.8	86.6	142.2		
	b_5 - Furia + Auxym	70.6	70.11	4.950	7.4-10.0	89.1	146.3		
Experimental mean (Mx)	b_1 - Unfertilized control	55.1	59.23	3.264	6.3-7.3	58.8	100.0	76.5	105.1
	b_2 - Cropmax	64.5	62.57	4.036	6.5-8.4	72.7	123.6		
	b_3 - Furia	69.3	67.18	4.656	7.0-9.3	83.8	142.5		
	b_4 - Auxym	67.4	67.83	4.572	7.1-9.6	82.3	139.9		
	b_5 - Furia + Auxym	68.8	68.63	4.722	7.3-9.9	85.0	144.6		
Experimental mean (Mx)		**65,0**	**65.38**	**4.250**	**6.8-8.9**	**76.5**	*	**76.5**	**105.1**

Table 2. Experimental results regarding the influence of fertilizers on production and quality in cornichon cucumber hybrids grown in heated protected spaces

Experimental factors		No. fruit/plant (piece)	Average weight/ fruit (g/piece)	Factor B					Factor A					
				kg/ plant	t/ha	% comp. to b_1	Of which Quality I		kg/ plant	t/ha	% comp. to a_1	Of which Quality I		
Factor A (Hybrid)	Factor B (Fertilizer)						t/ha	%				t/ha	%	% comp. to a_1
a_1 – SV-9007 F1	b_1 - Unfertilized control	54.1	58.11	3.144	56.6	100.0	45.0	79.5	4.044	72.8	100.0	65.6	90.1	100.0
	b_2 - Cropmax	63.2	61.36	3.878	69.8	123.3	59.8	85.7						
	b_3 - Furia	67.4	64.86	4.372	78.7	139.0	72.8	92.5						
	b_4 - Auxym	65.8	65.85	4.333	78.0	137.8	73.2	93.9						
	b_5 - Furia + Auxym	67.0	67.08	4.494	80.9	142.9	77.4	95.7						
a_2 – Kybria F1	b_1 - Unfertilized control	56.0	60.41	3.383	60.9	100.0	34.3	56.3	4.455	80.2	110.2	56.2	70.1	85.7
	b_2 - Cropmax	65.8	63.73	4.194	75.5	124.0	50.7	67.1						
	b_3 - Furia	71.2	69.37	4.939	88.9	146.0	64.5	72.5						
	b_4 - Auxym	68.9	69.82	4.811	86.6	142.2	64.1	74.0						
	b_5 - Furia + Auxym	70.6	70.11	4.950	89.1	146.3	67.4	75.7						
Experimental mean (Mx)	b_1 - Unfertilized control	55.1	59.23	3.264	58.8	100.0	39.7	67.4	4.250	76.5	105.1	61.0	79.7	92.9
	b_2 - Cropmax	64.5	62.57	4.036	72.7	123.6	55.3	76.1						
	b_3 - Furia	69.3	67.18	4.656	83.8	142.5	68.7	82.0						
	b_4 - Auxym	67.4	67.83	4.572	82.3	139.9	68.7	83.5						
	b_5 - Furia + Auxym	68.8	68.63	4.722	85.0	144.6	72.4	85.2						
Experimental mean (Mx)		**65,0**	**65.38**	**4.250**	**76.5**	*	**61.0**	**79.7**	**4.250**	**76.5**	**105.1**	**61.0**	**79.7**	**92.9**

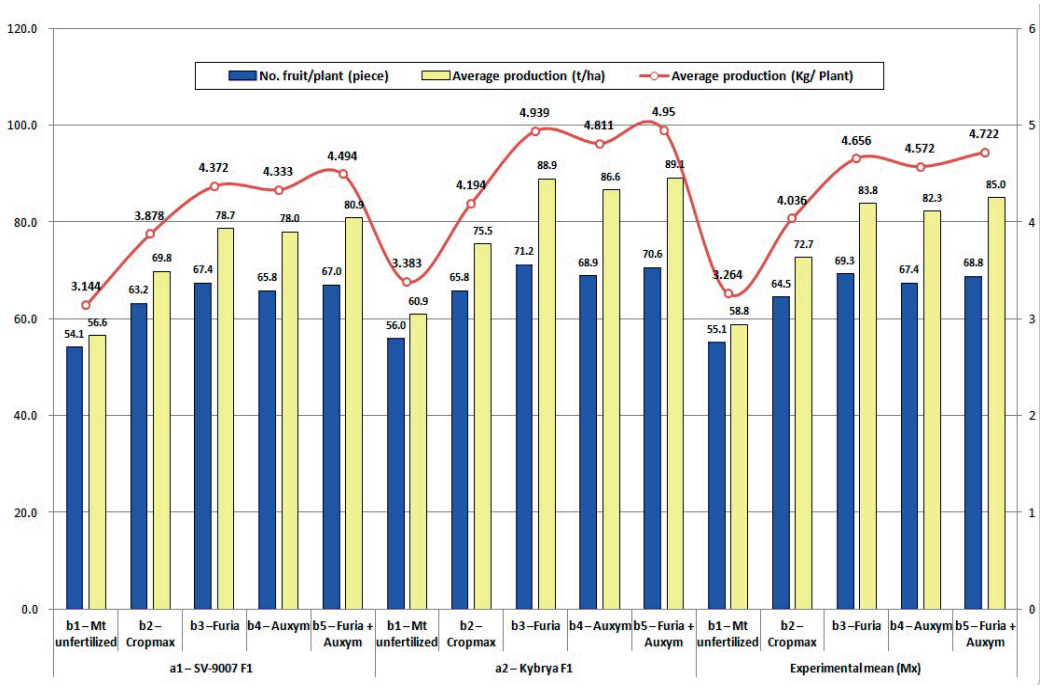

Figure 1. Experimental results regarding the influence of fertilizers on production and quality in cornichon cucumber hybrids grown in heated protected spaces

Since the level of the average production per plant is directly correlated to the product between the two production elements, an average production per hectare is determined depending on the average density per unit area.

This ranges between the limits of 56.6 t/ha (a_1b_1 - Unfertilized control) and 80.9 t/ha (a_1b_5 - Furia + Auxym) at SV-9007 F1, and between 60.9 t/ha (a_2b_1 - Unfertilized control) and 89.1 t/ha (a_2b_5 - Furia + Auxym) at Kybria F_1.

The production growth, according to the fertilizer used, in both hybrids gets to 142.9% (a_1b_5 - Furia + Auxym) compared to 100.0% (a_1b_1 - Unfertilized control) at SV-9007 F1, and to 146.3% (a_2b_5 - Furia + Auxym) compared to 100.0% (a_2b_1 - Unfertilized control) at Kybria F_1. The same Table 1 shows an average production of 72.8 t/ha for the hybrid SV-9007 F1, and 80.2 t/ha for the hybrid Kybria F1, the increase in production by comparison being 110.2%, namely 7.4 t/ha.

Table 2 and Figure 1, in addition to the data contained in the previous table, indicate conclusive elements in terms of production quality, namely 1st production quality. In the hybrid SV-9007 F1 (a_1), the 1st quality production is 65.6 t/ha - 90.1% of the total production of 72.8 t/ha; in the hybrid Kybria F1 (a_2) it is 56.2 t/ha - 70.1% of the total production of 80.2 t/ha. The percentage difference of 1st quality production in favor of the a_1-SV-9007 F1 hybrid is 20.0%, namely 9.4 t/ha of 1st quality production more than in a_2 - Kybria F1.

As a first conclusion, although in Kybria F1 (a_2) a production of 80.2 t/ha is obtained, that is 7.4 t/ha or 10.2% higher than in SV-9007 F1 (a1) - 72.8 t/ha, the 1st quality production of SV-9007 F1 (a_1) is higher both in percentage and in absolute numbers, namely 20.0%, representing 9.4 t/ha.

Under the influence of factor B fertilising products, there are obvious percentage differences in the 1st quality production between b_3 - Fury, b_4 - Auxym and b_5 - Fury + Auxym compared to b1 - unfertilized Control and b_2 - Cropmax, in the case of both hybrids, within the limits of 6.7 - 19.4%.

The highest amount of 1st quality production in the total production per unit area is recorded for b_5 - Fury + Auxym, 95.7% for a_1-SV-9007 F1,

75.7% for a_2 - Kybria F1, and 85.2% on the average of the two hybrids.
Between the individual influences of the two products, b_3 - Fury and b_4 - Auxym, there are also small differences.
Tables 3-6 and Figure 2 display the results of the research, which are interpreted based on the mathematical statistics and the variance analysis method.

Table 3. Analysis of variance for the effect of hybrid and fertilizer on cucumber yield

Source of variation	SS	DF	MS	F value
Total	7439.66	44		
Replications	11.08	2	5.54	2.22
Hybrid	568.36	2	284.18	113.79**
Residual hybrid	9.99	4	2.50	
Fertilizer	6523.12	4	1630.78	320.91**
Hybrid x fertilizer	205.15	8	25.64	5.05**
Residual fertilizer	121.96	24	5.08	

According to the results of the variance analysis method presented in Table 3 it is observed that both the hybrid and the fertilisation treatments, respectively the interaction of these two factors had considerable influences, ensured statistically on the production of cucumbers. The different fertilisation treatments had the highest contribution to the variability of production. The combined effect of the two factors also showed a significant influence on production, but considerably less than the separate effects of the factors. At the level of experience, the results obtained were influenced to a lesser extent by only 2% by other sources of variation not included in the experiment.
Given the unilateral effect of the hybrid (Table 4), the production recorded an amplitude of 9.44 t/ha with values ranging between the limits of 56.20 t/ha for Kybria hybrid and 65.64 t/ha for hybrid SV9007, having a reduced variability (7.75%) between hybrids.

Table 4. The effect of hybrid on cucumber yield

Hybrid	Yield (t/ha)		Relative yield (%)	Significance of difference
Kybria - SV9007	56.20	65.64	85.62	-9.44^{000}
Mean - SV9007	60.94	65.64	92.84	-4.70^{00}
Mean - Kybrya	60.94	56.20	108.43	4.74**

$LSD_{5\%}$=1.60 t/ha $LSD_{1\%}$=2.65 t/ha $LSD_{0,1\%}$=4.97 t/ha

Regarding the differences between the hybrids, it is observed that SV9007 showed a significantly higher production potential by about 15% compared to Kybria and by 7% compared to the average of the two hybrids.
The average values of production under the influence of different fertilisation treatments (table 5) showed an amplitude of 32.74 t/ha, with the limits between 39.66 t/ha in case of the untreated variant up to 72.40 t/ha for the associated application of Furia and Auxym, with a high variability (22.26%) between the five treatments. Compared to the untreated control, it is found that the application of fertilisation treatments allowed to obtain production increases between 39.34% for Cropmax and 82.57% for Furia + Auxym. It is also found that the individual or associated application of Furia and Auxym treatments resulted in significant increases in production by 24-31% compared to Cropmax. The associated application of Furia and Auxym showed a higher production efficiency of about 5.5% compared to the separate effects of the two fertilizers.

Table 5. The effect of fertilizer on cucumber yield

Fertilizer	Yield (t/ha)		Relative yield (%)	Significance of difference
Cropmax - Control	55.26	39.66	139.34	15.60***
Furia - Control	68.67	39.66	173.16	29.01***
Auxym - Control	68.66	39.66	173.13	29.00***
(Furia+Auxym) - Control	72.40	39.66	182.57	32.74***
Furia - Cropmax	68.67	55.26	124.27	13.41***
Auxym - Cropmax	68.66	55.26	124.25	13.40***
(Furia+Auxym) - Cropmax	72.40	55.26	131.03	17.14***
Auxym - Furia	68.66	68.67	99.98	-0.01
(Furia+Auxym) - Furia	72.40	68.67	105.44	3.73**
(Furia+Auxym) - Auxym	72.40	68.66	105.45	3.74**

$LSD_{5\%}$=2,19 t/ha $LSD_{1\%}$=2,98 t/ha $LSD_{0,1\%}$=3,99 t/ha

Considering the combined effect of the hybrid and fertilisation on the production (Table 6 and Figure 2.) it is observed that the fertilisation showed a higher influence on obtaining the production for Kybria hybrid. The hybrid had the highest effect on the production of cucumbers in the non-fertilised variant.

Table 6. The combined effect of hybrid and fertilizer on cucumber yield

Fertilizer	Hybrid				
	SV-9007	Kybria	Mean	$\bar{x} \pm s_{\bar{x}}$	s%
Control	x 45.00 d	z 34.30 c	y 39.67 d	39.66 ±1.67	12.66
Cropmax	x 59.80 c	z 50.70 b	y 55.27 c	55.26 ±1.41	7.67
Furia	x 72.80 b	z 64.50 a	y 68.70 b	68.67 ±1.33	5.81
Auxyn	x 73.20 b	z 64.10 a	y 68.67 b	68.66 ±1.50	6.53
Furia+ Auxym	x 77.40 a	z 67.40 a	y 72.40 a	72.40 ±1.54	6.40
$\bar{x} \pm s_{\bar{x}}$	65.64 ±3.22	56.20 ±3.35	60.94 ±3.26	60.93 ±1.94	
s%	18.98	23.10	21.72	21.33	

Hybrid - $LSD_{5\%}$=3.74 t/ha $LSD_{1\%}$=5.23 t/ha $LSD_{0,1\%}$=7.47 t/ha
Fertilizer - $LSD_{5\%}$=3.80 t/ha $LSD_{1\%}$=5.15 t/ha $LSD_{0,1\%}$=6,90 t/ha
Note: Different letters within the same row indicate significant differences between hibryds or between fertilizers

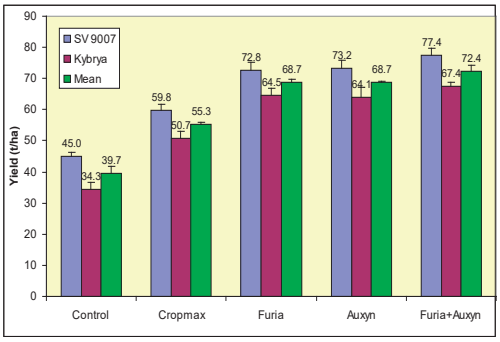

Figure 2. The yield of cucumber hybrids under the effect of different fertilizers

In the case of SV-9007 hybrid, the fertilisation treatment generated an amplitude of 32.4 t/ha with limits between 45 t/ha for the untreated control to 77.4 t/ha for Furia + Auxym variant. As such, this hybrid capitalized at a significantly higher level the treatment associated with Furia + Auxym, registering significant increases in production (5.7-29.4%) both compared to separate treatments with these products and compared to Cropmax. Treatments with Furia and Auxym had significantly equal effects on the production of this hybrid, but approximately 22% higher than Cropmax, on the basis of production increases of approximately 62% compared to the untreated control. Under the effect of Cropmax treatment, the plants of this hybrid recorded a significant increase in production of about 33%.

Regarding the influence of different fertilisation treatments, the plants of the Kybria hybrid registered a variation of the production between 34.3 and 67.4 t/ha, having as limits the untreated control and the one based on the association between Furia and Auxym. The plants of this hybrid capitalized at a similar level the separate and associated effects of the treatments based on Furia and Auxym, achieving production increases of 27.21-32.94% compared to Cropmax and 88.04-96.50% compared to untreated control. Cropmax treatment allowed an increase in plant production of this hybrid by 47.81%.

Considering the productions of hybrids under the effect of the same fertilisation treatment, it is found that regardless of the applied treatment, the plants of the hybrid SV9007 capitalized at a significantly higher level of fertilisation, registering production increases compared to the hybrid Kybria between 8.3 t/ha on the application of Fury and 10.7 t/ha on the unfertilized control.

CONCLUSIONS

Despite the fact that the hybrid with the highest yield proved to be Kybria F1, the hybrid that excels in terms of quality is SV-9007 F1, which exhibited the highest quality production. Although the production of the Kybria F1 hybrid exceeded that of the SV-9007 F1, its 1st quality production proved to be lower.

The research has concluded that Auxym is the fertilizer product with the highest influence on production, both in terms of quantity and quality, followed by Furia, which displays insignificant differences in production. However, the combination of the two products (Furia + Auxym) proved to have the greatest influence on production in terms of both quantity and quality.

Based on these results, it is recommended to cultivate the cornichon hybrid SV-9007 F1 as best suited to heated protected spaces, and to apply the combination of Furia and Auxym fertilizers.

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