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RESEARCH ON THE INFLUENCE OF THE IRRIGATION REGIME AND ORGANIC FERTILIZATION ON THE CUCUMBER PRODUCTION GROWN ON PERLITE SUBSTRATE

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Abstract

Food security has become an increasingly pressing global challenge, especially with the continuous growth of the world population and the reduction of arable land due to urbanization. Greenhouses, as controlled environments, provide an ideal framework for improving crop production and quality. Hydroponics is an intensive method of agricultural production that offers advanced environmental protection and increased food safety control. Cucumber production is one of the most successful crops in hydroponic systems. The study was conducted in the Automated Research Greenhouse at the Research Center for Studies of Food Quality and Agricultural Products, focusing on the cultivation of the long-fruited cucumber hybrid Peloton. The crop was established in the first cycle using a soilless cultivation system with perlite-filled mats (4 mm diameter). This system serves as an alternative to greenhouse cucumber cultivation. Three fertigation rates of 4 L/day, 3.6 L/day, and 3.2 L/day were employed. The main objective of the study is to identify the most efficient variant regarding the influence of fertigation rates on the number and weight of fruits per plant and overall cucumber production.

Key words*: Cucumbers, hydroponic culture, greenhouse, perlite.*

INTRODUCTION

The cultivation systems employed in Romania for cucumbers, including greenhouses, solar structures, polytunnels, and open fields, along with the use of nutrient substrates in technology-equipped farms. These systems allow for year-round production but require careful management of environmental factors, especially in controlled environments like greenhouses where fertigation is crucial. This meticulous control over environmental conditions directly impacts pest and disease management, as described in the second paragraph. Controlled environments can help mitigate the risks of pests and diseases by allowing for more precise management of crop timing and yield, which are noted as key factors in pest and disease prevalence.

Soilless culture, as defined by Raviv et al. (2019), encompasses plant production methods that do not rely on mineral soil in the growing medium. This includes both liquid culture and substrate-based cultivation. In the realm of high-value vegetable crop production, soilless-grown greenhouse methods serve as a viable alternative to traditional field production (Chu and Brown, 2021a; Petre 2014 a; Petre 2016b; 2016c; Rodriguez et al., 2006; Asaduzzaman et al., 2015; Cantliffe and Vansickle, 2001; Chu and Brown, 2021). Consequently, the adoption of soilless culture has experienced a significant surge globally in recent years (Asaduzzaman et al., 2015; Chu and Brown, 2022). Perlite serves as a granular substrate commonly used in soilless cultivation, known for its high porosity and limited water-holding capacity (Goddek et al., 2019, Yang et al., 2021). Its characteristics include excellent drainage, but it retains a significant portion of water that may not be easily accessible to crops (Maher et al., 2008).

Pests and diseases pose lower risks for cucumbers compared to other crops like solanaceous or cruciferous plants, yet the success in preventing and controlling them is closely linked to agricultural practices adopted (He et al., 2022; Mahmood et al., 2021). Issues with pests and diseases are often related to the

timing of cultivation and yield, and the use of resistant varieties and the implementation of proper cultural practices, such as crop rotation and moisture control, can significantly reduce their incidence (Chen et al., 2021; Bondarenko et al., 2021). For instance, cultivation in greenhouses or on nutrient substrates can facilitate the efficient use of resistant varieties and the precise application of fertigation practices, reducing the need for chemical interventions and improving the sustainability of production.

In this context, the advanced cultivation methods adopted in Romania, such as the use of greenhouses and protected structures, allow for better control of the plant environment, thereby contributing to the prevention of disease and pest outbreaks (Sorin et al., 2015)

MATERIALS AND METHODS

The study was conducted within the Research center for studies of food and agricultural products in the period 2021-2022. The biological material used was the cucumber hybrid Peloton, with long fruit, designed for a crop grown in the greenhouse. It has a fast growth, long fruits of 32-38 cm and a big productive capacity.

The crop was grown in a soilless system, on mattresses filled with perlite substrate, having the length of 1 m and a capacity of 30 l of perlite. Three plants were planted on each mattress, having a volume of 10 l of perlite substrate per plant.

The crop was established in the greenhouse, in the first cycle (January-May), the production being obtained especially from the main stem.

The seedling was produced in the greenhouse, in pots filled with perlite.

The fertilization of the seedling was conducted daily with the product Organic Grow, in dose of 1 ml/l.

We have used three watering norms as experimental variants:

- norm a (first irrigation at 7:00 and the last one at 17:00)
- norm b (first irrigation at 8:00 and the last one at 17:00)
- norm c (first irrigation at 9:00 and the last one at 17:00)

We have administrated the ecological fertilizer Gel1 before planting, in a quantity of 15 ml/plant.

Table 1. Experimental variants

Variant		Number of fertilisation/day	Norm	The quantity of solution/ fertigation	Total quantity of solution ml/ day/plant
V1	unfertilised	Unfertilised	unfertilised	unfertilised	unfertilised
V2	unfertilised	Unfertilised	unfertilised	unfertilised	unfertilised
V3	unfertilised	Unfertilised	unfertilised	unfertilised	unfertilised
V4	fertilised	20 fertilisations /day	a	200 ml/ fertilisation	4000
V5	fertilised	18 fertilisations /day	b	200 ml/ fertilisation	3600
V6	fertilised	16 fertilisations /day	c	200 ml/ fertilisation	3200

The main care works consisted of: trellising of the plants right after the planting, removing the first 10 flowers/fruits from the main stem and removing all the shoots from the main stem.

During the growing period we have ensured the optimal conditions for the growth of the plants. In the first week after planting, we have ensured a constant temperature of 24ºC during daytime and night time. During the production period we have maintained a temperature of 23ºC during daytime and 19ºC at night. In the cloudy days we have supplemented the light, using the lamps belonging to the greenhouse, ensuring a constant intensity within 9000 lux-11000 lux. The atmospheric humidity was maintained at 75%. The content of carbon dioxide was maintained at a value of 800 ppm.

We have ensured a nutrient recipe adequate to the growing phase. In the first week, we have maintained an EC of 1.2 and a pH of 5.5. In the next weeks, we have increased the EC at 1.6-1.8, the pH being maintained at a value of 5.5 during the whole period.

We have conducted measurements regarding the height of the plants, the growth rate, the number of fruits per plant at the beginning and the end of harvesting. Biochemical determinations were also conducted regarding the content of nitrates of the cucumber fruit.

The objective of the research was to identify the most efficient variants of the cucumber production regarding the consumption of nutrient solution. The data was processed for statistical purposes using analysis of variance (ANOVA), and the differences regarding significance were determined using the Duncan test.
We have conducted correlations between the average mass of the fruits and the fertigation norm and also between the production obtained and the fertigation norm.

RESULTS AND DISCUSSIONS

In the case of applying the watering norm, analyzing the data in Table 2, it was found that at V(2) where gel was applied at planting, the average number of fruits was 16.66 fruits per plant with 2.36 more fruits than the control V1 equivalent to an increase of 16.50%. From a statistical point of view, a positive effect of the gel on the number of fruits is indicated.

Table 2. The influence of organic fertilization on the number of fruits in the case of norm a fertilized variant

Variant	Number of fruits	Difference		Significance
	no	No	%	
V(0) in average on experiment	15.48	1.18	108.25	N
V(1) Control)	14.30	0.00	100.00	Control
V(2) with Gel	16.66	2.36	116.50	*

DL5% = 2.110 DL5% in % = 14.7552
DL1% = 4.580 DL1% in % = 32.0280
DL0.1% = 15.520 DL0.1% in % = 108.5315

In the case of the fertigation norm *b*, we obtained a higher number of fruits per plant (19.7 fruits/plant) in the variant to which Gel was applied compared to the control variant to which it was not applied (17.4 fruits/plant). The difference in growth was 13.22% supported by the statistical calculation which showed a very significant increase (Table 3).

Table 3. The influence of organic fertilization on the number of fruits in the case of norm b fertigated variant

Variant	Number of fruits	Difference		Significance
	no	no	%	
V(0) average	18.55	1.15	106.61	*
V(1)	17.40	0.00	100.00	Mt
V(2)	19.70	2.30	113.22	**

DL5% = 0.740 DL5% in % = 4.2529
DL1% = 1.610 DL1% in % = 9.2529
DL0.1% = 5.480 DL0.1% in %= 31.4943

We also concluded that, in the case of the c fertilization norm, we obtained an increase in the number of fruits per plant, with a percentage of 8.15%. In the case of this variant, compared to the variant to which Gel was not applied. A significant increase in the number of fruits/plant was obtained 19.25 fruits/plant (V2) compared to 17.8 fruits/plant in V1- Control (Table 4).

Table 4. The influence of organic fertilization on the number of fruits in the case of norm c fertigated variant

Variant	Number of fruits	Difference		Significance
	No	no	%	
V(0) average	18.52	0.73	104.07	*
V(1) Control	17.80	0.00	100.00	Mt
V(2)	19.25	1.45	108.15	**

DL5% = 0.360 DL5% in % = 2.0225
DL1% = 0.790 DL1% in % = 4.4382
DL0.1% = 2.700 DL0.1% in %= 15.1685

The statistical analysis revealed that the application of both b and c fertigation norms significantly influences the number of fruits when compared to a control fertigation variant.

Table 5. The influence of fertilization norm on the number of fruits in the case of the unfertilised variant

Variant	Number of fruits	Difference		Significance
	No	no	%	
V(0) average	16.50	2.20	115.38	***
V1 – norma a	14.30	0.00	100.00	Control
V2 – norma b	17.40	3.10	121.68	***
V3 – norma c	17.80	3.50	124.48	***

DL5% = 0.130 DL5% in % = 0.9091
DL1% = 0.210 DL1% in % = 1.4685
DL0.1% = 0.400 DL0.1% in % = 2.7972

In the case of the variant to which the Gel organic fertilizer was applied, a significant increase in the average number of fruits/plant was observed (Table 6).

Table 6. The influence of fertilization norm on the number of fruits in the case of the organic fertilized variant

Variant	Number of fruits	Difference		Significance
	no	No	%	
V(0) average	18.54	1.87	111.23	***
V1 – norma a	16.67	0.00	100.00	Control
V2 – norma b	19.70	3.03	118.20	***
V3 – norma c	19.25	2.58	115.50	***

DL5% = 0.570 DL5% in % = 3.4200
DL1% = 0.940 DL1% in % = 5.6400
DL0.1% = 1.770 DL0.1% in % = 10.6200

Regarding the average weight of the obtained cucumber fruits, we noticed that, in the case of the application of norm a, the fertilized version showed a significant increase in the average weight of the fruits. Cucumber fruits recorded 302.33 g in V2, an increase of 28.78 g/fruit and 10.52% over V1 (Table 7).

Table 7. The influence of the organic fertilization on the average mass of fruits in the case of the norm *a* fertilized variant

Variant	Mass of fruits	Difference		Significance
	g/fruit	g/fruit	%	
V(0) average	287.94	14.39	105.26	***
V(1) control	273.55	0.00	100.00	Mt
V(2) with Gel	302.33	28.78	110.52	***

DL5% = 0.500 DL5% in % = 0.1828
DL1% = 1.090 DL1% in % = 0.3985
DL0.1% = 3.720 DL0.1% in %= 1.3599

In the case of *b* fertigation norm, we noticed that, from a statistical point of view, at V2 the average weight of the fruits was distinctly very significant compared to the variant to which Gel was not applied at planting. The average mass in this case being 315.75 g/fruit with 13.87% more than the control variant V1 (Table 8).

Table 8. The influence of organic fertilization norm on the average mass of the fruits in the case of the variant fertigated with norm *b*

Variant	Mass of fruits	Difference		Significance
	g/fruit	g/fruit	%	
V(0) average	296.52	19.22	106.93	***
V(1)	277.30	0.00	100.00	Control
V(2) fertilized	315.75	38.45	113.87	***

DL5% = 1.430 DL5% in % = 0.5157
DL1% = 3.100 DL1% in % = 1.1179
DL0.1% = 10.530 DL0.1% in %= 3.7973

In the case of the fertigation norm c, at V2, where Gel was used, an increase in the average fruit weight was observed according to the fertigation norm.
Thus, for norm *c*, the average weight of the fruits was 287.65 g/fruit in the control variant (V1) and 317.8 g/fruit in the variant fertilized with the organic product (Table 9).

Table 9. The influence of oganic fertilization norm on the average mass of the fruits in the case of the variant fertigated with norm c

Variant	Mass of fruits	Difference		Significance
	No	No	%	
V(0) average	302.65	15.15	105.27	***
V(1)	287.50	0.00	100.00	Control
V(2)	317.80	30.30	30.30	***

DL5% = 0.350 DL5% in % = 0.1217
DL1% = 0.770 DL1% in % = 0.2678
DL0.1% = 2.630 DL0.1% in %= 0.9148

The number of fruits obtained per 1 m² was lower in the unfertilized version when applying the 3 fertigation rules (*c*), varying from 31,777 fruits/m² in the case of the *a* norm to 39,555 fruits/m² in the case of the *c* norm.
In the case of the variant to which Gel was applied, the number of fruits/plant increased between 37,044 fruits/m^2 for norm *a* and 42,777 fruits/m^2 for norm c.
To evaluate the influence of the watering rate, we performed an analysis of the correlation between the number of fruits obtained per square meter and the watering rate. Our findings indicate that watering rate significantly influenced both variants (Figure 1).

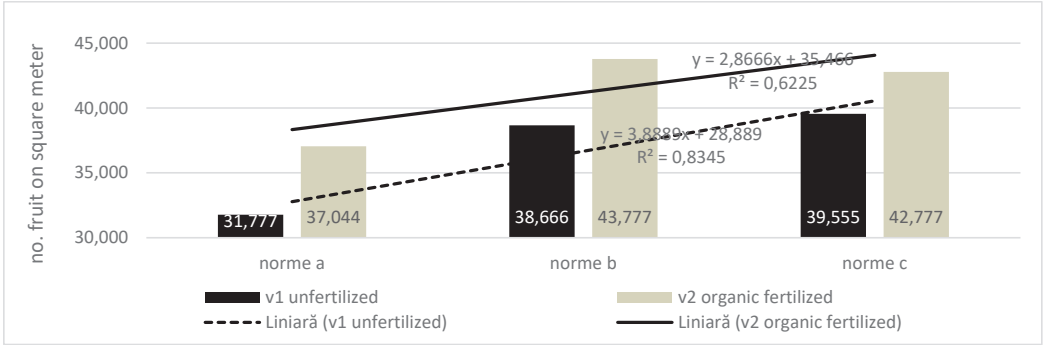

Figure 1. Total number of fruits obtained on 1 m^2

The average weight of the cucumber fruits was lower in the case of the variants without Gel, of all the watering norms (a, b and c), these being between 273.55 g and 287.5 g/fruit. The

application of Gel at planting led to obtaining an increased average mass of the fruits in the case of the watering norm c. At the same time, after making the correlations between the average weight of the fruits and the fertigation rate, we concluded that the amount of nutrient solution played a significant role. The correlation coefficients were R^2=0.8474 in the case of the unfertilized variant. and R^2=0.9335 in the case of the variant where Gel was used (Figure 2).

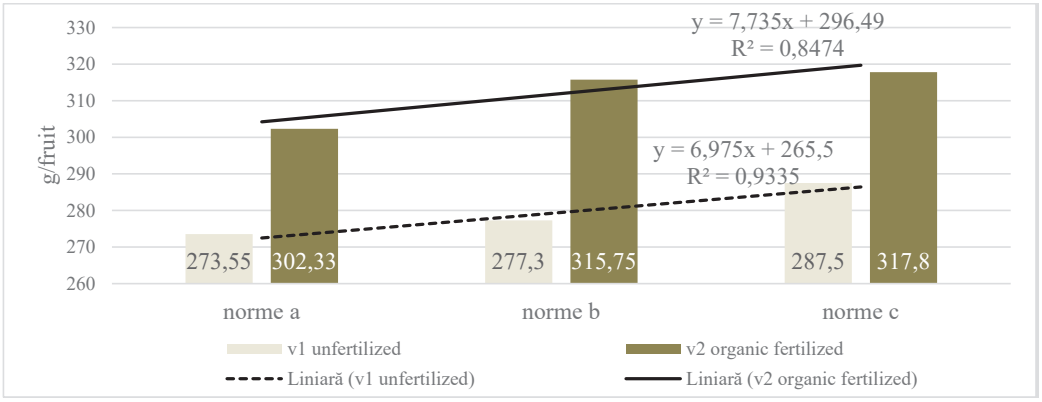

Figure 2. The average mass of cucumber fruits obtained on plant

Analyzing the production obtained per 1 m^2, we concluded that it was higher in the case of the variants where Gel 1 was used, regardless of the fertigation rate. I saw that we obtained an increased production in the case of all variants by increasing the irrigation rate. The correlation coefficients indicated that the fertilization rate has a significant role (Figure 3).

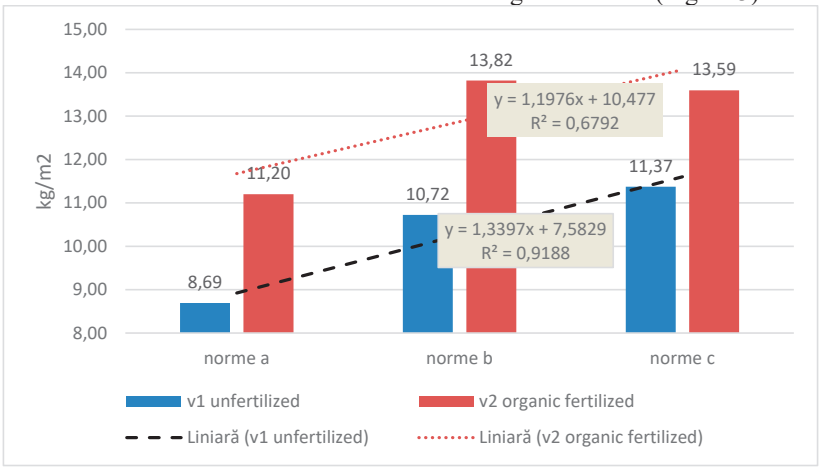

Figure 3. The cucumber production obtained on 1 m^2

CONCLUSIONS

Regarding the number of fruits/plant, in the case of the variant where Gel was used, we obtained the lowest number of fruits on the variant on which we applied the norm (14.3 fruits/plant) and the highest number on the variant on which we applied norm c (17.8 fruits); In the case of the fla variant that used Gel, an increased number of fruits/plant was obtained in the case of all the fertigation variants, between 16.66 fruits (norm *a*) and 19.7 fruits (norm *b*);

Between the fertilization norms, regarding the number of fruits/plant, significant results were obtained; The lowest number of fruits per 1m^2 was obtained in the case of the variant in which Gel was not used, norm *a*, and the highest number of fruits was obtained in the case of the

variant in which Gel was used, of 43,777 fruits/m^2 (norm *b*); The lowest production on 1 m^2 was obtained in the case of the control variant, norm *a*, of 8.69 kg/m^2 and the highest production was obtained in the case of the variant with Gel, norm *b*, of 13.82 kg/m^2.

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