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THE IMPACT OF FOLIAR FERTILIZERS ON THE PRODUCTION OF FIELD-GROWN ZUCCHINI

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Abstract

In Romania, zucchini crop is extending more and more as it is one of the vegetable ~~cultures~~ preferred especially by the population around larger cities, where a higher variety of produces is necessary. It is a vegetable species rich in minerals and vitamins, being prepared in different forms. For these reasons, there are concerns regarding the improvement of crop technology through the use of high quality seedling material, of foliar fertilizers with high impact on the production capacity of plants and environmentally friendly, this being also the purpose of the present research. For the research, the following were used: three hybrids F1, Eskenderany, Opal and Ismalia, and three organic fertilizers, Cropmax 0.1%, Aur verde Extra 0.1% and Bombardier 0.15%. After data processing and results interpretation, it was observed that all the hybrids that had been fertilized with Aur verde Extra 0.1% produced the best results in what concerns the number of flowers per plant. The fruit production per plant and the fruit production per square meter were higher for the F1 hybrids Eskenderany and Ismalia fertilized with Aur verde Extra 0.1%, while for Opal F1 the highest production per plant and per m^2 was obtained after applying Cropmax 0.1%. The highest increase of the production per plant was obtained for all hybrids fertilized with Cropmax 0.1%, while the highest profit per m^2 was obtained for Eskenderany F1 and Ismalia F1 fertilized with Aur verde Extra 0.1% and for Opal F1 fertilized with Cropmax 0.1%.

Key words*: foliar fertilizers, hybrids, yield, zucchini.*

INTRODUCTION

Zucchini *(Cucurbita pepo,* var. *oblonga*) is part of the *Cucurbitaceae* family and it originates from South and Central America (Peru, Mexico), Africa, where it was brought from during ancient times also to Europe (Ciofu et al., 2004), being amongst the oldest known plants for human diet. In Romania, zucchini is grown throughout the country, but in the neighborhood of larger cities it is cultivated more. This vegetable is appreciated by the consumers for its nutritional properties, important for the organism and the seeds' anthelmintic effect. Several varieties and hybrids are cultivated, and for identifying them DNA measurements are made, using the SSR method (Verdone et al., 2018). Vegetables from the Cucurbitacee family have a positive influence on human health, and various studies have clearly indicated that these vegetables have antioxidant, antidiabetic, anti-inflammatory and purgative properties (Becherescu et al., 2010; Becherescu et al., 2012; Mittler, 2002; Rolnik and Olas, 2020). After harvest, zucchini must be consumed as soon as possible, within 1-2 days when it is harvested with flower, and within 3-4 days if it is larger in size. It can be cultivated in field or in protected spaces. There are concerns regarding organic crops as it is a species of international interest. Research conducted on loamy soil, in ecological system, showed a higher accumulation of K in the fruit compared to other crops on sandy soil (Maggio et al., 2013), while using green fertilizers prior to the crop leads to good yields (Ciacciua et al., 2015). Using green fertilizers based on *Crotalaria juncea* L. *(Fabaceae)* to the prior crop ensures the quantity of N necessary for the following zucchini culture (De Oliveira et al., 2017). Using compost in the organic crop ensured a good tolerance of the zucchini plants against *Phytophtora* sp. through its favorable

influence on the rhizosphere (Cucu et al., 2020). Using organic mulch ensure a better plant tolerance against diseases and pests, helping reduce the number of protective treatments (Robacer et al., 2016). Reduced soil works and using ameliorative plants (*Trifolium* sp. *and Lolium* sp.) within bio culture determined a net superior fruit quality, expressed through their antioxidant activity and phenol content, compared to the classical culture technology with deep works (Bucki et al., 2021). Using compost based on rice and sugarcane waste determined an increase in soil fertility, expressed in the C/N ratio, and also a good plant growth (Farid et al., 2022). The comparative study of several varieties in bio and classical systems showed that for the bio crop, the content in active elements was higher than for the classical culture. The content in essential amino acids was higher by 1.3%, K by 9%, Mg by 67%, Na by 29%, tocopherol 4 times higher etc. Also, differences were recorded amongst the varieties within the same crop system, which indicates that the system and variety are responsible for the quality of the edible part (Armesto et al., 2020).

Zucchini is a species tolerant to the quality of irrigation water. Using water with NaCl concentration of up to 80 mM (Villor et al., 2000), respectively with content of Ca up to 3mM (Neocleous et al., 2018) did not affect the production or its quality. Research conducted by Savvas et al. (2009) showed that zucchini tolerates saline water for irrigation if 1 mM Si is added, and water salinity favorably influenced zucchini plants' tolerance to mildew.

The comparative study of applying irrigation water through dripping and underground showed higher efficiency of the dripping irrigation regarding production, but in what concerns the quality underground irrigation proved more effective (Rouphael et al., 2006). Concerning the idea to efficiently user irrigation water within greenhouse, several watering moments were tested, and irrigating at a water deficit with pressure of -25 kPa and applying 2 l/m^2 water ensured the best result, a production of 15 kg/m^2 (Contreras et al., 2017). Zucchini crop in hydroponics with nutritional solutions of EC 2.2 dS/m^{-1} and 4.4 dS/m^{-1} concentrations showed a good plant behavior. For the 4.4 dS/m^{-1} concentration it was recorded a slight increase in the number of male flowers, but the content in dry substance was higher compared to the 2.2 dS/m^{-1} concentration (Liopa-Tsakalidi et al., 2015).

For classical crop in the field, correct application of pesticides does not determine the accumulation of certain residues above the accepted limits (Oliva et al., 2017). A lot of fields are infested with nematodes. Research regarding nematodes tolerance for the zucchini plants showed that varieties and hybrids manifest a different tolerance, genetically controlled, but in order for the culture to succeed, the nematodes population must be kept under control, either through chemical treatments, either through prior crops with repellent effect (Soledad et al., 2019).

Vegetable waste resulted after clearing the zucchini crop represent a source for obtaining biogas, while research showed a good yield, either directly, either through treatments with different substances that accelerate anaerobic fermentation (Gu et al., 2020; Gu et al., 2021).

In order to stimulate the growth capacity of zucchini plants, stem cutting and stimulating the rooting of the shoots from the nods that are in contact with the soil were tried, but these interventions did not determine the growth of biomass compared to the control (Low et al., 2011).

MATERIALS AND METHODS

Research was carried out within the Vidra village, Ilfov county, in 2020. The area is favorable for vegetable crop being close to Bucharest, which represents the main sales market. The experiment was organized with two variable factors, one the hybrid and the other the foliar fertilizer used during the vegetation period. The main objective was to evaluate the influence of hybrids and fertilizing products on the growth and fructification of zucchini plants in the climatic conditions of the Vidra vegetable area. The biological material used was represented by 3 cultivars as it follows:

Eskenderany F1, early hybrid (40-50 days), has light-green colored fruit and is productive. Plants are vigorous, semi-right, compact and resistant to lower temperatures, being

recommended for early crop. Fruit is uniform, cylindric, with thin, bright epidermis, with whitish small spots.
Opal F1, early hybrid (55 days), is productive, has a high capacity to adapt for different environmental conditions. Plants are semi-compact, which allows an easier harvest. Fruit is cream colored and shaped as elongated cylinder.
Ismalia F1**,** is an early hybrid, cold tolerant, recommended for open field and within protected crop. Plants are vigorous, compact. Fruit is whitish with a slight greenish tinge, cylindric and uniform. It is resistant to disease, transport and mechanical damages.
Three stimulation and foliar fertilization products were used, applied at a 10-day interval. Cropmax, the organic stimulator for plant metabolism, which contains amino acids, microelements, polysaccharides, vitamins and ensures a very good growth for roots and foliar mass, increases the plants' capacity to easily adapt to stressful conditions.
Aur verde Extra, complex foliar fertilizer with NPK and microelements (120 g/l N, 80 g/l P205, 105 g/l K20, 0.3 g/l MgO, 0.6 g/l B, 0.2 g/l Cu, 0.5 g/l Fe, 0.3 g/l Mn, 0.2 g/l Zn), is applied to vegetables, decorative plants, fruit trees and vines, at a 7-14 day interval. It has effects on the fast and vigorous plant growth, increases productive yield.
Bombardier, biostimulator and fertilizer resulted from the controlled bacterial fermentation of several plants, contains micronutrients, organic matter, vitamins, coenzymes, proteins, auxins and antioxidants necessary for plants (free amino acids 16.51%, total nitrogen 10.60%, P 0.64%, K 0.25%, polysaccharides 7.87%, total humic extract 29.34, total organic matter 76.70%, total organic carbon 38.10%). It has effects on plant growth and development, adaptation to stress and on the increase in fruit quality.
From combining the two factors, 12 variants resulted, each variant organized 3 repetitions and 5 plants per repetition, as it follows:
V1 - Eskenderany F1+Cropmax 0.1%,
V2 - Eskenderany F1+Aur verde extra 0.1%,
V3 - Eskenderany F1+Bombardier 0.15%,
V4 - Eskenderani F1 nonfertilized,
V5 - Opal F1+ Cropmax 0.1%,
V6 - Opal F1+Aur verde extra 0.1%,
V7 - Opal F1+Bombardier 0.15%,
V8 - Opal F1 nonfertilized,
V9 - Ismalia F1+Cropmax 0.1%,
V10 - Ismalia F1+Aur verde extra 0.1%,
V11 - Ismalia F1+Bombardier 0.15%,
V12 - Ismalia F1 nonfertilized.

Zucchini crop, as a thermophilic species, was set up through direct sowing on April 24th, at a distance of 0.9/0.9 m, resulting in 1.23 pl/m^2. Plant emergence was over 70% after 7 days, while 9 days after it was fully emerged, temperature during the day being 20-25ºC, while during the night only 6-7ºC. During the vegetation period, specific maintenance works were applied, except for phasal fertilization, which was performed according to the experimental variants. When plants began to grow, weekly measurements were made regarding plant height and diameter, number of flowers and fruit formed, determination of fruit size through their length and diameter, average fruit weight and calculating yield, according on the cultivated hybrid and fertilizer used. The interpretation of the results was made using the variant analysis and calculating the correlation coefficient.

RESULTS AND DISCUSSIONS

The comparative study of 3 zucchini varieties, fertilized with 3 products, showed a different reaction. Thus, what concerns plant diameter, fertilization determined a higher growth for all hybrids, the differences in diameter being influenced by the fertilization and less by the hybrid used (Table 1). The more vigorous hybrid was Eskenderany F1, with an average plant diameter of 84.73 cm. the combination between Opal hybrid and Bombardier fertilizer gave the highest plant vigor, 87 cm. Generally, Ismalia T1 hybrid had plants with a smaller diameter.
Plant height was influenced more by the fertilizer. Bombardier 0.15%, determined a different hybrid reaction, the highest plant growth was recorded for Eskenderany F1 hybrid, reaching values of 99.9 cm, while Cropmax and Aur verde Extra had similar influences on plant growth (Figure 1).

Table 1. Plant diameter for several zucchini varieties in different fertilization conditions (cm)

Variety/ Fertilizer	Cropmax 0.1%	Aur Verde Extra 0.1%	Bombardier 0.15%	Nonfertilized	Average (cm)	Significance
Eskenderany	86.65	85.55	86.25	80.45	84.73	N
Opal	84.30	85.45	87.00	78.50	83.81	N
Ismalia	84.95	83.70	82.55	78.70	82.47	N
Media	85.30	84.90	85.26	79.22	83.67	Mt
LSD 5%					2.03	
LSD 1%					3.08	
LSD 0.1%					4.90	

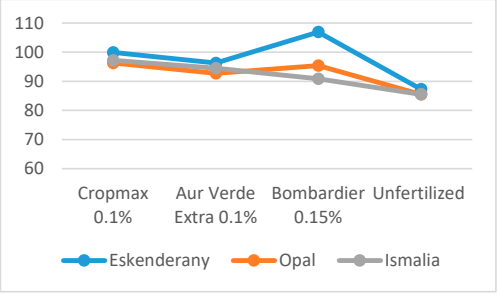

Figure 1. Plant height for studied zucchini hybrids (cm)

Fruit size was influenced more by the hybrid, and for the same hybrid by the fertilizer. The longest fruit was recorded for Opal F1 hybrid, with different values depending on the fertilizer, while the smallest fruit was recorded for Ismalia (Figure 2a.).

Fruit diameter was slightly higher for Eskenerany F1 (Figure 2b.)

The fructification process was influenced more by the hybrid and its biological particularities, differences between hybrids being larger than between fertilizers.

In what concern the number of formed flowers, the fertilizers did not influence at the same level all 3 hybrids, from which the conclusion is drawn that the influence was determined by the combination between the hybrid and fertilizer (Table 2).

The highest blooming capacity was recorded for Eskenderany F1, with more than 16.7 flowers per plant, having a maximum value of 17.4 for Cropmax fertilization and a minimum value of 15.97 for nonfertilized plants.

The Opal F1 hybrid the lowest blooming capacity, with approximately 11.65 flowers per plant, while Ismalia F1 had intermediary values between the other two hybrids, with an average value of 14.60 flowers per plant. For the hybrids Opal and Ismalia, the Aur Verde Extra 0.1% fertilizer slightly influenced the blooming, followed by Cropmax. Differences between hybrids, but also between fertilizers for the same hybrid, were statistically ensured.

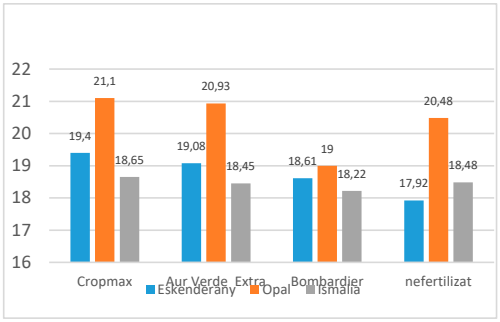

Figure 2a. Fruit length (cm)

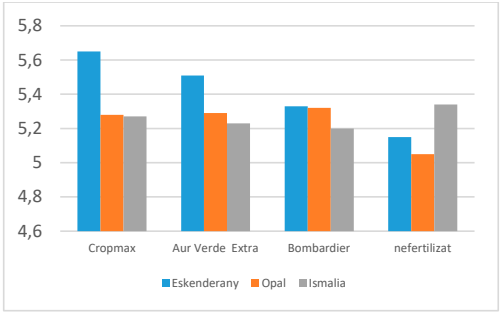

Figure 2b. Fruit diameter (cm)

The fructification capacity, expressed through the number of harvested fruit followed, in general, the same tendency as the blooming, but in this case it was recorded a better influence of the fertilizer Aur verde Extra 0.1% for all hybrids, closely followed by Cropmax 0.1% (Table 3).

Table 2. Influence of fertilization on the number of flowers for several hybrids (piece)

Variant/ Repetition	R1	R2	R3	Average (Pieces)	Difference %	The meaning
V1	18.8	17.2	16.2	17.40	121.14	***
V2	18.2	16.6	17.0	17.27	120.21	***
V3	17.0	15.6	17.4	16.67	116.03	**
V4	15.2	16.0	16.7	15.97	111.16	*
V5	12.8	11.6	11.8	12.07	84.01	oo
V6	13.0	11.0	13.2	12.40	86.33	oo
V7	12.0	10.8	10.6	11.13	77.51	ooo
V8	10.3	11.7	11.1	11.03	76.81	ooo
V9	14.6	15.2	15.4	15.07	104.89	N
V10	16.8	13.8	15.4	15.33	106.75	N
V11	16.8	13.2	14.4	14.80	103.04	N
V12	13.8	12.5	13.4	13.23	92.13	N
Average	14.94	13.77	14.38	14.36	100	Control
LSD 5%				1.36	9.81	
LSD 1%				2.45	13.36	
LSD 0.1%				2.82	17.96	

The highest number of fruit was harvested from the combination between Eskenderany and Aur Verde Extra 0.2%, de 17.15 fruit/plant, while the lowest number was harvested for Opal nonfertilized or fertilized with Bombardier 0.15%. The statistical analysis of data showed that compared to the experiment average, the hybrid Opal had values that were negatively statistically ensured, while Eskenderany had positive differences. In case of Ismalia, differences were not statistically ensured.

Table 3. Influence of fertilizer on fruit formation for several zucchini hybrids (piece)

Variants	R1	R2	R3	Average (Pieces)	Differences %	The meaning
V1	18.55	15.65	16.25	16.82	118.76	**
V2	18.50	16.65	16.30	17.15	121.53	**
V3	18.80	14.80	15.60	16.40	115.82	*
V4	15.05	15.90	14.90	15.28	107.93	N
V5	13.85	10.75	11.80	12.03	85.69	o
V6	12.95	11.20	12.80	12.32	86.98	o
V7	11.55	11.10	10.35	11.00	77.68	ooo
V8	10.90	11.10	11.00	11.00	77.68	ooo
V9	13.95	14.15	15.10	14.40	101.69	N
V10	16.20	14.42	14.45	15.02	106.09	N
V11	15.85	13.85	13.75	14.48	102.28	N
V12	13.50	13.55	12.64	13.23	93.00	N
Average	14.97	13.59	13.91	14.16	100	Control
DL5%				1.72	12.16	
DL 1%				2.35	16.59	
DL 0.1%				3.16	22.31	

In what regards the average fruit weight, differences were not as large as for the previously analyzed parameters; fertilizers had a rather low influence, not statistically ensured, except for one variant: Eskenderany+ Cropmax 0.1% (Table 4). The average value for fruit weight was between 376.5 g for Eskenderany and 361.58 g for Ismalia.

Table 4. Fertilizer influence on average fruit weight for several zucchini hybrids (g)

Variant	R1	R2	R3	Average (g)	Differences %	The meaning
V1	377	380	417	391.33	106.62	*
V2	372	377	394	381.00	103.81	N
V3	377	385	375	379.00	103.26	N
V4	375	339	350	354.67	96.63	N
V5	380	362	372	371.33	101.17	N
V6	369	351	377	365.67	99.63	N
V7	370	345	369	361.33	98.45	N
V8	361	357	361	359.67	97.99	N
V9	369	367	385	359.67	101.81	N
V10	377	356	349	373.67	98.27	N
V11	349	360	348	360.67	96.00	N
V12	367	345	349	352.33	96.36	N
Average	370.25	360.33	370.5	352.67	100	Control
DL5%				19.90	5.42	
DL 1%				27.08	7.37	
DL 0.1%				36.47	9.93	

Fruit production was influenced more by the hybrid and less by the fertilizer. The highest production per plant was obtained for the hybrid Eskenderany F1 of 6.18 kg, followed by Ismalia with 5.19 kg, while Opal F1 produced only 4.24 kg (Table 5a). For the same hybrid, the fertilizer Aur Verde Extra 0.1% had a better influence on Eskenderany F1 and Ismalia F1, while Cropmax 0,1% better influenced hibridul Opal F1. The production per unit of area (m^{-1}) followed the same distribution and it was slightly different for the same hybrid depending on the fertilizer, having values of 6.6-8.12 kg m^{-1} for Eskenderany F1, 6.27- 6.70 kg m^{-1} for Ismalia F1 and 4.85-5.59kg m^{-1} for Opal F1 (Table 5b.).

Correlations

The used fertilizers determined a good fruit formation, most flowers forming fruit, as it can be observed from the correlation coefficient between the two parameters r^2 = 0.99, even though it was a hot summer (Figure 3).

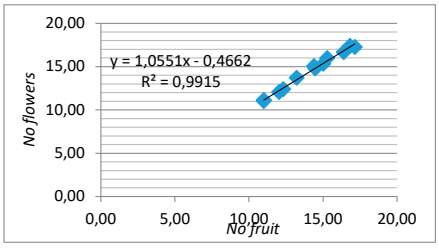

Figure 3. Correlation between number of flowers and number of fruits

In order to determine the influence of fruit size on the number of fruits formed per plant, the correlation coefficient was calculated (Figure 4). The value of the coefficient (r^2 = 0/004) did not show an independence between the two parameters neither positive nor negative, which indicates that fructification is determined by the genetically characteristics and applied culture technology.

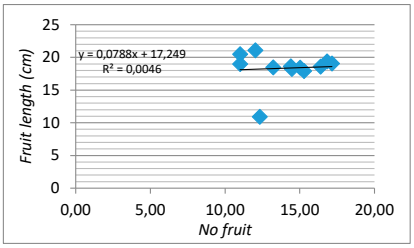

Figure 4. Correlation between fruit size and number of fruits per plant

Harvesting zucchinis for consumption, even at a larger size, did not determine a decrease in the capacity to form new fruit, the correlation between these two parameters showed a weak positive dependency, with a coefficient value of r^2 = 0.36 (Figure 5).

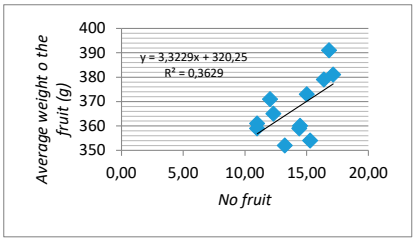

Figure 5. Correlation between fruit weight and number of fruits per plant

Table 5a. Fertilizer influence on the production capacity for several zucchini hybrids (kg/pl)

Variety/ Fertilizer	R1	R2	R3	Average (kg/pl)	Difference %	The meaning
V1	7.00	5.94	6.77	6.57	126.47	***
V2	6.89	6.28	6.64	6.60	127.11	****
V3	7.10	5.62	5.86	6.19	119.22	**
V4	5.65	5.39	5.22	5.36	99.84	N
V5	5.26	3.89	4.52	4.56	87.71	o
V6	4.78	3.93	4.83	4.51	86.88	o
V7	4.28	3.83	3.82	3.98	76.55	ooo
V8	3.93	3.93	3.97	3.94	75.91	ooo
V9	5.16	5.19	5.83	5.39	103.82	N
V10	6.11	5.13	5.12	5.45	104.97	N
V11	5.53	4.99	4.78	5.10	98.17	N
V12	4.95	4.68	4.92	4.85	93.36	N
Average	5.55	4.90	5.19	5.37	100	Mt
DL 5%				1.72	12.16	
DL 1%				2.35	16.59	
DL 0.1%				3.16	22.31	

Table 5b. Fertilizer influence on the production capacity for several zucchini hybrids (kg m^{-1})

Variety/ Fertilizer	R1	R2	R3	Average (kg m^{-1})	Difference %	The meaning
V1	8.61	7.30	8.32	8.08	125.12	***
V2	8.47	7.72	8.16	8.12	125.74	***
V3	8.73	6.91	7.20	7.61	117.00	**
V4	6.94	6.62	6.42	6.66	94.00	N
V5	6.46	4.78	5.52	5.59	103.17	o
V6	5.87	4.83	5.94	5.55	86.54	o
V7	5.26	4.71	4.69	4.89	85.92	ooo
V8	4.83	4.83	4.88	4.85	75.70	ooo
V9	6.34	6.38	7.17	6.63	102.71	N
V10	7.51	6.30	6.29	6.70	103.79	N
V11	6.80	6.13	5.87	6.27	97.08	N
V12	6.08	5.75	6.05	6.53	101.21	N
Average	6.83	6.46	6.29	6.46	100	Mt
LSD 5%				0.72	11.15	
LSD 1%				0.99	15.33	
LSD 0.1%				1.33	20.60	

CONCLUSIONS

The present research showed that the genotype has a great influence and manifests specifically for all characteristics related to productivity: number of flowers, number of fruits, average fruit weight and production. The used fertilizers influenced the production capacity for all hybrids, except for the fertilizer Bombardier in case of the hybrid Ismalia F1, compared to which the results were higher for the control variant. The combination between hybrid and fertilizer is important and influences the obtained production. Fruit size was more a characteristic of the hybrid and less an influence of the fertilizer.

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