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RESEARCH ON THE QUALITY OF TOMATOES GROWN WITH VERMICOMPOST FERTILIZATION, SOLARIUM CULTIVATION

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Abstract
The nutrition regime for tomatoes is very complex and must consider the specific consumption that differs depending on the variety, vegetation phase, cropping system and others. The super-intensive character of the protected and forced vegetable crops determines a special specificity regarding the requirements towards the soil and its state of supply with nutrients. Vermicompost, also known under the name of earthworm humus, is an organic fertilizer that is produced utilizing the assistance of earthworms. Vermicompost can completely replace any other chemical or even organic fertilizer, as it contains, up to 100 times more nutrients and microorganisms that are beneficial for plants. The researches have been carried out since 2020 in Matca, Galati County and aimed at producing vermicompost and testing it on different crops in protected areas. Tomatoes - Yigido F1 is a hybrid of semi-early tomatoes, with undetermined growth, intended for cultivation in protected areas. There were made determinations on tomatoes culture regarding the influence of vermicompost on the development of plants and quality of tomatoes.

Keywords: earthworm, organic fertilizer, tomatoes, vermicompost.

1.INTRODUCTION

The nutrition regime for tomatoes is very complex and must take into account the specific consumption that differs depending on the variety, vegetation phase, cropping system and others.
The super-intensive character of the protected and forced vegetable crops determines a special specificity regarding the requirements towards the soil and its state of supply with nutrients. The problems regarding the state of soil supply with nutrients are greater than those for field crops. A number of factors such as pH, water regime, monoculture system, relative humidity, etc. it effectively acts on the availability of water-soluble chemicals, easily accessible to plants.
Organic matter content is a basic characteristic of soils in greenhouses and solariums. The value of the organic matter content should be high and the humus content should be around 5%.
Other parameters considered from an agrochemical point of view are: pH, soluble salt content, macroelement content. The requirements of tomato plants for agrochemical parameters are: pH_{H2O}5.5-7.0, EC salt content mmho / cm 4-8, Equilibrium ratio N: P2O5: K2O is 1: 0.07: 1. (Davidescu V., Davidescu D., 1999)
Both organic and chemical fertilizers are used to supplement the nutrient requirements in the cultivation of greenhouses and solariums in order to achieve the optimal level required by the crop.

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The nutritional importance of vegetable products can be assessed by their contribution to the need for nutritional principles in the population food. As a percentage, vegetables provide about 10 % of the total human energy needs, 15 % of protein, 20 % of vitamins PP, B1 and Fe, 25 % of Mg, 35 % of vitamin B6, 50 % of vitamin A and 90 % of vitamin C. About a third of the body of knowledge on the use of fruits and vegetables focuses on detailed aspects of their nutritional value. (Kader A.A. et. al., 1978); (Gherghi A., 1994); (Gherghi A., 1999); (Seward II A. R., 2003)
The chemical composition of the fruit is greatly influenced by variety and external factors and the accumulation of dry matter and ascorbic acid (vitamin C) in September and August are strongly influenced by temperature and solar radiation. (Ciofu R. et. al., 1992); (Chira A**.,** 2001)
This new generation organic fertilizer, known as earthworm compost, earthworm humus or vermicompost, is produced as a result of the decomposition processes carried out with the aid of earthworms. The resulted product is a mineral concentrated organic fertilizer that is considered to be the best fertilizer, as it has high concentration content of valuable bacteria and microorganisms, which are, in their majority, biologically active stimulants for plants. This earthworm humus can also contain amino acids, vitamins, humic and fulvic acid, which are all produced and added in the course of the digestive processes of earthworms. This humus produced by earthworms can successfully replace any other organic or chemical fertilizing substance, as it incorporates 100 times more microorganisms and nutrients that are extremely helpful for plants (Bogdanov P., 1996); (Beetz A., 1999); (Atiyeh R.M. et. al., 2002).

2. MATERIAL AND METHODS

Researches have been carried out since 2020 in Matca, Galati County and aimed at producing vermicompost and testing it on different crops in protected areas. The vermicompost was produced in our own household for a period of 9 months from manure and the addition of earthworms. At the end of the 9 months, the resulting material was sifted to remove the earthworms, crushed for loosening and then the liquid vermicompost extract was made. Prior to use, specific analyzes have been performed which are shown in Table 1.

Table 1. The chemical characteristics of Vermicompost

No.	Chemical characteristic	Value	Method of analyse
1	pH-ul 1:2,5 in H_2O	6.7	Potentiometric method
2	Humus %	6.35	Warkley-Black Method
3	Soluble salts %	0.303	Conductometric Method
4	Nitric compounds N-N03 ppm	1662.5	Colorimetric method with 2,4 fenol-disulfonic acid
5	Amoniacal compounds N-NH4 ppm	19.125	Colorimetric method with Nessler reactive
5	Asimilabile phosphorus P ppm	19.05	Colorimetric method with Egner-Riehm-Domingo reactive
7	Asimilable potassium K ppm	20	Plamphotometric Method
8	Calcium Ca ppm	22	Titrimetric Method
9	Magnezium Mg ppm	20	Titrimetric Method

Compost analysis methods are I.C.P.A. Romania. (Borlan Z., Hera Cr., 1973); (Borlan Z., Rauta C., 1981); (CAC/RCP 1, 1969, Rév.4-2003)

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After performing the analysis, the application doses were established in order to test the obtained vermicompost, variants presented in table 2.

Table 2. Experimental variants scheme

No.	Variant	Components
1	V1	Control
2	V2	Control trateted with Cropmax
3	V3	Vermicompost solid, 2 t/ha applyed before transplantation
4	V4	Vermicompost solid, 3 t/ha applyed before transplantation
5	V5	Vermicompost liquid applyed foliar in 3 l/ha dose applyed at 14 days
6	V6	Vermicompost liquid applyed foliar in 5 l/ha dose applyed at 14 days
7	V7	Vermicompost solid, 3 t/ha applyed before transplantation and vermicompost liquid applyed foliar 5 l/ha dose at 14 days

Prior to the application of vermicompost, an agrochemical analysis of the soils from the experimental variants was performed. The applied methods are accredited in Romania and performed by I.C.P.A.respectively: pH1:2,5 in H_2O, potentiometric method, Humus % Warkley-Black Method, Soluble salts % Conductometric Method, N- nitric and ammoniacal Colorimetric method, Asimilabile phosphorus P ppm- Colorimetric method, Kppm - Plamphotometric Method. (Borlan Z., Hera Cr., 1973); (Borlan Z., Rauta C., 1981)

Table 3. The soils analyses from experimental variants

No.	Variant	pH	Humus	Nt	P_{AL}	K_{AL}	Ca_{AL}	Zn	Cu	Fe	Mn	Mg
			%	*%*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*
1	V1	7.52	2.13	0.227	890	256	5130	19.7	7.8	14.3	51.4	28.5
2	V2	7.77	1.78	0.114	906	391	5022	19.3	9.3	10.9	40.1	25.2
3	V3	7.65	2.07	0.106	836	246	4656	19	9.4	14.9	45.6	26.3
4	V4	7.74	2.01	0.115	820	367	4370	21	9.6	17.4	44.2	30.8
5	V5	7.47	1.95	0.113	960	373	5674	23.5	9.4	15.8	54.1	32.1
6	V6	7.29	2.01	0.117	922	450	5674	21.7	9.4	13.4	51.2	51.4
7	V7	7.9	1.78	0.11	1202	357	4696	23.1	9.7	14.4	47.3	30.3

Tomatoes - Yigido F1 - a hybrid of semi-early tomatoes, with undetermined growth, intended for cultivation in protected areas, vigorous plants with very high production potential were used for testing. (Universal Group, 2021)

Tomato cultivation technology

The tomatoes were sown on 01.06.2020 in alveolar trays of 288 cells. On 17.06.2020, the seedlings were transplanted into pots with a diameter of 9 cm, where they remained until planting. The planting was done on 15.07.2020, in equidistant rows with a distance of 90 cm between them and 35 cm between plants in a row. The tomato maintenance was made at 5 inflorescences.

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Ecologically accredited water-soluble fertilizers have been applied by drip at a dose of 300 kg/ha, throughout the vegetation period.
The data corresponding to the tomato crop were collected from a number of 10 plants for each variant and the crop had a density of 30,000 plants/ha. Regarding the plants, during the vegetation period, the height of 10 previously significant plants was measured in each variant as well as the distance between the inflorescences. Tomatoes were harvested on plants in 3 repetitions and on variants.
Tomatoes were analyzed for their diameter and height as well as their corresponding weight. During the vegetation in order to determine the quality of tomatoes, agrochemical and biochemical analyzes were performed. Agrochemical analyzes were performed according to the INCDAP Bucharest methodology and included the determination of N-NO3- by extraction in CH3COOH 2%, 1:20 and colorimetric dosing with AFDS (Griess Method - STAS 3048-77), P-PO43- extraction in CH3COOH 2 %, 1:20 and colorimetric dosing with Duval reagent and K + extraction in CH3COOH 2%, 1:20 and flamphotometric dosing (SR ISO 3696-2002). Biochemical analyses used were acidity extraction in water 1:10 and for dosing titrimetric method, soluble glaucids Abbe method, vitamin C titrimetric method.

3. RESULTS AND DISCUSSION

The morphological analysis of the tomato plants showed an increase in height between 174 cm and 183 cm. Analyzing the experimental variants, it is observed that V3 (applied solid vermicompost, 2 t/ha before planting) had the highest height 183 cm followed by V5 (applied liquid leaf vermicompost in a dose of 3 l/ha at 14 days) with 182 cm and V4 (applied solid vermicompost, 3 t/ha before planting) with 181 cm. It can be said that vermicompost fertilization has helped the plants to develop normally by providing the necessary nutrients.

Table 4. Height of tomato plants and distance between inflorescences and average number of fruits per plant (average of 10 plants / variant)

No.	Variant	Total height, cm	Distance between inflorescences, cm					Average number of fruits per plant.
			Infl.1	Infl.2	Infl.3	Infl.4	Infl.5	
1	V1	174	60	21	28	26	22	22.03
2	V2	180	64	25	30	28	23	23.40
3	V3	183	65	26	31	30	23	25.23
4	V4	181	62	24	27	27	22	24.73
5	V5	182	63	25	28	28	21	23.87
6	V6	174	65	26	29	30	23	23.70
7	V7	180	62	24	30	28	22	27.40

If we examine the flowering, it is observed that the greatest distances were obtained at V3 (applied solid vermicompost, 2 t / ha before planting) at all flowering and V6 (applied vermicompost foliar liquid at a dose of 5 l / ha at 14 days) at 50% of them.
Regarding the number of fruits harvested, average values per variant showed that the best results were obtained in V3 (applied solid vermicompost, 2 t / ha before planting) with 25, 23 tomatoes and in V7 (applied vermicompost solid, 3 t / ha before planting and vermicompost foliar liquid at a dose of 5 l / ha at 14 days) with 27.40 tomatoes.

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Table 5. Diameter, height and average weight of tomatoes

No.	Variant	Medium diameter of tomatoes cm	Medium height of tomatoes cm	Medium weight of tomatoes g
1	V1	6.91	5.32	142.39
2	V2	6.96	5.45	149.8
3	V3	6.88	5.54	145.6
4	V4	6.92	5.35	145.63
5	V5	6.91	5.36	146.74
6	V6	6.96	5.42	145.56

From the analysis of the harvested tomatoes (Table 5) we notice that in terms of their average diameter the results were close between 6.88 cm and 6.96 cm because it is the uniformity of the hybrid and not the influence of fertilization with vermicompost. The same can be said by examining the height of the tomatoes, which oscillate in small limits of 5.32 cm and 5.54 cm, these being influenced by the quality of the cultivated hybrid. The third characteristic, respectively the weight of the tomatoes, the variations are small: 142.39g and 149.80g between the experimental variants. Thus, it can be concluded that vermicompost fertilization does not influence the physiology of tomatoes, they are within the limits set by the producer.

Table 6. Agrochemical characteristics of tomatoes

Variant	Components	$N\text{-}NO_3^-$ ppm	$P\text{-}PO_4^{3-}$ ppm	K^+ ppm
V1	Control	154	266.5	1915
V2	Control trateted with Cropmax	162	335.94	1876
V3	Vermicompost solid, 2 t/ha applyed before transplantation	213	366.5	1765
V4	Vermicompost solid, 3 t/ha applyed before transplantation	202	244.32	1760
V5	Vermicompost liquid applyed foliar in 3 l/ha dose at 14 days	157	381.76	1780
V6	Vermicompost liquid applyed foliar in 5 l/ha dose at 14 days	220	282.5	1870
V7	Vermicompost solid, 3 t/ha applyed before transplantation and vermicompost liquid applyed foliar 5 l/ha dose at 14 days	178	267.2	1760

The accumulation of non-metabolized nutrients in tomatoes is a major indicator of their quality. A nitrate content too high can lead to the downgrading of tomatoes for consumption. If we examine the nitrate content accumulated in tomatoes and comparing them with the maximum allowed limit of 150ppm specified by Order no. 293/2001 (Order no. 293/2001); (JIFSAN, 2002) we can say that the highest accumulation of this compound was achieved in variants V3 (applied solid vermicompost, 2 t/ha before planting) with 213ppmN-NO3-, V4 (applied solid vermicompost, 3

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t/ha before planting) with 202ppmN-NO3- and V6 (applied liquid leaf liquid vermicompost at a dose of 5 l/ha applyed at 14 days) with 220 ppmN-NO3-. The other variants have a good nitrate content which does not affect the quality for consumption.
If we examine nitrates through the application of vermicompost we can say that with the application of 2 t/ha solid vermicompost applied before planting at V3, even 3 t/ha applied before planting at V4 and then even 5 l/ha liquid applied at 14 days nitrogen absorption was raised above the allowable limit.
Phosphates ranged from 244.32 ppm to 381.76 ppm values considered to be good values for tomatoes according to the literature, the limits being between 200 ppm and 400 ppmP-PO43-. In the case of potassium, the amount accumulated is also good, ensuring firmness and the possibility of transporting tomatoes.
Other characteristics examined in tomatoes were the biochemical ones, namely acidity (%), soluble carbohydrates (%) and vitamin C (mg / 100g fresh tomatoes).

Table 7. Biochemical characteristics of tomatoes

Variant	Components	Acidity %	Soluble glucid %	Vitamin C mg/100g fresh tomatoes
V1	Control	0.41	2.67	18.34
V2	Control trateted with Cropmax	0.42	2.23	18.65
V3	Vermicompost solid, 2 t/ha applyed before transplantation	0.43	2.20	18.67
V4	Vermicompost solid, 3 t/ha applyed before transplantation	0.45	2.56	17.34
V5	Vermicompost liquid applyed foliar in 3 l/ha dose at 14 days	0.44	2.21	17.86
V6	Vermicompost liquid applyed foliar in 5 l/ha dose at 14 days	0.43	2.23	17.34
V7	Vermicompost solid, 3 t/ha applyed before transplantation and vermicompost liquid applyed foliar 5 l/ha dose at 14 days	0.40	2.35	18.67

Acidity, % ranged from 0.40% to 0.45%, close values that were not affected by vermicompost fertilization. Soluble carbohydrates, % varied between 2.20% and 2.67% also close values that were not negatively influenced by fertilization. Vitamin C is in high amounts ranging between 17.34 mg / 100g p.p at V4 (applied solid vermicompost, 3 t / ha before planting) and 18.67 mg / 100g p.p at V3 and V7.
From the examination of the biochemical results it can be said that the vermicompost did not have a negative influence on the tomato crop.

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4. CONCLUSIONS

• Morphological analysis of tomato plants showed an increase in height between 174 cm and 183 cm. It can be said that vermicompost fertilization has helped the plants to develop normally by providing the necessary nutrients.
• At flowering the greatest distances were obtained at V3 (applied solid vermicompost, 2 t/ha before planting) at all flowering and V6 (applied liquid leaf vermicompost at a dose of 5 l/ha at 14 days) at 50% of they.
• In tomatoes, their height, diameter and weight are within the limits set by the producer, so fertilization with vermicompost does not influence the physiology of tomatoes.
• The accumulation of non-metabolized nutrients in tomatoes is a major indicator of their quality. The highest accumulation of this compound was achieved in variants V3 (applied solid vermicompost, 2 t/ha before planting) with 213 ppm N-NO3-, V4 (applied solid vermicompost, 3 t/ha before planting) with 202 ppm N-NO3- and V6 (applied leaf liquid vermicompost at a dose of 5 l/ha at 14 days) with 220 ppm N-NO3-. The other variants have a good nitrate content which does not affect the quality for consumption.
• Phosphates ranged between 244.32 ppm and 381.76 ppm values considered to be good values for tomatoes according to the literature, the limits being between 200 ppm and 400 ppm P-PO43-.
• The accumulated amount of potassium is also good, ensuring firmness and the possibility of transporting tomatoes.
• From the examination of the biochemical results it can be said that the vermicompost did not have a negative influence on the tomato crop, the content of acidity, soluble carbohydrates and vitamin C being high.

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