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MODERN BIOTECHNOLOGIES - THE USE OF VERMICOMPOST IN HORTICULTURE

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Abstract

Vermicompost or earthworm humus is a new generation, organic fertilizer, produced with the help of earthworms. It is a concentrated, mineral-organic fertilizer. Earthworm humus obtained from vermicompost is the best fertilizer, as it contains high concentrations of beneficial bacteria and other microorganisms, many biologically-active stimulants for plants, vitamins, amino acids, fulvic and humic acids, added during the digestive process of the earthworm. Vermicompost is one of the fertilizers accepted in the EU for organic farming. The research has been carried out since 2020 in Matca commune, Galați County and focused on the production of vermicompost and its testing on different crops. The experimental variants scheme contains 7 variants with 3 repetitions: Control, Control treated with Cropmax, solid vermicompost - 2 t/ha applied before transplantation, solid vermicompost - 3 t/ha applied before transplantation, liquid vermicompost applied at foliar level in 3 l/ha dose at 14 days, liquid vermicompost applied at foliar level in 5 l/ha dose at 14 days, solid vermicompost - 3 t/ha applied before transplantation and liquid vermicompost applied at foliar level in a 5 l/ha dose at 14 days. For this experiment, the test plant was tomato. From the estimated results, at a density of 30,000 plants/hectare, it was shown that the highest quantity of tomatoes per hectare was obtained in variant V7 (118.33 t/ha; 116.94 t/ha; 123 t/ha), followed, in second, place by variant V3 (112.71 t/ha; 112.5 t/ha; 113.61 t/ha).

Key words*: vermicompost, eartworms, organic fertilizer, soil, tomatoes.*

INTRODUCTION

Vermicompost or earthworm humus is a new generation, organic fertilizer, produced with the help of earthworms. It is a concentrated, mineral-organic fertilizer. Earthworm humus obtained from vermicompost is the best fertilizer, as it contains high concentrations of beneficial bacteria and other microorganisms, many biologically-active stimulants for plants, vitamins, amino acids, fulvic and humic acids, added during the digestive process of earthworm.

Earthworm humus completely replaces any chemical or organic fertilizer and contains 100 times more nutrients and microorganisms beneficial to plants (Atiyeh et al., 2002; Beetz, 1999; Bogdanov, 1996).

Earthworms turn any organic matter into the richest organic fertilizer known to man - the earthworm humus. This humus has a large proportion of all the 16 elements that plants need. Vermicompost considerably improves the structure of the soil, decreasing its density, ncreasing its aeration and nitrogen absorption from the atmosphere, thus helping the plants to grow strong and healthy (Bogdanov, 2004; Canellas et al., 2002; Card et al., 2004).

Vermicompost does not contain or provide living conditions for *E. coli, Salmonella* or other pests. Moreover, it is one of the fertilizers accepted in the EU for organic farming, according to Regulation (EEC) No. 2092/91 and maintained according to art. 16, para. (3), lit. c. of Regulation (EC) No. 834/2007, Annex 1.

Liquid vermicompost is a 100% organic fertilizer extracted from solid vermicompost.

Liquid vermicompost is an active, purely organic humic fertilizer that stimulates plant growth and health, becoming more resistant to sudden changes in temperature or disease (Eastman, 1999; Eastman et al., 2000; Frederickson et al., 1997).

All nutrients available in the extract will be absorbed at cellular level by plants, which leads to the activation of physiological and biochemical processes allowing maximum assimilation of substances that are beneficial to plants (Georg, 2004).

MATERIALS AND METHODS

The research has been carried out since 2020 in Matca commune, Galați County and focused on the production of vermicompost and its testing on different crops.

Preparation of vermicompost

Earthworms live in nests of about 100,000 specimens. They are hermaphroditic, doubling their numbers every 100 days. A nest has an area of 2 sq. m and a thickness of 25 cm.

After the construction of the nest, the substrate for the earthworm bed is prepared, which has a thickness of 25 cm and consists of cattle manure, kept soaked for 4-5 months, and wheat straw for loosening.

After the bed was ready, the earthworms were introduced into the nest. After introduction, a layer of manure of about 10 cm was placed over the earthworms.

The first feeding took place one month after the earthworms were introduced into the nest, after which they were fed with 100 kilograms of manure and straw every 2 weeks.

They had to be watered almost daily especially during the summer. The aeration was done once a month, by loosening the first layer of 10 cm with a fork.

After 6 months, the earthworms were moved to another nest, but the vermicompost was left for another 3 months, after which it was removed, sieved for crushing and loosening, and then the liquid vermicompost extract was made (Table 1).

Before applying the scheme for the experimental variants, an agrochemical and a physical analysis of the soils from the experimental variants was performed (Table 3). The applied methods are methods accredited in Romania.

Table 1. The chemical characteristics of vermicompost

No.	Chemical characteristic	Value	Method of analysis
1	pH 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-NO_3, ppm	1662.5	Colorimetric method with 2,4 fenol-disulfonic acid
5	Ammoniacal compounds N-NH_4, ppm	19.125	Colorimetric method with Nessler reactive
5	Assimilable phosphorus P, ppm	19.05	Colorimetric method with Egner-Riehm-Domingo reactive
7	Assimilable potassium K, ppm	20	Plamphotometric Method
8	Calcium Ca, ppm	22	Titrimetric Method
9	Magnesium Mg, ppm	20	Titrimetric Method
Compost analysis methods used in Romania			

After performing the analysis, the application doses were established in order to test the obtained vermicompost (Table 2).

Table 2. Experimental variants scheme

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

Table 3. Soils analyses from the experimental variants

No.	Specification	Agrochemical analyses											
		pH	Humus	Nt	P_{AL}	P_{AL}[1]	K_{AL}	Ca_{AL}	Zn	Cu	Fe	Mn	Mg
		pH units	%	%	mg/kg								
1.	V1	7.52	2.13	0.2227	890	630	256	5130	19.7	7.8	14.3	51.4	28.5
2.	V2	7.77	1.78	0.114	906	553	391	5022	19.3	9.3	10.9	40.1	25.2
3.	V3	7.65	2.07	0.106	836	551	246	4696	19	9.4	14.9	45.6	26.3
4.	V4	7.74	2.01	0.115	820	511	367	4370	21	9.6	17.4	44.2	30.8
5.	V5	7.47	1.95	0.113	960	697	373	5674	23.5	9.4	15.8	54.1	32.1
6.	V6	7.29	2.01	0.117	922	724	450	5674	21.7	9.4	13.4	51.2	51.4
7.	V7	7.9	1.78	0.11	1202	667	357	4696	23.1	9.7	14.4	47.3	30.3

[1] - values corrected according to pH values

The plants used for testing were tomatoes - Yigido F1 - that is a hybrid of semi-early tomatoes, with undetermined growth, intended for cultivation in protected areas, with vigorous plants and very high production potential (Seminis presentation catalogue - Universal Group).

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. 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 culture was collected from a number of 10 plants for each variant and the culture had a density of 30,000 plants/ha. The tomatoes were harvested from plants, in 3 repetitions and in accordance with the variants.

RESULTS AND DISCUSSIONS

Before starting the experiment, some physical properties of the soils were checked: bulk density (g/cm^3), total porosity (%), degree of soil compaction (%), fertilized in the previous year with vermicompost, at a harvesting depth of 0-20 cm (Table 4).

Table 4. Physical characteristics of soils used in the tomato cultivation

Variant	Bulk density, BD g/cm^3	Total porosity, TP (%)	Degree of soil compaction, DC (%)
V1	1.3136	50.985	-7.461
V2	1.2833	52.116	-9.844
V3	1.244	53.582	-12.935
V3	1.2783	52.302	-10.238
V4	1.3354	50.172	-5.747
V4	1.3298	50.381	-6,187
V5	1.42	47.015	0.906
V5	1.3561	49.399	-4.119
V6	1.3079	51.198	-7.910
V6	1.3364	50.134	-5.668
V7	1.4173	47.116	0.694
V7	1.3829	48.399	-2.011

Below are the formulas according to which they were calculated: bulk density, total porosity and soil compaction degree.

PMN = 45 + 0.163 * A = 47.445
A = 15
Ad 0-20 cm = 100
YES = dry soil - cylinder country/100
TP = (1- BD / 2.68) * 100
DC = (PMN-TP / PMN) * 100

The results showed that in the experimental variants:

- At V1 - The bulk density is very low (moderately loose soil) with a value of 1.3136 g/cm^3, the total porosity is very high with a value of 50.985% and the degree of compaction /settlement is low (slightly loose soil) with a value of -7.461%.
- At V2 - The bulk density is very low (moderately loose soil) with a value of 1.2833 g/cm^3, the total porosity is very high with a value of 52.116% and the degree of compaction is low (slightly loose soil) with a value of -9.844%.
- In V3 - For both samples, the bulk density is very low (moderately loose soil) with a value of 1.244 g/cm^3 and 1.2783 g/cm^3, in both samples the total porosity is very high with a value of 53.582% and 52.302%. In the first sample, the degree of settlement is very low (moderately loose soil) with a value of -12.935%, and in the other sample, the degree of compaction /settlement is low (slightly loose soil) with a value of -10.238%.
- In V4 - For both samples the bulk density is very low (moderately loose soil) with a value of 1.3354 g/cm^3 and 1.3298 g/cm^3, in both samples the total porosity is high with a value of 50.172% and 50.381%. In both samples the degree of compaction is low (slightly loose soil) with the value of -5.747% and -6.187%.
- In V5 - For both samples the bulk density is low (slightly loose soil) with a value of 1.42 g/cm^3 and 1.3561 g/cm^3, in both samples the total porosity is high, with a value of 47.015% and 49.399%. In both samples the degree of compaction is low (slightly loose soil) with a value of 0.906% and -4.119%.
- In V6 - For both samples the bulk density is very low (moderately loose soil) with a value of 1.3079 g/cm^3 and 1.3364 g/cm^3. In the first test, the total porosity is very high with a value of 51.198%, and in the other sample, the total porosity is high with the value of 50.134%. In both samples the degree of compaction is low (slightly loose soil) with the value of -7.910% and -5.688%.

• In V7 - For both samples the bulk density is low (slightly loose soil) with a value of 1.4173 g/cm^3 and 1.3829 g/cm^3, in both samples the total porosity is high with a value of 47.116% and 48.399%. In both samples the degree of compaction is low (slightly loose soil) with a value of 0.694% and -2.011%.

During the growth season, weekly harvests were conducted. Harvests were performed on previously significant plants, on replicates and on experimental variants (Table 5).

Table 5. Results regarding the number of fruits and yields obtained

Variant	Average number of fruits/plant	Average number of fruits, thousands/ha	Average yield, kg/plant	Average yield, t/ha
V1	22.03	661	3.10	93.01
V2	23.40	702	3.30	99.05
V3	25.23	757	3.76	112.94
V4	24.73	742	3.65	109.47
V5	23.87	716	3.48	104.49
V6	23.70	711	3.46	107.57
V7	27.40	822	3.98	119.42

In Figure 1 the yields obtained for the tomato cultivation are presented, in fruits/plant, for all 7 variants and 3 repetitions.

Figure 1. Results obtained for tomato cultivation fruits/plant

The highest number of fruits was obtained in variant V7 (27.2 pcs; 26.8 pcs; 28.2 pcs), followed in second place by variant V3 (25.3 pcs; 25 pcs; 25.4 pcs).

In Figure 2 the productions obtained for the tomato crop are presented, in kilograms/plant, for all 7 variants and 3 repetitions.

From Figure 2 it can be seen that the highest amount was obtained in variant V7 (3.944 kg; 3.898 kg; 4.1 kg), followed in second place by variant V3 (3.757 kg; 3.75 kg; 3.777 kg).

The estimated yields for tomato crop, in tonnes/hectare, at a density of 30,000 plants hectare, for all 7 variants and 3 repetitions are shown in Figure 3.

From the estimated results at a density of 30,000 plants/hectare, it is shown that the highest quantity of tomatoes per hectare was obtained in variant V7 (118.33 t; 116.94 t; 123 t), followed, in second place, by variant V3 (112.71 t; 112.5 t; 113.61 t).

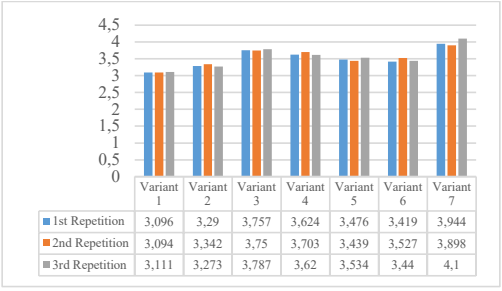

Figure 2. Results obtained for tomato cultivation kilograms/plant

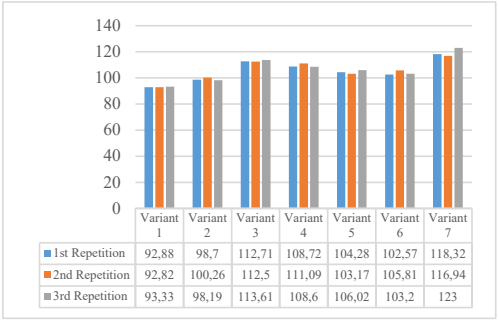

Figure 3. Results obtained for tomato cultivation tons/hectare

After analysing the results obtained in tomatoes, it can be concluded that V7 (solid vermicompost, applied at 3 t/ha before planting and liquid vermicompost applied at foliar level, in a dose of 5 l/ha at 14 days), was the variant with the best results, followed by V3 (solid vermicompost applied at 2 t/ha before planting).

Statistical interpretation of experimental results

In order to highlight the best experimental variants, statistical interpretations were conducted for the number of fruits and the production obtained (Tables 6 and 7). The method used is the analysis of variance.

Table 6. Statistical interpretations for the number of fruits obtained

Variant	Average number of fruits/plant	Differences to Ct 1, fruits/plant	%	Signifi-cance	Differences to Ct 2, fruits/plant	%	Signifi-cance
V1-MCt 1	22.03	-	100.00	-	-	-	-
V2- Ct 2	23.40	+1.37	106.22	*	-	100.00	-
V 3	25.23	+3.20	114.52	**	+1.83	107.82	*
V 4	24.73	+2.70	112.25	**	+1.33	105.68	*
V 5	23.87	+1.81	108.35	*	+0.47	102.00	o
V 6	23.70	+1.67	107.58	*	+0.30	101.28	o
V 7	27.40	+5.37	124.37	***	+4.00	117.09	***
		Diff. to M Ct 1 *LSD 5% = 1.29 fruits/plant* *LSD 1% = 2.37 fruits/plant* *LSD 0.1% = 4.05 fruits/plant*			Diff. to M Ct 2 *LSD 5% = 1.32 fruits/plant* *LSD 1% = 2.67 fruits/plant* *LSD 0.1% = 3.92 fruits/plant*		

Table 7. Statistical interpretation for yield obtained

Variant	Average yield t/ha	Differences between Ct 1, t/ha	%	Signifi-cance	Differences between Ct 2, t/ha	%	Signifi-cance
V1- Ct1	93.01	-	100.00	-	-	-	-
V2- Ct2	99.05	+6.04	106.49	*	-	100.00	-
V 3	112.94	+19.93	121.42	***	+13.89	114.02	**
V 4	109.47	+11.46	117.69	**	+10.42	110.52	*
V 5	104.49	+11.48	112.34	**	+5.44	105.49	ns
V 6	107.57	+14.56	115.65	***	+8.52	108.60	*
V 7	119.42	+26.41	128.39	***	+20.37	120.56	***
		Diff. to Ct 1 LSD 5% = 5.23 t/ha LSD 1% = 8.75 t/ha LSD 0.1% = 12.67 t/ha			Diff. to Ct 2 LSD 5% = 7.56 t/ha LSD 1% = 10.45 t/ha LSD 0.1% = 14.89 t/ha		

The statistical interpretation for the number of fruits obtained shows that the average/variant values ranged between 22.03 and 27.40 fruits/plant. Comparing the untreated control (V1) it is observed that all the variants treated with vermicompost obtained good and very good results.

It is shown that the results obtained for variants V3 (solid vermicompost applied in 2 t/ha before planting) and V4 (solid vermicompost applied in 3 t/ha before planting) offer significant results.

More than that, in variant V7 (solid vermicompost, applied in 3 t/ha before planting and liquid vermicompost applied at foliar level in a dose of 5 l/ha at 14 days) a very significant increase is shown, as compared to all other variants.

If we consider variant V2, which is control treated with Cropmax, the results for the number of fruits are significant at V3 (solid vermicompost applied in 2 t/ha before planting) and V4 (solid vermicompost applied in 3 t/ha before planting) and more significant at V7 (solid vermicompost applied in 3 t/ha before planting and liquid vermicompost applied at foliar level at a dose of 5 l/ha at 14 days).

Therefore, it can be said that variants V3 (solid vermicompost applied in 2 t/ha before planting), V4 (solid vermicompost applied in 3 t/ha before planting) and V7 (solid vermicompost applied in 3 t/ha before planting and liquid vermicompost applied at foliar level in a dose of 5 l/ha at 14 days) are the best for growing tomatoes.

In the case of production, measured in tonnes/ha, if we take into account the untreated control (V1) we notice that all productions are good, with some being better, as following: variants V4 and V5 have significant distinct results and V3, V6, V7 have greater statistically assured results.

If we compare the production with the control variant fertilized with Cropmax (V2), the results are significant in V4 and V6, distinctly better in V3 and the best in V7.

Therefore, it can be said that vermicompost fertilization was superior to Cropmax fertilization.

CONCLUSIONS

Based on the research carried out with solid and liquid vermicompost, applied in different doses and methods of application to tomato crops, the following conclusions were drawn:

From the results obtained in tomatoes - for Repetition 1 it can be concluded that V7 was the best option, obtaining 27.2 fruits/plant and 3.944 kilograms/plant. In second place was V3, with 25.3 fruits/plant and 3.757 kilograms/plant.

From the results obtained in tomatoes - for Repetition 2 it can be concluded that V7 was the best option, obtaining 26.8 fruits/plant and 3.898 kilograms/plant. In second place was V3, with 25 fruits/plant and 3.75 kilograms/plant.

From the results obtained in tomatoes - for Repetition 3 it can be concluded that V7 was the best option, obtaining 28.2 fruits/plant and 4.1 kilograms/plant. In second place was also V3, with 25.4 fruits/plant and 3.787 kilograms/plant.

From the estimated results at a density of 30,000 plants/hectare, it is shown that the highest quantity of tomatoes per hectare was obtained in variant V7 (118.33 t/ha; 116.94 t/ha; 123 t/ha), followed in second place by variant V3 (112.71 t/ha; 112.5 t/ha; 113.61 t/ha).

The statistical interpretation of the number of fruits, as well as of the production showed that variants V3 (solid vermicompost applied in 2 t/ha before planting), V4 (solid vermicompost applied in 3 t/ha before planting) and V7 (solid vermicompost applied in 3 t/ha before planting and liquid vermicompost applied at foliar level in a dose of 5 l/ha at 14 days) are the best for growing tomatoes.

In conclusion, in order to obtain the highest possible production, of the best quality, the vermicompost should be applied both at root and foliar level.

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***Regulation (CEE) No. 2092/91.

***Regulation (CE) No. 834/2007, Annex 1.