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Proceeding Paper

The Effect of Effective Microorganisms on the Performance of Tomato Transplants †

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Abstract: The purpose of this investigation was to assess the influence of effective microorganisms on the growth and nutrient content of tomato transplants. There were two treatments: 1. with effective microorganism's (EM) treatment; 2. without effective microorganism's treatment–control. The height of tomato transplants was higher in control treatment compared to EM treatment. The stem diameter of tomato transplants was larger in EM treatment compared to control variant. The nutrient content of tomato leaves was very good. The contents of nitrates, N, P, K, Ca and Mg were higher in EM treatment compared to control treatment.

Keywords: effective microorganisms; height; nutrient content; stem diameter; tomato; transplants

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1. Introduction

Effective microorganisms (EM) technology was discovered and described in the 1970's [1]. In the beginning the microbes from nature (soil) were isolated, then mixed. A mixture including lactic acid bacteria, photosynthetic bacteria, and yeast. pH 3.5 should be kept in the solution [2].

The explanation, what benefit EM can bring is following: EM is added to the soil to make the soil healthy for the growth of plants. EM will start to act in soil as follows: suppresses plant pathogens and agents of disease, solubilizes minerals, conserves energy, maintains the microbial balance of the soil, increases photosynthetic efficiency, and fixes biological nitrogen [3].

Scientists have shown that EM enhanced seed germination and vigour in tomato [4]. EM increases the yield of tomatoes [5–7].

EM inoculation to both Bokashi and chicken manure increased photosynthesis and fruit yield of tomato plants [7]. EM applied together with a green manure (i.e., Gliricidia leaves) enhnced tomato yields; in the third year, the yields due to EM were comparable to those obtained with chemical fertilizer [5].

It is well known that the quality of tomato transplants influences positively the yield afterwards. The purpose of this investigation was to assess the influence of effective microorganisms on the growth and nutrient content of tomato transplants.

2. Materials and Methods

The experiments in the greenhouse were carried out at the Estonian Crop Research Institute in the spring time of 2014. In the experiment tomato variety Malle was grown. There were two treatments: 1. with effective microorganism's (EM) treatment; 2. without effective microorganism's treatment–control.

Tomato seeds were sown on 21 of April 2014 into individual pot (9 cm diameter), where the seedlings were grown until the end of transplant age. The substrate for conventionally cultivated seedlings and transplants was peat-based mixture Kekkilä

14-16-18, which contained also Magnesium (5%) and limestone (4 kg m[3]).

Seeds were soaked in activated EM 1:500 solution half hour before sowing (treatment 1). Seeds were soaked in water half hour before sowing (treatment 2). Tomato seeds were sown in limed, fertilized and activated EM 1:500 solution treated peat (treatment 1) and in limed, fertilized and water treated peat (treatment 2). From 28.04.14 until 26.05.14 with weekly intervals the EM treatment plants were watered with activated EM solution (1:500) and control treatment plants at the same time were watered with solution of Superex (12-5-27).

Each variant consisted of 4 plants. The experiment had four replicates. The experiment was repeated at the same time, i.e., the second experiment was carried through simultaneously. Therefore, the total amount of plants in trials was 64, while additional plants were grown in protection strip.

The greenhouse lighting at a plant level was approximately 12,000 lux from high pressure sodium lamps. The plants were additionally lighted in the period of 18 h (23.00–16.00). All plants were grown with a minimum day and night temperature of 20 °C and 18 °C, respectively.

On 28.05.14 the height and stem diameter were recorded.

The contents of Nitrates in raw shoots of tomato were measured. The contents of Nitrogen, Phosphorus, Potassium, Calcium and Magnesium were determined in dry matter of tomato shoots. Nitrate content was determined in plant extracts by Fiastar 5000. Nitrogen content was determined according to the Copper Catalyst Kjeldahl Method (984.13). Phosporus determination was carried through in Kjeldahl Digest by Fiastar 5000 (AN 5242; Stannous Chloride method, ISO/FDIS 15681). Potassium determination was by the Flame Photometric Method (956.01). Calcium determination was by the o-Cresolphthalein Complexone method (ISO 3696, in Kjeldahl Digest by Fiastar 5000). Magnesium determination was by Fiastar 5000 (ASTN90/92; Titan Yellow method).

Analyses of variance were carried out on the data obtained using programme Excel. Signs used: *** $p < 0.001$; ** $p = 0.001–0.01$; * $p = 0.01–0.05$; NS not significant, $p > 0.05$.

3. Results

The height of tomato transplants was significantly higher and plants looked elongated in control treatment compared to EM treatment (Table 1). In the experiment the plants in EM variant were 26% smaller than plants in control.

The stem diameter of tomato transplants was significantly larger in EM treatment in the experiments compared to control treatment (without EM; Table 1). In the experiment the plants in EM treatment had 20% larger stem diameter than plants in control.

Table 1. The height (cm) and stem diameter (cm) of tomato transplants according to treatments (EM, Control).

		EM	Control	*p*
Height (cm)	Av.	27.63	37.31	***
	St.dv.	1.50	1.85	
Stem diameter (cm)	Av.	0.98	0.78	***
	St.dv.	0.04	0.04	

The Nitrate content of tomato transplants was higher in the EM variant than in the control variant (Table 2). The EM variant had 75% more Nitrates in the tomato transplants than in the control transplants.

The Nitrogen content of tomato transplants was higher in the EM variant than in the control variant (Table 2). The EM variant had 28% more Nitrogen in the tomato transplants than in the control transplants.

The Phosphorus content of tomato transplants was higher in the EM variant than in the control variant (Table 2). The EM variant had 11% more Phosphorus in the tomato transplants than in the control transplants.

The Potassium content of tomato transplants was higher in the EM variant than in the control variant (Table 2). The EM variant had 26% more Potassium in the tomato transplants than in the control transplants.

The Calcium content of tomato transplants was higher in the EM variant than in the control variant (Table 2). The EM variant had 18% more Calcium in the tomato transplants than in the control transplants.

The Magnesium content of the tomato transplants was higher in the EM variant than in the control variant (Table 2). The EM variant had 12% more Magnesium in the tomato transplants than the control transplants.

Table 2. The content of Nitrates (mg kg-1) in raw tomato shoots and the contents of N, P, K, Ca and Mg (%) in tomato shoot dry matter according to treatments (EM, Control).

The Content of:		EM	Control	*p*
Nitrates mg kg^{-1}	Av.	1765.2	438.7	***
	St.dv.	244.5	189.6	
N%	Av.	4.09	2.95	**
	St.dv.	0.26	0.35	
P%	Av.	0.74	0.66	*
	St.dv.	0.03	0.05	
K%	Av.	5.02	3.71	**
	St.dv.	0.34	0.45	
Ca%	Av.	2.38	1.95	**
	St.dv.	0.12	0.13	
Mg%	Av.	0.68	0.60	*
	St.dv.	0.05	0.03	

4. Discussion

The height of tomato transplants was significantly higher and plants looked elongated in control treatment in both experiments compared to EM treatment. Oppositely Idris [8] found that EM treatment significantly increased the plant height, but it was considered plant height in fruiting phase, and we had in our research seen on transplants height. It can be that EM increases also the height of tomato plants by giving also more primary branches and number of fruits.

The stem diameter of tomato transplants increased in EM treatment. If stem diameter increases then the plant can get better the nutrients from soil. In addition EM improve mineral solubilization, and therefore tomato plants are more nutritious [3].

It is well known that the quality of tomato transplants influences positively the yield afterwards. Then it is important that transplant is of a good quality, which happened in present investigation. Similarly, Pavlovic et al. [9] found in their study on tomatoes. Low yield of tomatoes came from poor quality transplants [9]. Mohan [10] found that higher yield and lower glycoalkaloid content in Bokashi-treated (includes EM) tomatoes. EM inoculation increased photosynthesis and fruit yield of tomato plants [7]. For tomato Bokashi and EM1 when used singly, or in combination with each other, or in combination with inorganic fertilizer, significantly increased mean fruit weight over untreated control and increased the total marketable fruits harvested during the crop season [11]. EM applied with a green manure (i.e., Gliricidia leaves) increased tomato yields [5]. In accordance, Zanudin [6] found that EM increases the production of tomatoes. The lower number of tomato fruits associated with EM application resulted in improved average fruit weight of tomatoes grown in the greenhouse, possibly as a result of more assimilates being partitioned to the fewer fruits formed [12]. The application of EM appeared to promote early fruiting in tomato [13].

Increased nitrate uptake was found in present research. This could also influence plants negatively, because of: A high nitrate accumulation, which was present in our investigation, in plants might be undesirable, because it results in nitrite production, which is converted to nitric oxide by nitrate reductase and converted into the extremely toxic compound peroxynitrite under aerobic conditions, which is harmful to plant growth [14]. More seriously, the accumulation of peroxynitrite in humans may result in conditions such as chronic heart failure, diabetes, chronic inflammatory diseases, cancer, and neurodegenerative disorders [15].

In the present investigation, it was shown increased Phosphorus contents in plants. A high content of this element is needed especially for good root growth [16].

Data sowed in the present investigation that Potassium contents increased in plants. A high content of this element is very important in stomatal function and water relations of plants [16].

EM gives a good start to tomato transplants because it solubilises minerals, including Ca, from substrate. It is very good, because Ca influences followed processes: the incidence of diseases is less in the plant with higher Ca content, insects is less on the plant with higher Ca content, plants are with higher transportability and storability, when containing more calcium [17,18].

Magnesium contents in the present investigation increased in plants. A higher Mg content could have desirable; because of a higher Mg content reduces the incidence of insect pests and diseases [19].

5. Patents

There are not applied a patent, however those results are highly innovative and I consider it as one of my discoveries regarding following:

Effective microorganisms (EM) improve the quality of tomato transplants because they remain compact with greater stem diameter (Margit Olle discovery).

Supplementary Materials: Poster presentation might be available.

Author Contributions: M.O. contributed alone all parts of the scientific work. M.O. have read and agreed to the published version of the manuscript.

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