The Influence of Effective Microorganisms on the Growth and Nitrate Content of Vegetable Transplants

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***Abstract*—The rationale behind effective microorganisms (EM) is based on the inoculation of soil with mixed cultures of beneficial microorganisms to create an environment more favourable for the growth and health of plants. The purpose of this investigation was to assess the influence of effective microorganisms on the growth and nitrate content of cucumber and squash transplants. There were two treatments: 1. with effective microorganisms (EM); 2. without effective microorganisms – control. In both experiments, cucumber, pumpkin and squash transplants grown with EM were significantly shorter and had thicker stems than those grown without EM. Nitrate content of transplants was lower in transplants grown with EM than in those grown without. Conclusion: EM improves the growth and reduces the nitrate content of cucumber, pumpkin and squash transplants.**

***Index Terms*—cucumber, effective microorganisms, height, nitrates, pumpkin, squash, stem diameter, transplants**

I. Introduction

The rationale behind effective microorganism (EM) technology is based on the inoculation of mixed cultures of beneficial microorganisms into the soil to create an environment favourable for the growth and health of plants.

This technology was first developed in the 1970’s [1]. Initially microbes from various ecosystems were isolated, then remixed. However, due to repeated lack of success, some microbes were eliminated, and simpler mixtures, comprising primarily lactic acid bacteria, photosynthetic bacteria, and yeast, maintained at pH 3.5. [1] were tested. Species used in an EM mixed culture of beneficial, naturally-occurring micro-organisms, may include the photosynthetic bacteria (e.g., *Rhodopseudomonas palustris*, *Rhodobacter sphaeroides*), lactobacilli (e.g., *Lactobacillus plantarum*, *L. casei*, and *Streptococcus lactis*), yeasts (e.g. *Saccharomyces* spp.), and Actinomycetes (*Streptomyces* spp.) [2].

EM interact with the soil-plant ecosystem to suppress plant pathogens and agents of disease, to solubilise minerals, to conserve energy, to maintain the microbial-ecological balance of the soil, to increase photosynthetic efficiency, and to fix biological nitrogen [3].

Previous data from a randomized experiment showed statistically significant differences to indicate that EM increased seed germination and vigour in tomato [4]. Several authors have shown that the use of EM increases the yield of tomatoes [5]-[7].

It is well known that the quality of cucumber, pumpkin and squash transplants influences their final yields. The purpose of this investigation was to assess the influence of effective microorganisms on the growth and quality of cucumber, pumpkin and squash transplants.

II. Materials and Methods

The experiments were carried out in spring 2014 in a heated glasshouse at the Estonian Crop Research Institute. The cucumber (*Cucumis sativus*) variety Landora F_1, pumpkin (*Cucurbita maxima*) variety of Atlantic Giant and the squash (*Cucurbita moschata*) variety Black Beauty were grown. There were two treatments: 1. with EM; 2. without EM (control).

Cucumber seeds were sown on 21 March into individual pots (9 cm diameter) and transplanted into 22 cm pots (24 April). Pumpkin and squash seeds were sown on 17 April into individual pots (14 cm diameter). The substrate for conventionally cultivated seedlings and transplants was a peat-based mixture fertilized with PeatCare 11-25-24 2 kg m^{-3}, magnesium sulphate 0, 5 kg m^{-3}, mixed with dolomite lime (7 kg m^{-3}).

Seeds were soaked either in activated EM 1:500 solution (treatment 1) or in water (treatment 2) 30 minutes before sowing. Seeds were sown on in limed, fertilized and activated EM 1:500 solution treated peat (treatment 1) or in limed, fertilized and water treated peat (treatment 2). Once each week after sowing, plants were watered with either activated EM 1:500 solution (treatment 1) or with water (treatment 2) using 4 L liquid per 32 plants in each treatment.

Manscript received August 29, 2014; revised January 22, 2015.

doi: 10.12720/joaat.2.1.25-28

Each treatment comprised 4 plants. The experiment had four replicates, grown concurrently.

The glasshouse lighting at plant level was approximately 12000 lux from high pressure sodium lamps, lit for 18 hours (23.00 – 16.00h) each day. Minimum day and night temperatures were 20 ^{o}C and 18 ^{o}C, respectively.

Plant height and stem diameter of cucumber were measured on 5 May and of pumpkin and squash on 12 May. Nitrate contents were determined in cucumber, pumpkin and squash transplants extracts by Fiastar 5000. Analyses of variance were carried out on the data obtained using programme Excel. Used signs: *** p<0,001; ** p= 0,001 - 0, 01; * p= 0, 01 - 0, 05; NS not significant, p>0, 05.

III. Results

EM treated cucumber plants were significantly shorter than control plants not treated with EM (Fig. 1); the former were 16% shorter than the latter.

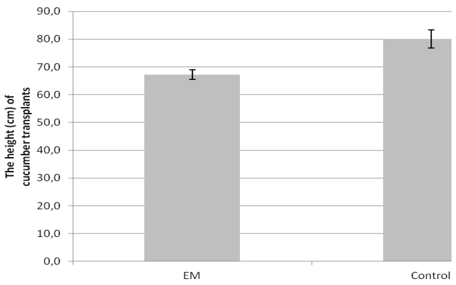

Figure 1. The height (cm) of cucumber transplants (***).

The stem diameter of cucumber transplants treated with EM was significantly greater than that of plants not treated with EM (Fig. 2); the former were 29% larger than the latter.

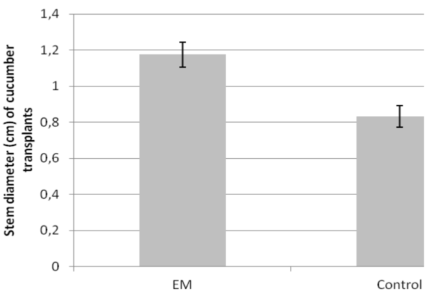

Figure 2. The stem diameter (cm) of cucumber transplants (***).

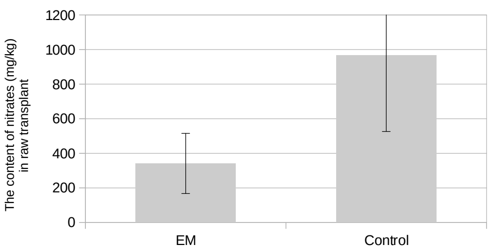

Figure 3. The content of nitrates (mg kg-1) of fresh cucumber transplants (*).

Nitrate content of fresh cucumber transplants treated with EM was significantly lower than that of control transplants not treated with EM (Fig. 3); the former contained 65% less than the latter.

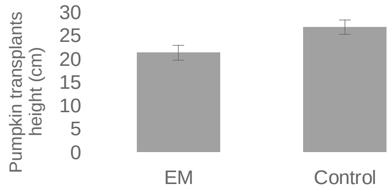

Figure 4. The height of pumpkin transplants (***).

Pumpkin transplants treated with EM were significantly shorter than those not treated with EM (Fig. 4); the former were 20% shorter than the latter.

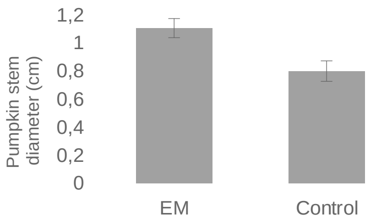

Figure 5. The stem diameter (cm) of pumpkin transplants (***).

The stem diameter of pumpkin transplants treated with EM was significantly larger than those not treated with EM (Fig. 5); the former were 28% larger than the latter.

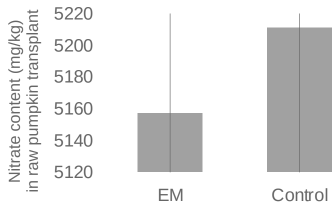

Figure 6. The content of nitrates (mg kg-1) of raw squash transplants (NS).

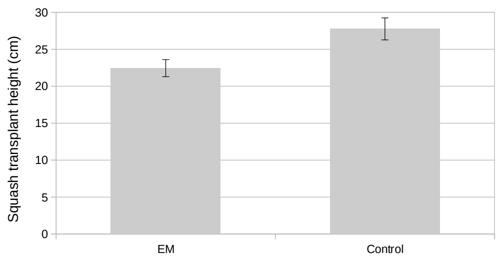

Figure 7. The height of squash transplants (***).

Nitrate content of fresh pumpkin transplants treated with EM was tended to be less than that in those grown without EM, but not significantly different (Fig. 6).

Squash transplants treated with EM were significantly shorter than those not treated with EM (Fig. 7); the former were 19% shorter than the latter.

The stem diameter of squash transplants treated with EM was significantly larger than those not treated with EM (Fig. 8); the former were 32% larger than the latter.

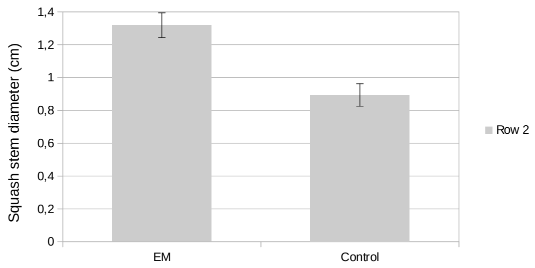

Figure 8. The stem diameter (cm) of squash transplants (***).

Nitrate content of fresh squash transplants treated with EM was significantly less than that in those grown without EM (Fig. 9); the former contained 20% less nitrates than the latter.

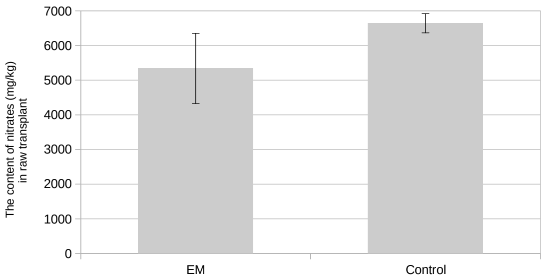

Figure 9. The content of nitrates (mg kg^{-1}) of raw squash transplants (*).

IV. Discussion

Cucumber, pumpkin and squash transplants were significantly shorter when grown with EM than when grown without in both experiments. Similarly, EM treated tomato transplants are shorter than those grown without [8]. By contrast, treatment with EM has been found to increase plant height at fruiting [9]. Possibly in later stages (i.e. fruiting stages), EM would similarly increase the height of cucumber plants producing more fruits.

The stem diameter of cucumber, pumpkin and squash transplants was significantly larger in EM treatment in both experiments compared to the control. The larger the stem diameter is the better the plant can obtain the nutrients from soil, especially Ca, which flows through the plants with water flow of transpiration. Similar results have been obtained with tomato transplants [8]. The larger the stem diameter the better the plant can obtain nutrients from the soil, especially Ca, which flows through the plants with the water flow of transpiration. In addition EM helps to solubilise minerals, including Ca, and the Ca content can increase in tomato plants [3]. This is desirable because a higher Ca content reduces the incidence of insect pests and diseases and improves fruit transport and storage qualities.

EM improved the quality of tomato transplants, because they stayed compact and stem diameter was greater. It is known that good tomato transplant quality results in higher yields. This statement is supported by a study on tomatoes [10]. The lowest yield of tomatoes was noticed with the transplants of poorer quality [10].

The manufactures of EM are sometimes mentioning also that by using EM the number of leaves of tomato can increase. The data from literature are confirming that EM may have negative influence on the number of fruits [11]. They pointed out that the reason could be followed: nitrogen immobilization by EM, which could have resulted in reduced nitrogen availability to the plants. The same research also revealed that the lower number of 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 few fruits formed. In contrast to previous investigation and research [11] some scientists found that EM treatment increases the number of fruits [12]. Mohan [13] evaluated the traditional Ayurvedic growth-promoters, Panchagavya and Amrit Pani, which were compared with ‘Bokashi’ made using EM technology. The results indicated higher yield and lower glycoalkaloid content in Bokashi-treated tomatoes, followed by Panchagavya. EM inoculation to both Bokashi and chicken manure increased photosynthesis and fruit yield of tomato plants [7]. For tomato, the generated data from initial field trials showed that 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 [14]. EM applied with a green manure (i.e., Gliricidia leaves) significantly increased tomato yields throughout the study; in the third year, the yields due to EM were comparable to those obtained with chemical fertilizer [5]. In accordance, Zaenudin [6] concluded that EM is needed in Indonesia because EM increases the production of tomatoes.

The content of nitrates was lower in EM treated transplants than in control transplants. If EM were found to reduce nitrate content also in cucumber, pumpkin and squash fruits, this would be a very desirable and important effect on their quality. The reason could be followed: nitrogen immobilization by EM, which could have resulted in reduced nitrogen availability to the plants [11].

Acknowledgement

This research was financially supported by the Estonian Agricultural Registers and Information Board, the Estonian target financing project no. SF170057s09 and with the help of the Jaagumäe Agro OÜ and the Estonian Crop Research Institute.

References

[1] T. Higa. (2012). Kyusei Nature arming and Environmental Management Through Effective Microorganisms - The Past, Present and Future. [Online]. Available: http://www.infrc.or.jp/english/KNF_Data_Base_Web/7th_Conf_KP_2.html

[2] A. Javaid, “Beneficial microorganisms for sustainable agriculture,” *Sustainable Agriculture Reviews*, vol. 4, pp. 347-369, 2010.

[3] N. N. Subadiyasa, "Effective microorganisms (EM) technology: Its potential and prospect in Indonesia," *Majalah Ilmiah Fakultas Pertanian Universitas Udayana*, vol. 16, pp. 45-51, 1997.

[4] M. F. B. Siqueira, C. P. Sudré, L. H. Almeida, A. P. R. Pegorerl, and F. Akiba. (2012). Influence of Effective Microorganisms on Seed Germination and Plantlet Vigor of Selected Crops. [Online]. Available: http://futuretechtoday.com/em/EMSeedGermPlantVigor.pdf

[5] B. Marambe and U. R. Sangakkara. (1996). Effect of EM on weed populations, weed growth and tomato production in Kyusei nature farming. [Online]. Available: http://www.futuretechtoday.net/em/index2.htm

[6] S. Zaenudin. (1993). Effective Microorganisms (EM4) Technology in Indonesia. [Online]. Available: http://www.futuretechtoday.net/em/index2.htm

[7] H. L. Xu, R. Wang, and M. A. U. Mridha, "Effects of organic fertilizers and a microbial inoculant on leaf photosynthesis and fruit yield and quality of tomato plants," *Journal of Crop Production*, vol. 3, pp. 173-182, 2001.

[8] M. Olle, "Efektiivsete mikroorganismide mõju tomati istikute kasvule," *Põllumaj and Usteaduselt Tootjatele*, Jõgeva, Rebellis, pp. 100-103, 2014.

[9] I. I. Idris, M. T. Yousif, M. E. Elkashif, and F. M. Bakara, "Response of tomato (Lycopersicum esculentum Mill.) to application of effective microorganisms," *Gezira Journal of Agricultural Science*. vol. 6, no. 1, October 2008.

[10] R. Pavlovic, S. Petrovic, and D. D. Stevanovic, "The influence of transplants quality on the yield of tomato grown in plastic house," *Acta Horticulturae*, vol. 456, pp. 81-86, 1998.

[11] L. Ncube and B. Calistus, "Effects of the integrated use of effective microorganisms, compost and mineral fertilizer on greenhouse-grown tomato," *African Journal of Plant Science*, vol. 6, pp. 120-124, 2012.

[12] I. I. Idris, M. T. Yousif, M. E Elkashif, and F. M. Bakara. "Response of tomato (Lycopersicum esculentum Mill.) to application of effective microorganisms," *Gezira Journal of Agricultural Science*, North America, vol. 6, Oct. 2012.

[13] B. Mohan, "Evaluation of organic growth promoters on yield of dryland vegetable crops in India," *Journal of Organic Systems*, vol. 3, pp. 23-36, 2008.

[14] C. R. Escano. (1996). Experiences on EM technology in the Philippines. [Online]. Available: http://www.futuretechtoday.net/em/index2.htm

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M. Olle and A. Viršile. "The effects of light-emitting diode lighting on greenhouse plant growth and quality," *Agricultural and Food Science* , vol. 22, pp. 223 - 234, 2013.

M. Olle, M. Ngouajio, and A. Siomos. "Vegetable quality and productivity as influenced by growing medium: A review," *Žemdirbystė Agriculture*, vol. 99, no. 4, pp. 399 - 408, 2012.

M. Olle. "Increase of leaf tipburn in chervil and lettuce by restricting volume of growing medium," *Acta Agriculturæ Scandinavica, Section B - Soil & Plant Science*, vol. 62, pp. 188 - 192, 2012.

M. Olle and I. Bender. "Causes and control of calcium deficiency disorders in vegetables: A review," *Journal of Horticultural Science & Biotechnology*, vol. 84, pp. 577-584, 2009.

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