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SHORT COMMUNICATION: THE IMPROVEMENT OF THE QUALITY, AND NUTRIENT CONTENT OF LEAF CELERY TRANSPLANTS BY EFFECTIVE MICROORGANISMS

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ABSTRACT. Effective microorganisms (EM) comprise a mixture of live natural cultures of microorganisms isolated from fertile soils that are used to improve crop production. The purpose was to assess the influence of EM on the growth and nutrient content of leaf celery transplants. Two treatments were compared: 1) EM treatment comprised of seed soaking in EM 1:500 solution, sowing in EM treated peat and watering the plants weekly with EM solution. 2) Control treatment included similar treatments with water. Leaf celery transplants grown with EM were significantly shorter and had thicker stems than those grown without EM. The contents of nitrogen, phosphorus, potassium and calcium increased in transplants grown with EM compared to those grown without EM. The contents of nitrates and magnesium did not show statistically significant differences. Conclusion: EM improves the growth and increases nitrogen, phosphorus, potassium and calcium contents of leaf celery transplants.

Introduction

Dr Tero Higa in Japan (Higa, 2012) developed effective microorganisms (EM) technology over 40 years ago. EM comprises a mixture of live natural cultures of microorganisms isolated from fertile soils that are used to improve crop production. In 70% of published studies, it was concluded that EM has a positive effect on the growth of vegetables, while in the other 30% there was no significant influence (Olle, Williams, 2013). They also reported that on the effects of EM on the yields of vegetables, 84% were positive, 4% were negative, and 12% showed no significant influence.

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 (Olle, Williams, 2015). 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, (Higa, 2012) were tested. Species used in an EM mixed culture of beneficial, naturally occurring microorganisms, 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.) (Javaid, 2010). The same authors concluded in their review paper that EM can improve the quality and yield of vegetables by reducing the incidence of pests and diseases, and by protecting against weeds, thereby contributing to sustainable agriculture.

To the knowledge of the author of the present investigation, no research on how EM influences the growth parameters of leaf celery transplants is available. The author of the present investigation made research also with other vegetables and found that tomato transplants respond well to EM, by remaining compact and having greater stem diameter (Olle, 2015). It is well known that the quality of leaf celery transplants influences their final yields.

Therefore, the aim of the present investigation was to assess the influence of effective microorganisms on the growth parameters of leaf celery transplants. Another aim was to see whether EM has also some effect on the nutrient content of leaf celery transplants.

Materials and Methods

The experiments were carried out in spring 2014 in a heated glasshouse at the Estonian Crop Research Institute. There were two treatments: 1. with EM; 2. without EM (control).

Leaf celery seeds were sown on 21 March into plastic trays 36×28 cm, height 6.5 cm (one hole was 6.4×6.2 cm, height 6.5 cm), where plants were growing until the end of transplant age. 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}).

In treatment 1 (EM treatment) the seeds were soaked in activated EM 1:500 solution 30 minutes before sowing. Seeds were sown on in limed, fertilized and activated EM 1:500 solution treated peat. Once each week after sowing (28.03.14–26.05.14), plants were watered with either activated EM 1:500 solution using 4 L liquid per 32 plants. Also once each week all plants in EM treatment were watered with fertilizer Superex (12-5-27).

In control treatment, the seeds were soaked in water 30 minutes before sowing. Seeds were sown on in limed, fertilized and water treated peat. Once each week after sowing (28.03.14–26.05.14), plants were watered with water using 4 L liquid per 32 plants in each treatment. Also once each week all plants in control treatment were watered with fertilizer Superex (12-5-27).

Each plot comprised of 6 plants. The experiment had four replicates, grown concurrently. The experiment was repeated at the same time, so there were running two experiments at the same time, both with 4 replications.

The glasshouse lighting at plant level was approximately 12 000 lux from high-pressure sodium lamps, lit for 18 hours (23.00–16.00) each day. Minimum day and night temperatures were 20 ºC and 18 ºC, respectively.

Plant height and stem diameter of leaf celery transplants were measured on 28 May.

The contents of nitrates, nitrogen, phosphorus, potassium, calcium and magnesium were determined. Nitrite and nitrate contents were determined in plant extracts by Fiastar 5000. Nitrogen content was determined according to the Copper Catalyst Kjeldahl Method (984.13). The phosphorus 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. Used signs: *** $P < 0.001$; ** P = 0.001–0.01; * P = 0.01–0.05; NS not significant, $P > 0.05$.

Results

Leaf celery transplants treated with EM were significantly shorter than those without EM (Table 1); they were 36% shorter. The stem diameter of transplants was 13% greater in those treated with EM than in those without EM (Table 1). The contents of nitrates and magnesium were not statistically different between treatments (Table 2). However, the treatment affected nitrogen, phosphorus and potassium contents, which were 22, 21 and 17% higher in EM variant compared to control.

A little bit lower, was increased in the content of calcium which was 11% higher in EM variant compared to control (Table 2).

Table 1. The height and the stem diameter of leaf celery transplants

Group	Plant height, cm	Stem diameter, cm
EM	14.06	1.0125
Control	21.88	0.8813
P	***	***

Table 2. The content of nitrates in leaf celery transplants raw plants and the contents of nitrogen, phosphorus, potassium, calcium, and magnesium in leaf celery transplants dry matter

Group	In raw plant, mg kg^{-1}	In plant dry matter, %				
	Nitrates	N	P	K	Ca	Mg
EM	4739	4.55	0.95	6.58	2.99	0.389
Control	3063	3.55	0.75	5.46	2.66	0.408
P	NS	**	**	*	*	NS

Used signs: *** $P < 0.001$; ** P = 0.001–0.01; * P = 0.01–0.05; NS not significant, $P > 0.05$.

Discussion

In this study, we found that leaf celery transplants treated with EM were significantly shorter than untreated control transplants. Olle and Williams (2015) reported a similar result also with cucumber and squash transplants. This does not concur with Idris *et al.* (2008) results with tomato plants, because they found that EM treatment significantly increased plant height; however, they measured plant height at fruiting while we measured the height of transplants. EM application appeared to promote early fruiting in tomato (Ncube *et al*., 2011) and root growth, but not a leaf and shoot development in Chinese cabbage (In-Ho, Ji-Hwan, 2012). The combined application of phosphorus fertilizer (P_2O_5) 0, 75, 150 l ha^{-1} and EM 50 l ha^{-1} enhanced vegetative and reproductive growth in cabbage (Zahoor *et al*., 2003).

Chantal *et al.* (2010) showed increased leaf areas in cabbages treated with EM. Although there was no significant difference in plant height, treatment with EM 'Bokashi' plus an EM solution resulted in the highest diameter stems, followed by the chemical fertiliser (Nakano, 2007). The increase in stem diameter is in accordance with the results of the present investigation and of results of other experiments (Olle, Williams, 2015). On another hand, Puranapong and Siphuang (2001) studied the use of a mixture of EM with chicken, quail, pig or cow manure on the growth of yard long bean and snake eggplant, but showed no significant differences of plant growth parameters.

EM improved the quality of leaf celery transplants, because they remained more compact with a greater stem diameter than untreated plants. The golden rule is that transplant with very good quality results in higher yields. EM gives a good start to leaf celery transplants because EM solubilise minerals (Olle, Williams, 2013), including Ca, from the substrate. Ca influences many processes beneficially: plants with a higher Ca content have less disease, are attacked by fewer insects, and have better transport and storage qualities (Olle, 2013).

The content of nitrogen, phosphorus, potassium and calcium in leaf celery transplants were higher in EM treatment compared to control treatment. Nitrate and magnesium contents in leaf celery were not statistically different between treatments. It was good that nitrate content did not show increased content in plants; because of high nitrate, accumulation in plants might be undesirable. Chards treated with EM 'Bokashi'+ EM had higher phosphorus content than control plants (Daiss *et al.* 2008), which is in accordance with findings in the present investigation. Similarly, with the present investigation, the application of EM to plants induced higher levels of calcium compared with non-treated plants (Daiss *et al*., 2008). In accordance with results from the present investigation, EM significantly enhanced nitrogen, phosphorus and potassium nutrition of the test plant in farmyard manure amendment both at flowering stage and at maturity. However, in NPK amended the soil, EM application markedly enhanced plant nutrition at a later growth stage only (Javaid, Bajwa, 2011).

Phosphorus is needed especially for good root growth (Durner, 2013). Potassium is very important in stomatal function and water relations of plants (Durner, 2013). A higher Ca content is beneficial, suppressing insect and disease attack and increasing transportability and storage quality (Olle, 2013). A higher Mg content could have desirable; because of a higher Mg content reduces the incidence of insect pests and diseases (Cakmak, 2013).

Conclusions

Leaf celery transplants with EM were significantly shorter and had a greater stem diameter and the content of nitrogen, phosphorus, potassium and calcium were higher than in the control treatment. Therefore, it can be suggested in the production of leaf celery transplants to treat plants with EM in order to plant healthier transplants with the higher quality of them.

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Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author contributions

MO contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.
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