Agraarteadus
1 • XXXI • 2020 70–73

Journal of Agricultural Science
1 • XXXI • 2020 70–73

SHORT COMMUNICATION: THE IMPROVEMENT OF THE GROWTH OF TOMATO TRANSPLANTS BY BOKASHI TEA

Margit Olle

Estonian Crop Research Institute, J. Aamissepa 1, 48309 Jõgeva alevik, Estonia

Saabunud: Received: 17.03.2020
Aktsepteeritud: Accepted: 25.05.2020

Avaldatud veebis: Published online: 26.05.2020

Vastutav autor: Corresponding author: Margit Olle
E-mail: margit.olle@gmail.com

Keywords: bokashi tea, height, number of leaves, stem diameter, tomato transplants.

DOI: 10.15159/jas.20.10

ABSTRACT. Effective microorganisms' bokashi fermentation is proposed to upcycle food waste to novel feed supplements, and to (partially) replace traditional composting of food waste (and secondary residues from industrial processes) to facilitate both plant production and soil quality as well as to reduce greenhouse gas emissions. The purpose was to assess the influence of bokashi tea treatment on the growth of tomato transplants. There were two treatments: one with bokashi tea and second without bokashi tea (control). Tomato transplants treated with bokashi tea tended to be higher than those in control; while the results were not significantly different. The number of leaves of tomato transplants treated with bokashi tea was not significantly different. The stem diameter of tomato transplants was 13% greater (P = 0.04) in bokashi tea treated plants than in control. Conclusion: Bokashi tea improves the growth of tomato transplants by increasing stem diameter and is allowing for plants to take up more nutrients.

Introduction

Bokashi technology is a method for treating biowaste in general and food waste in specific, using controlled lactic acid fermentation (LAF) under anaerobic conditions (Boechat *et al.*, 2013). The term is based on a traditional Japanese method of the same name. Unlike standard aerobic composting, bokashi waste treatment is performed in closed bioreactors or unaerated piles to create anoxic conditions. To control the breakdown of organic matter under LAF conditions, a mixture of biowaste is inoculated with a defined mixture of (facultative) anaerobic microorganisms (effective microorganisms – EM).

Assuming collection routines maintain nutritional quality, bokashi fermentation of food waste with an effective microbiome (EM) is a form of biological treatment that stabilizes the bio-waste and provides an animal feed (supplement), or a nutrient-rich growth-promoting fertilizer for field- and greenhouse-based food production systems. Thus, in the sense of circular economy and zero-waste, more complete utilization of food waste will be achieved. To promote the industry-scale use of this innovative technology in Europe, the end products of EM bokashi treatment have to be effective, safe for the environment and human health, and economical. EM bokashi fermentation is proposed to upcycle food waste to novel feed supplements, and to (partially) replace traditional composting of food waste (and secondary residues from industrial processes) to facilitate both plant production and soil quality as well as to reduce greenhouse gas emissions.

Effective microorganisms (EM) consist of a mixed culture of beneficial ("effective"), naturally-occurring microorganisms such as purple non-Sulphur bacteria (PNSB; *e.g. Rhodopseudomonas palustris*, *Rhodobacter sphaeroides*), lactobacilli (LAB; *e.g. Lactobacillus plantarum*, *L. casei*, and *Streptococcus lactis*), yeasts (*e.g. Saccharomyces* spp.), and *Actinomycetes* (*Streptomyces* spp.) (Olle, 2016). All microbes in EM are derived from nature (Footer, 2013). The concept of EM is based on the inoculation of substrates to shift the microbial equilibrium and thus create an improved microbiome that favours improved productivity. Besides, secondary metabolites produced by the modified microbiome (*e.g.* inositol, ubiquinone, saponin, low-molecular polysaccharides, polyphenols and chelating agents) are a relevant mode of action (Boechat *et al.*, 2013).

A couple of theories exist to justify the complex mode of action of EM, or plant growth-promoting microorganisms (PGPM), in agricultural production (Balogun *et al.*, 2016). These include the biological suppression of pathogens theory, energy conservation theory, mineral solubilization theory, microbial ecological balance theory, and biological nitrogen fixation theory. EM can thus e.g. decompose biogenous waste and residue, detoxify pesticides, suppress plant diseases and soil-borne pathogens, enhance nutrient cycling and produce bioactive secondary metabolites such as vitamins, hormones, and enzymes that stimulate plant growth/reroute C allocation. For example, it is increasingly realized that LAB, as being an important part of the EM inoculate, is powerful organic fertilizers, bio-control agents, and bio-stimulants (Lamont *et al.*, 2017).

Bokashi can stimulate microbial, meso- and macro-fauna activity, thereby increasing soil aggregate abundance and stability (Amezketa, 1999), which will improve soil drainage and aeration especially in heavy soils; in more coarse soils it increases the water holding capacity of the soil. Thereby Ginting (2019) shows that bokashi applications are improving soil fertility.

EM increases crop yield and growth Megali *et al.* (2014), because of improved plant nutrition. EM bokashi fertilization leads to greater yield increases than other growth promotors (Mohan, 2008). The fact that not all species respond positively to EM application suggests: not all plant species are responsive to EM effects on the soil/root microbiome (Hayat *et al.*, 2010) or soil amendment might not have resulted in the sufficient establishment of EM's constitutive microbial species into the local soil microbiome (Mayer *et al.*, 2010).

Therefore, the present investigation aimed to assess the influence of bokashi tea on the growth parameters of tomato transplants.

Material and Methods

The experiments were carried out in spring 2019 in a heated glasshouse at the Estonian Crop Research Institute.

In experiment tomato variety Valve was grown. There were two treatments: 1. with bokashi tea treatment; 2. without bokashi tea treatment – control. Each treatment consisted of 3 plants. The experiment had three replicates. The experiment was repeated at the same time, *i.e*. simultaneously.

Tomato seeds were sown on 17 April 2019 and transplants were grown in a heated glass greenhouse. The greenhouse lighting at a plant level was approximately 12 000 lux from high-pressure mercury lamps. The plants were additionally lighted in 18 hours (4.00–23.00). All plants were grown with a minimum day and night temperature of 20 °C and 18 °C, respectively.

Young plants were transplanted two times: at first at spacing 5 cm into larger boxes (23 April 2019), second time into an individual pot (9 cm diameter), (3 May 2019). Substrate for organically cultivated seedlings and transplants was organic vegetable soil from Matogard Ltd. Ingredients: peat, compost, organic fertilizers, humic substance, clay. Characteristics: capacity/mass <0.7 kg L^{-1}; acidity (pH KCl) 5.6–6.5; salts content 1.2–2.0 g L^{-1}.

Seeds were soaked in bokashi tea 1:500 solution (bokashi tea treatment) or water (control) half-hour before sowing. Tomato seeds were sown on in bio-vegetable soil treated with bokashi tea 1:500 solution (treatment 1) and in organic vegetable soil treated with water (treatment 2). 2 L liquid per 12.5 L peat in both treatments was used. At first spacing, larger boxes were filled with organic vegetable soil treated with bokashi tea 1:500 solution (treatment 1) and with organic vegetable soil treated with water (treatment 2). The same amount of liquid was used per 12.5 L peat in both treatments. A second spacing the pots were filled with bio-vegetable garden soil treated with bokashi tea 1:1000 solution (treatment 1) and with bio-vegetable garden soil treated with water (treatment 2). This time 4 L liquid per 25 L peat was used in both treatments. 06.05–27.05.19 the plants were watered with weekly intervals with bokashi tea 1:1000 solution (treatment 1) and with water (treatment 2). Here 4 L liquid per 32 plants in both treatments was used.

On 07.06.2019 the height, stem diameter and the number of leaves were recorded. The height was measured with measuring tape, the stem diameter was measured with a shear calliper, and the number of leaves was counted.

Analyses of variance were carried out on the data obtained using programme MS Excel 2019.

Results

The stem diameter of tomato transplants was 13% greater (P = 0.04) in bokashi tea treated plants than in control (Table 1). Tomato transplants treated with bokashi tea tended to be 5 cm higher than those in control (Table 1); while the results were not significantly different (P = 0.06). The number of leaves of tomato transplants treated with bokashi tea was not significantly different (P = 0.1) (Table 1). The standard deviation of the bokashi tea treatment for the plant height was 1.528 and for control 3.055 cm and the number of leaves, it was 0.577, while in control treatment 1.155, large variation in the control group was the reason that results were not statistically different. The examples of the tomato transplants are shown in Figure 1 and the stem diameters of tomato transplants are in Figure 2.

Table 1. The height, the number of leaves and the stem diameter of tomato transplants according to treatments: bokashi tea and control

Traits	Height of plants, cm		Number of leaves		Stem diameter, mm	
	bokashi tea	control	bokashi tea	control	bokashi tea	control
Average	31.667	26.667	8.667	7.667	9.667	8.333
Standard deviation	1.528	3.055	0.577	1.155	0.577	0.577
P-value	0.064		0.251		0.047	

Figure 1. The photo of tomato transplants according to treatments: bokashi tea (left) and control (right)

Figure 2. The photo of tomato transplants stems according to treatments: bokashi tea (left) and control (right)

Discussion

In present investigation was found that tomato transplants treated with bokashi tea tended to be higher than untreated control transplants. Earlier experiments (Olle, 2014, 2015; Olle, Williams, 2015), have been reported that tomato, cucumber and squash transplants contrary were shorter by using EM treatment. This is in agreement with Idris *et al.* (2008) results with tomato plants because they found that EM treatment increased plant height; however, they measured plant height at fruiting while in present research the height of transplants was measured.

One reason why the height of tomato transplants tended to be higher in bokashi tea treatment (bokashi tea includes also EM) is that this tea is a product of food waste fermented with bokashi containing EM. Food waste gives a lot of useful nutrients to bokashi tea, which can be the reason tomato transplants tended to be higher in bokashi tea treatment than in control.

The second reason could be that EM inoculation to both bokashi and chicken manure increased photosynthesis of tomato plants (Xu *et al.*, 2001), and increased photosynthesis gives better growth of plants.

Chantal *et al.* (2010) showed increased leaf areas in cabbages treated with EM. Although there was no significant difference in cabbage 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 following the results of the present investigation and results of other experiments (Olle, 2014; Olle, Williams, 2015). On other 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.

Bokashi tea improved the quality of tomato transplants because they tended to be higher with a greater stem diameter than untreated plants. The golden rule is that transplant with very good quality results in higher yields. Bokashi tea gives a good start to tomato transplants because EM solubilise minerals (Olle, Williams, 2013), including Ca, from the bokashi tea solution. 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 plant protection effect is confirmed by the integrated results of Xu *et al.* (2012), who suggest that the advantage of nitrogen metabolism in EM bokashi-fertilized tomato plants accounted for the high phytophthora resistance.

Conclusion

Bokashi tea improves the growth of tomato transplants by increasing stem diameter and is allowing for plants to take up more nutrients.

Acknowledgements
NutriLoop Ltd. provided for my trials the bokashi tea.

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.

References

Amezketa, E. 1999. Soil aggregate stability: a review. – Journal of Sustainable Agriculture, 14:83–151. DOI: 10.1300/J064v14n02_08.

Balogun, R.B., Ogbu, J.U., Umeokechukwu, E.C., Kalejaiye-Matti, R.B. 2016. Effective Microorganisms (EM) as Sustainable Components in Organic Farming: Principles, Applications and Validity. – In: Organic Farming for Sustainable Agriculture. Springer International Publishing(Ed. D. Nandwani), Cham. pp. 259–291

Boechat, C.L., Santos, J.A.G., Accioly, A.M.D.A. 2013. Net mineralization nitrogen and soil chemical changes with application of organic wastes with Fermented Bokashi Compost. – Acta Scientiarum.

Agronomy, 35(2):257–264. DOI: 10.4025/ actasciagron.v35i2.15133.

Chantal, K., Xiaohou, S., Weimu, W., Basil, T.I.O. 2010. Effects of effective microorganisms on yield and quality of vegetable cabbage comparatively to nitrogen and phosphorus fertilizers. – Pakistan Journal of Nutrition, 9:1039–1042. DOI: 10.3923/ pjn.2010.1039.1042.

Footer, A. 2013. Bokashi composting: Scraps to soil in weeks. – New Society Publishers. 176 p.

Ginting, S. 2019. Promoting bokashi as an organic fertilizer in Indonesia: A mini review. – International Journal of Environmental Sciences & Natural Resources, 21(4):556070. DOI: 10.19080/ IJESNR.2019.21.556070.

Hayat, R., Ali, S., Amara, U., Khalid, R., Ahmed, I., 2010. Soil beneficial bacteria and their role in plant growth promotion: a review. – Annals of Microbiology, 60(4): 579–598. DOI: 10.1007/ s13213-010-0117-1.

Idris, I.I., Yousif, M.T., Elkashif, M.E., Bakara, F.M. 2008. Response of tomato (*Lycopersicum esculentum* Mill.) to application of effective microorganisms. – Gezira Journal of Agricultural Science, 6(1), North America, 6. Oct. 2012. Available at: http://journals.uofg.edu.sd/index.php/GJAS/article/view/4. Accessed 06.04.2013

Lamont, J.R., Wilkins, O., Bywater-Ekegärd, M., Smith, D.L. 2017. From yogurt to yield: Potential applications of lactic acid bacteria in plant production. – Soil Biology and Biochemistry, 111:1–9. DOI: 10.1016/j.soilbio.2017.03.015.

Mayer, J., Scheid, S., Widmer, F., Fließbach, A., Oberholzer, H.R. 2010. How effective are 'Effective microorganisms® (EM)'? Results from a field study in temperate climate. – Applied Soil Ecology, 46(2):–230–239. DOI: 10.1016/j.apsoil.2010.08.007.

Megali, L., Glauser, G., Rasmann, S. 2014. Fertilization with beneficial microorganisms decreases tomato defenses against insect pests. – Agronomy for Sustainable Development, 34(3):649–656. DOI: 10.1007/s13593-013-0187-0.

Mohan, B. 2008. Evaluation of organic growth promoters on yield of dryland vegetable crops in India. – Journal of Organic Systems, 3(1):23–36.

Nakano, Y. 2007. Effects of Effective Microorganisms™ on the growth of *Brassica rapa*. – http://ebookbrowse.com/effects-of-effective-microorganisms-tm-on-the-growth-of-brassica-rapa-pdf-d18075139. Accessed 06.04.2020

Olle, M. 2013. The effect of effective microorganisms (Em) on the yield, storability and calcium content in Swede. – International Plant Nutrition Colloquium and Boron Satellite Meeting Proceeding Book: International Plant Nutrition Colloquium and Boron Satellite Meeting, Istanbul/Turkey, 19–23 August 2013. Sabanci University, pp. 714−715.

Olle, M. 2014. Efektiivsete mikroorganismide mõju tomati istikute kasvule. – Põllumajandusteaduselt tootjatele. Jõgeva, Rebellis, lk 100–103.

Olle, M. 2015. Effective microorganisms influences vegetables and soybeans production. – LAP LAMBERT Academic Publishing. 118 p.

Olle, M. 2016. Köögivilja istikute kasv paraneb kasutades efektiivseid mikroorganisme. – Konverentsi Terve loom ja tervislik toit 2016 artiklite kogumik (toim. Marko Kass), Ecoprint, lk 107−112.

Olle, M., Williams, I.H. 2013. Effective microorganisms and their influence on vegetable production. – a review. – Journal of Horticultural Science & Biotechnology, 88(4):380−386.

Olle, M., Williams, I.H. 2015. The influence of effective microorganisms on the growth and nitrate content of cucumber and squash transplants. – Journal of Advanced Agricultural Technologies, 2(1):25−28. DOI: 10.1080/14620316.2013.11512979.

Puranapong, N., Sipuhang, C. 2001. Utilization of manures fermented with EM (effective microorganism) in vegetable. – In: Proceedings of the 3rd Maejo University Annual Conference. Maejo University, Chiang Mai, Thailand, pp. 120–126.

Xu, H.L., Wang, X., Wang, J. 2001. Modeling photosynthesis decline of excised leaves of sweet corn plants grown with organic and chemical fertilization. – Journal of Crop Production, 3(1):245–253. DOI: 10.1300/J144v03n01_20.

Xu, H.L., Wang, R., Mridha, M.A.U., Umemura, U. 2012. Phytophthora Resistance of Tomato Plants Grown with EM Bokashi. http://www.futuretechtoday.net/em/index2.htm. Accessed 06.04.2020