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Effect of Vermicompost and Isopod (*Porcellio laevis*) Fertilizers on The Emergence and Seedling Quality of Lettuce (*Lactuca sativa* var. *capitata* cv. Wismar)

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Abstract

A great number of insects play an essential role in stabilizing and sustainability of ecosystems. The terrestrial isopods are also important members of soil macrofauna in many habitats, and they are considered as an integral part of the decomposition process. Although the role of isopod in decomposing organic matter and recycling nutrients is very well known, there is no available scientific research or information dealing with the utilization of fertilizer obtained from it as the plant and seedling growing media or soil conditioner in agriculture production. The main goal of this study was to evaluate the usability of fertilizer obtained from a terrestrial isopod (*Porcellio laevis*) and the effect of vermicompost added into the growing media in the growing of lettuce seedlings. By this purpose, 10 different mixtures containing 1, 5, 10 and 20% of each fertilizer [including agricultural soil (control) and peat] as seedling growth media were used. According to results the differences among growing media in terms of emergence and seedling characteristics were not significant. However, the leaf number, fresh-dry shoot weight, and fresh-dry root weight of seedling in all mixtures were equal or higher than control. Results from the study suggest that the isopod fertilizer for the evaluation of agricultural organic wastes which are sometimes regarded as pollutants could be confidently used.

Keywords: Lettuce, *Porcellio laevis*, Vermicompost, Seedling

Introduction

Lettuce (*Lactuca sativa* L.), the most commonly consumed salad vegetable, is rich in several minerals, vitamins and an important source of antioxidants. It is cultivated by the seedling in both the field and greenhouse. The lettuce is taking place in second place with a 13% share among commercial vegetable seedling production in Turkey (Yelboğa, 2014). Peat is widely using as the main growing medium for the production of commercial vegetable seedling in the container. Since the used peat is imported and not cheap, it constitutes a significant production cost. Other hand, the need to recycle wastes and the increasing environmental pressures against peat extraction leads to an increasing interest in utilizing low cost, environmentally friendly materials. Also, the organic wastes, which are considered as sources of pollution during agricultural production and crop processing, are not sufficiently utilized as organic fertilizer and soil conditioner (Hernandez et al., 2010). It has been stated that organic materials like compost, vermicompost can be a good alternative to peat-based substrates for the production of vegetable seedling (Ribeiro et al., 2007). Vermicompost, processed organic material by earthworm, which is increasingly used in agricultural practices, has high porosity, drainage, water-holding capacity, and microbial activity. It improves absorbability and retention of nutrient

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due to having a large surface area, and thus contains nutrients in forms that are readily taken up by the plants (Edwards and Burrows, 1988; Orozco et al., 1996; Atiyeh et al., 1999; Sharma and Banik, 2014). Because of these properties, vermicompost is considered as bio-fertilizer that played a significant role in soil biology, chemistry, and physics (Singh et al., 2010). There are many researches dealing with the positive influence of vermicompost on growth, productivity, and quality of vegetables in literature. For instance, Edwards et al., (2006) demonstrated that vermicompost enhanced the seed germination and growth of tomato and cucumber plants. In a study conducted by Kumar and Raheman (2012), the vermicompost has been added to the soil sand mix (in equal proportion) at 20, 25, 33.33 and 50% by volume to produce the seedlings of tomato, eggplant, and chili pepper. The high-quality seedlings of all vegetables were obtained from a mix of 25% vermicompost and 75% sand and soil. However, in some research related to the effects of vermicompost on seed germination and seedling quality are reported inconsistent results or adverse effects depending on the mixing ratio used, the main organic material of the vermicompost, the species of earthworm, the used soil properties, etc. For instance, in a study conducted to evaluate the effect of compost on lettuce growth parameters, it was determined that yield was not affected by compost applications (Leon et al., 2012). Ievinsh (2011) determined that the vermicompost substitution inhibited the seed germination and seedling growth of several vegetable crops with an almost linear decrease of growth with increasing concentration of vermicompost in the substrate. By Tombion et al. (2016), the effect of substrates with different amounts of vermicompost (0, 20, 40%) added and a commercial mix of peat and perlite of the mixture on lettuce seedling quality has been assessed. As result, it was determined that the mixture containing 40% vermicompost gave the lowest leaf number, and the fresh and dry weight of leaf and root decreased (even lower than the control), while the seedling quality in which mix containing 20% vermicompost is higher than others.

Terrestrial isopods (Isopoda: Oniscidea), a member of soil macrofauna, are invertebrate species that playing an important role in the decomposition of agriculture and livestock waste material (Drobne, 1997; Odendaal and Reinecke, 2003; Hussein et al., 2006; Loureiro et al., 2006). They are identified as an integral part of the decomposition proses, which recycles essential nutrients of the soil and maintains its fertility by the fragmentation of organic matter and stimulating and/or ingesting fungi and bacteria. Due to its high physiological adaptation capacity and exhibiting a broad distribution, they have become an important model organism for the monitoring of pollution and to test the hypotheses in global change biology (Kammenga et al, 2000; Zimmer, 2002). Among terrestrial isopods, particularly *Porsellio laevis*, since it is cosmopolitan and shows plasticity in physiological and life-history traits in response to different geographic–climatic conditions and can accumulate the heavy metals, it is utilized more intensively according to other species for the mentioned purpose (Powers and Bliss, 1983; Castañeda et al., 2004; Bacigalupe et al., 2007; Lardies and Bozinovic, 2008; Dailey et al., 2009; Folguera et al., 2009; Da Silva Junior et al., 2014).

Although the important role of isopods in the decomposition of organic materials, and the soil ecosystem is known very well, there is no available scientific research or information dealing with the utilization of fertilizer obtained from isopod as the plant growing media in agriculture production. The main objective of this study was to evaluate the usability of terrestrial isopod (*Porcellio laevis*) fertilizer added to growing media as a substrate component in different proportions for lettuce seedling production which is having an important place in vegetable production. Also, the effect of vermicompost added at a different ratio to the growing media has been tested.

Materials and Methods

The trial was conducted at the unheated greenhouse of the experimental field of the Department of Horticulture, Faculty of Agriculture, Tekirdağ Namik Kemal University, Turkey (40.99 N°, 27.58° E). By taking into consideration the results of the previous studies, the following seedling growing mediums were tested (Edwards and Burrows, 1988; Atiyeh et al., 1999; Ali et al., 2007; Hosseinzadeh et al., 2017).

1. Agricultural soil (collected from the top 30 cm depth)
2. Agricultural soil mixed with 1% vermicompost (v/v)
3. Agricultural soil mixed with 5% vermicompost (v/v)
4. Agricultural soil mixed with 10% vermicompost (v/v)
5. Agricultural soil mixed with 20% vermicompost (v/v)
6. Agricultural soil mixed with 1% isopod fertilizer (v/v)
7. Agricultural soil mixed with 5% isopod fertilizer (v/v)
8. Agricultural soil mixed with 10% isopod fertilizer (v/v)
9. Agricultural soil mixed with 20% isopod fertilizer (v/v)
10. Peat

Cow manure vermicompost, processed by red earthworm (*Eisenia foetida* L.), and peat that are using for vegetable seedling production were provided from commercial firms. The salinity and pH value of vermicompost used for the experiment were 3,46 dS/m and 6.8 (respectively). It had a 42,8% organic matter, 56,4% moisture, 1,40% N, 1,2% P_2O_5, 0.71% K_2O, 8.02% CaO. The peat recommended for the production of vegetable seedlings was used (Klasmann Potgrond H, Doktor Tarsa Inc., Antalya, Turkey). It had pH of 6.0, EC-value of 0.72 dS/m 160-260 ppm N, 180-280 ppm P_2O_5, 200-300 ppm K_2O and 80-150 ppm Mg. To prepare isopod fertilizer, the plastic pot having dimension 40-50x40 cm was used (Figure 1.) Firstly, three-liter agricultural soil was put into the pot and watered with tap water until the water drains. Then, two kg dry cow manure (old cow dung) that was obtained from the research farm of our university, and lettuce and carrot waste, wheat straw (each one 0.5 kg) were added. The mixture was stirred thoroughly and again was moistened. Three hundred adult isopods (*Porcellio laevis*) per pot was released into the pot and covered with fine mesh and left for 3 months at room temperature. During this period, it was mixed and moistened to provide the appropriate decomposition medium when it is necessary.

Figure 1. Preparation of isopod fertilizer: a) isopods, b) mixture, c) used pots and decomposing

The basic chemical properties of the agricultural soil and isopod fertilizer used in the experiments are presented in Table 1.

The agricultural soil had the clay loam texture (35.13% clay, 24.40% silt, 40.47% sand). Seeds of commercial lettuce (*Lactuca sativa* L.), iceberg type, 'Wismar' (Vilmorin-Anadolu Vegetable Seeds, Istanbul, Turkey) were sown at a depth of approximately 1 cm in multi-cell trays with cell volume 30 cc filled with media mentioned above. The trays were placed on benches inside the greenhouse. In order to clearly see the effect of the growing media, no additional fertilizer was applied during the experiment period. Regular watering by hand to keep the soil with adequate water supply was made. The minimum and maximum temperatures recorded during the growing period were given in Figure 2. In this period, the relative humidity ranged from 46% to 95%.

Table 1. The basic chemical properties of the agricultural soil and isopod fertilizer (If) were used in the experiments.

	pH	Salt (%)	Lime (%)	Organic matter (%)	N (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Fe (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
Soil	7.74	0.13	4.72	1.73	0.025	32.31	95.37	531.41	56.20	0.43	1.37	0.71	16.07
If	7.02	0.74	1.71	6.52	0.33	480.61	9591.45	7763.27	2528.88	6.89	3.18	42.43	21.59

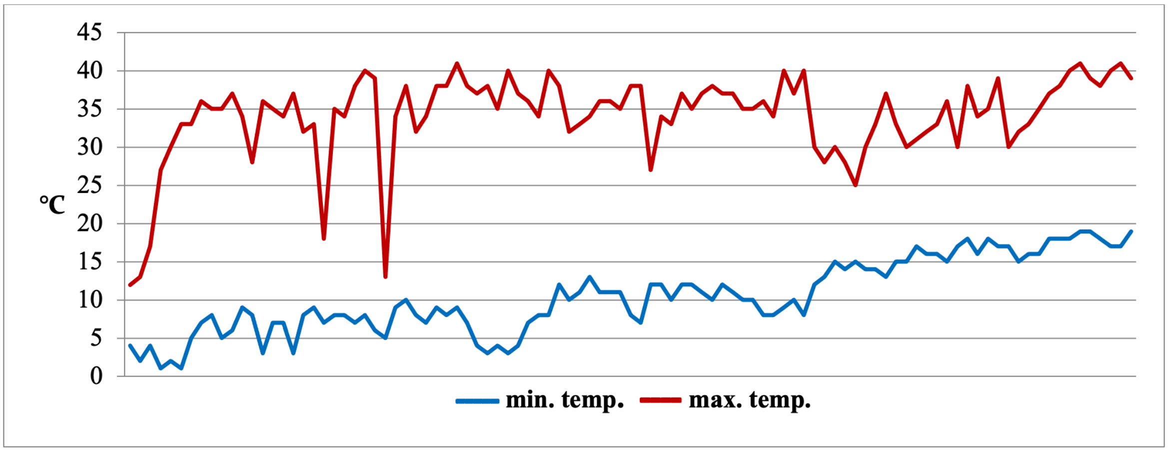

Figure 2. Daily minimum and maximum temperatures during the experiment period.

Emergence was daily recorded until there were no newly emerged seedlings for 3 days. The seedlings with fully opened cotyledons were recorded as 'emergence', and mean emergence time (MET) was calculated by using the following formula (Demir and Okcu, 2004):

Mean emergence time $=\Sigma nd/\Sigma n$

Where n = Number of seeds which emergence on day d, d = Number of days counted from the beginning of the emergence

Thirty-five days after sowing, 10 seedlings selected randomly for each replication were carefully removed from trays and the media adhering to the roots of seedlings was washed using tap water. were carefully removed from trays and the media adhering to the roots of seedlings was washed using tap water. After counting the leaves and measuring the stem diameter, seedlings were cut to separate the root and stem portions for determining the fresh and dry weight. The dry weight of shoot and root was determined by drying in an oven at 65°C for 24 hours. The weight of the root and shoot of each seedling were taken using an electronic weighing balance (least count=0.01 g).

The experimental design was a randomized complete block with three replications. All data were subjected to analysis of variance (ANOVA) and mean values were compared with the LSD ($P \leq 0.05$) test.

Results and Discussion

It is desirable to germination at a high rate and in a short time in the vegetable seedlings production. Also, stem diameter, weight, etc. are useful data tools for the identification of plants with desirable horticultural characteristics and the ideal a seedling should have a substantial weight, thick stem, adequate leaf area, etc. (Song and Tan, 1989). According to the results of this study shown in Table 2, there was no statistical difference among different growing media regarding the germination and the seedling characters of lettuce. Besides the differences among the growing media concerning germination percentage were not important statistically, the highest germination percentage (64%) was obtained from seeds sown in peat. A good growing media should be porous for root aeration and drainage besides capable of retaining water and nutrients (Kumar and Raheman, 2012). The fresh and dry weight of shoot and the fresh and dry weight of root of seedling grown in peat, and in mixtures containing vermicompost or isopod fertilizer in different proportions were higher than control (soil). The shoot and root growth of seedlings grown in soil were poor probably because of poor aeration and insufficient of some plant nutrients. As similar to the results of our study, it has reported an increase in the weight of tomato seedlings when vermicompost and compost were substituted in the growth medium up to 20% by volume (Subler et al., 1998; Atiyeh et al., 2000). Kumar and Rahemann (2012) revealed that the best growth media was a mix of 25% vermicompost and 75% soil for three vegetable seedlings (tomato, eggplant, and chili peppers). Bachman and Metzger (2008) have stated that additional vermicompost in the growth medium very little affected the growth of pepper seedlings. In a study conducted to analyze substrate changes according to vermicompost doses and evaluate the effect of the mixtures on lettuce seedling quality, the substrates with different amounts of vermicompost added and a commercial mix of peat and perlite had been used (Tombion et al., 2016). As a result, the addition of vermicompost resulted in a linear increase in pH, electrical conductivity, nutrient level, bulk density and total porosity of the substrate and a 20% increase was determined in seedling size. In a study conducted by Ribeiro et al. (2007), substrates containing compost at different ratio was used as an alternative to peat-based substrates for the production of vegetable seedlings. While the growth of tomato seedlings was higher on the substrates containing compost, both the emergence and growth of lettuce seedlings were not affected by the presence of compost.

Table 2. The effect of different growing media on the emergence percentage (%), mean emergence time (days), number of leaves, stem diameter (mm), shoot fresh weight (FW, g), shoot dry weight (DW, g), root fresh weight (FW, g) and root dry weight (DW, g) of lettuce seedling*.

	Emergence percentage (%)	MET (days)	Number of leaves	Stem diameter (mm)	Shoot FW (g)	Shoot DW (g)	Root FW (g)	Root DW (g)
Soil	48.6	12.1	3.89	1.74	1.23	0.25	0.27	0.14
1% Vc**	48.6	13.0	4.00	1.60	1.32	0.27	0.32	0.15
5% Vc	54.9	11.7	3.89	1.86	2.49	0.42	0.49	0.23
10% Vc	49.3	11.7	4.22	1.96	1.53	0.31	0.36	0.20
20% Vc	46.5	12.0	3.89	2.02	1.49	0.31	0.36	0.17
1% If***	50.0	11.8	3.89	1.70	1.40	0.27	0.31	0.16
5% If	48.6	11.5	4.11	1.75	1.44	0.29	0.34	0.17
10% If	58.3	11.7	4.11	1.93	2.33	0.39	0.51	0.20
20% If	55.6	11.4	4.22	2.05	2.14	0.32	0.47	0.17
Peat	64.6	11.5	3.99	2.14	2.32	0.43	0.40	0.18

*According to the analysis of variance, the differences among mean values of the emergence and seedling parameters were not significant.
**Vc: Vermicompost, ***If: Isopod fertilizer

Conclusion

When the vermicompost and isopod fertilizer was added to the seedling growing medium, the differences seen in terms of emergence and seedling characteristics among applications were not found statistically significant. This may be due to very short of a lettuce seedling growing time to see the effect of vermicompost or isopod fertilizer adding. However, fresh and dry weights of seedlings in isopod fertilizer and vermicompost containing media were higher than those grown in soil. Indeed, the same growing media was used in lettuce cultivation and by adding vermicompost and isopod fertilizer into the soil, the increase of yield and quality was provided (data not presented).

Compliance with Ethical Standards

Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Not applicable.

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Data availability

Not applicable.

Consent for publication

Not applicable.

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