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SHORT COMMUNICATION

Municipal solid waste compost and its derivatives, a suitable alternative to peat moss in the growth of *Dracaena marginata* tricolor

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Abstract

Purpose This study aimed to investigate the effects of compost and vermicompost of municipal solid waste application on the growth of *Dracaena marginata* tricolor. Then, the results of foliar application of compost tea and vermicompost tea on the plants were examined.

Method Experimental treatments included compost and vermicompost of municipal solid waste in proportions of 50 and 70% combined with the perlite. Then we sprayed compost tea and vermicompost tea on the plants at a concentration of 10 ml. At the end of the study, the physical and chemical properties of the substrates, the amounts of macronutrients in the substrates and the plants, growth indices, as well as anthocyanin content, were evaluated.

Results The results showed that conversion municipal solid waste compost to vermicompost improved the physical and chemical properties of this material and the absorption of nutrients. Also, the vegetative indices and anthocyanin content of this plant were positively affected. Foliar application of compost tea and vermicompost tea caused higher nutrient absorption and improved plant growth indices, except for dry root weight. In general, combining 50% of the organic components of substrates with perlite achieved better results.

Conclusion Based on the findings, compost, and vermicompost of municipal solid waste are cheap and available alternatives to peat moss in the cultivation of *Dracaena marginata* tricolor. Also by spraying compost tea and vermicompost tea, it significantly improved the amounts of nutrients, vegetative indicators, and its appearance.

Keywords Compost, Dracaena, Growing media, Municipal solid waste, Recycling, Vermicompost

Introduction

Ornamental shrubs have long been widely grown indoors, such as homes, and special among decorative plant lovers. One of the most special and beautiful of these plants is *Dracaena* spp, from the Agavaceae family. This plant has 40 different species and grows as a tree in its natural habitats, such as tropical Asia and Africa (Dole and Wilkins 1999). *Dracaena marginata* tricolor can be easily distinguished from other species by its unique leaf shape and different growth habit.

Dracaena marginata tricolor, like other ornamental leaf plants, needs a suitable substrate for proper growth. The growing media and nutritional requirements are the most critical factors affecting ornamental pot plant's well-being (Mohamed 2018). A suitable growing medium should provide the plant with water and nutrients and have the desired physical and chemical properties. Other essential features of an ideal growing medium include good permeability, sufficient strength for plant establishment, and a high ability to retain water and transport gases (Dresboll 2010). Therefore, an optimal pot substrate can significantly reduce the management required to produce quality plants (Mohamed 2018).

Accordingly, an optimal substrate consists of two components, organic and inorganic. Peat moss is the most important and main organic component of conventional growing media in different plants (Vaughn et al. 2011). This organic substance has all the above characteristics for an ideal growing media. This unique

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and natural substance has a significant share of organic matter in the culture media of various plants (Ribeiro et al. 2007). Therefore, the uncontrolled harvesting of endangered ecosystems has become a primary global concern (Vaughn et al. 2011) About 80% of world peat moss production goes to Finland, Ireland, Germany, Sweden, Belarus, Russia, and Canada (Apodaca 2018). This issue has led to various studies finding new and quality substrates as an alternative to peat moss (Benito et al. 2005).

Composts produced from various organic materials are among the materials that can be considered suitable alternatives to peat moss. Organic compost can have positive effects on the better growth and yield of plants. These organic matters become a source of fiber and the elements like nitrogen, phosphorus, and potassium for plant growth and rooting (Vandecasteele et al. 2018). When these materials begin to rot, the mineral elements in them are released. This release improves the photosynthetic pigments of the plant, increases the levels of nutrients, and as a result, the plant grows better in that growing medium (Rady et al. 2016). Therefore, by preparing compost from different organic materials, it is possible to produce desirable substrates. These growing media are much cheaper and more accessible than peat moss and with similar quality can guarantee better plant growth.

Accordingly, one of the materials from which compost production has received much attention is municipal solid waste, which has flourished in agriculture. Population growth, changing consumption patterns, people's tendency to live in cities, and the use of materials that decompose late are factors that cause the production of a considerable amount of waste in small and large cities in each country daily. Municipal solid waste compost is a suitable organic fertilizer for growing different types of plants. The use of this compost can affect the physical, chemical, microbial, and biological properties of the soil. This organic fertilizer provides plant nutrients such as nitrogen, phosphorus, potassium, and microelements and increases plant growth regulators, help to better plant performance (Arancon et al. 2004). This substance improves the efficiency of the plant's photosynthetic system. Subsequently, municipal solid waste compost stimulates the growth of roots, stems, and leaves of the plant. The municipal solid waste compost increases the production of storage materials in the leaves and absorbs nutrients and water by the roots (Sallaku et al. 2009). This organic material can also increase the plant's hormonal activity, strengthening the root system, more nutrient uptake, and better plant growth (Alvarez and Grigera 2005). The results of research by many researchers such as Ryals and Silver (2013), Haden et al. (2014), Rady et al. (2016), and Gruda et al. (2019) show that the use of municipal solid waste compost can effectively lead to better results in different plants. This compost increases the absorption of nutrients, photosynthetic activity, and better growth of the plant.

Municipal solid waste compost can produce an output product, which is vermicompost. This means that we can turn these organic materials into vermicompost in stages. Vermicompost which is a type of plant fertilizer is obtained from the interaction of a kind of earthworm called *Eisenia foetida* and microorganisms (Arancon et al. 2004). This organic fertilizer has very beneficial effects on soil improvement and plant growth. Since vermicompost is produced from organic matter, it can add various nutrients to the soil, and develop the plant's root system. Vermicompost increases the absorption of nutrients and photosynthetic efficiency of the plant and ultimately improves plant growth. Vermicompost has high total porosity and high water holding capacity. Also, this organic fertilizer has a positive effect on the production potential of fruits, vegetables, and ornamental plants (Deepmala et al. 2016). The findings of Ayyobi et al. (2013) showed that the use of vermicompost positively affects the growth indices of peppermint. Senthilkumar et al. (2004) also reported that this organic matter could significantly affect the growth and yield of roses.

0n the other hand, compost tea, and vermicompost tea can also be extracted from these materials, as another by-product. Compost tea and vermicompost tea are obtained by placing a certain amount of compost and vermicompost in the water (Scheuerell and Mahaffee 2004). The use of compost tea and vermicompost tea has many positive effects on plant growth and yield. These substances can improve plant growth by increasing nutrients, microorganisms, and plant growth regulators (Edwards et al. 2006). Compost tea and vermicompost tea by having elements such as zinc and iron can increase the chlorophyll content and the rate of plant photosynthesis (Tejada and González 2009). The findings of Reeve et al. (2010) on wheat and Pant et al. (2011) on *Brassica napus* also show the favorable effects of compost tea application on these plants.

Based on the above, municipal solid waste compost and vermicompost can be used as quality alternatives and much cheaper than peat moss, and affect plant growth. Therefore, in this study, the effect of municipal solid waste compost and its derivatives on the growth of *Dracaena marginata* tricolor was investigated. Also, the possibility of replacing these substrates with peat moss was evaluated.

Materials and methods

Experimental design and treatments

The present study was conducted from April to November 2019 in a commercial greenhouse located in Izad Shahr city (Mazandaran province, Iran). All laboratory measurements were performed in a private laboratory located in Babol city (from other cities of this province). This research was carried out in a factorial experiment and based on a complete randomized design with two factors: growing medium and foliar application. As in the beginning, we investigated the effect of compost and vermicompost of municipal solid waste on *Dracaena marginata* tricolor. Then, two months after the start of the experiment, compost tea (S_1) and vermicompost tea (S_2) in a concentration of 10 ml were sprayed on some of these plants once every two weeks. The substrates used in this study were:

M_1- 50% peat moss + 50% perlite (Control)
M_2- 50% municipal solid waste compost + 50% perlite
M_3- 70% municipal solid waste compost + 30% perlite
M_4- 50% municipal solid waste vermicompost + 50% perlite
M_5- 70% municipal solid waste vermicompost + 30% perlite

Test method

Perlite is a mineral that has many applications as a mineral component in a variety of growing media and uses for rapid root development and the balance of the climate ratio in the substrates (Asaduzzaman et al. 2013). The perlite grains used in this study had sizes of 1.5 to 2 mm. Also, the peat moss brand used was Helioflor, made in Estonia, and municipal solid waste compost was purchased from Tehran Municipality. Vermicompost was obtained from the same compost and *Eisenia foetida* earthworm (1.6 kg of earthworm per square meter of compost). To make the compost tea and vermicompost tea, tap water was first aerated for 8 hours to remove chlorine. Then municipal waste compost and vermicompost were mixed in a ratio of 1 to 5 with this water in a 25-liter container at room temperature. The mixture was aerated for 14 days every day for 4 hours using an aquarium air pump. In the next step, the aerated mixture was passed through several filters to obtain compost tea and vermicompost tea finally. The obtained tea was stored in a dark polyethylene container at room temperature for 15 days before consumption (Morales-Corts et al. 2018). Before spraying, the compost tea was diluted twice with distilled water and then spread with a concentration of 10 ml. The characteristics of the organic and inorganic components are in Table 1.

Day and night temperatures in this glass-covered greenhouse were 24±1°C and 18±1°C, respectively, and its relative humidity was in the range of 60 to 70 percent. The intensity of light entering the greenhouse was in the field of 7000 lx, and in summer, to reduce the intensity of light entering the greenhouse, exceptional dark curtains were used. For this study, 4-liter pots disinfected by 2% sodium hypochlorite were used, and in each pot was placed a rooted cutting of *Dracaena marginata* tricolor with the 10 cm height and five leaves. The plants were irrigated to ensure leaching from the pot, with a frequency depending on greenhouse temperature and solar radiation. Also, no chemical fertilizer was used during the experimental period.

Table 1 Some chemical properties of organic and inorganic components used in the experiment

Component	pH	EC (dS cm^{-1})	N (%)	P (%)	K (%)	CEC (centimol kg^{-1})
Peat moss	5	0.71	1.77	1.53	1.60	141.11
Municipal solid waste compost	7.85	2.93	1.31	1.16	1.04	116.40
Municipal solid waste vermicompost	7.69	1.88	1.45	1.22	1.30	123.24
Compost tea	8.02	1.33	0.66	0.73	0.80	67.71
Vermicompost tea	7.86	1.21	0.61	0.88	0.85	70.16
Perlite	7.00	0.10	0	0	0	0.11

Measurement of essential elements and physical and chemical properties of growing media

At the end of the experiment, the studied traits were evaluated to determine the effects of municipal solid waste compost application and its derivatives on Dracaena plant growth. The physical and chemical properties of growing media were investigated at the end of the experiment, and physical properties were determined by Spomer (1990) and Webber et al. (1999). PH and EC were obtained by Milford's (1976) method. The amounts of nitrogen, phosphorus, and potassium in growing media were calculated by Kjeldahl, Olsen, and Flame photometer methods, respectively (Page et al. 1982). The organic carbon and cation exchange capacity was obtained by Walkly and Black (1934) and Harada and Inoko's (1980) methods, respectively.

In addition to the nutrient intake in substrates, the amount of these elements in plant tissue was also investigated. The amounts of nitrogen and phosphorus were measured by Kjeldahl and Ammonium molybdate-vanadate methods (Ryan et al. 2001), and potassium was measured by flame photometer method.

Measurement of plant growth indices

The most critical growth indices of the plant were measured at the end of the study. The height of the plant was a distance between the edges of the pot to the end of the plant. The dry weight of aerial organs and roots of the plant was obtained by placing the samples in an oven at 60 °C for 24 hours (Rosalina et al. 2019). Also, the total chlorophyll content of plant leaves was measured by Arnon (1949) method. Since the leaves of *Dracaena marginata* tricolor is red over the green, and the redness of the leaves of this species adds to its marketing, the content of anthocyanin in plant's leaves was investigated by Bates et al. (1973). At the end of the research, data analysis was done by SPSS, and the comparison of averages was made by Duncan's multiple range test (DMRT) at 1 or 5 percent possibility level.

Results and discussion

Physical and chemical properties of growing media

pH and EC

The results of the physical and chemical properties of the growing media are shown in Table 2. As expected, the lowest pH and EC were observed in the control treatment (50% peat moss + 50% perlite) because peat moss is an entirely acidic substance and perlite is a completely neutral substance.

On the other hand, the conversion of municipal solid waste compost to vermicompost significantly reduces its pH and EC. This matter shows the superiority of municipal solid waste vermicompost over the compost. Therefore, the increase in the volume of organic matter in these substrates has caused a rise in pH and EC in treatments M_3 and M_5. Of course, excessive use of these composts can increase the pH and EC of growing media in the long run. Gruda et al. (2019) consider the biggest challenge facing the use of municipal solid waste compost to increase soil electrical conductivity and states that excessive application of municipal solid waste compost increases soil EC. Navas et al. (1998) and Grigatti et al. (2007) reported that high use of composts could hurt the pH and EC, and the absorption of nutrients in the growing medium. Therefore, observing moderation in the consumption of these organic fertilizers is one of the necessary conditions for their use as a substrate for various plants in the agricultural sector.

Table 2 Comparison of chemical and physical properties in different substrates

Treatment	pH	EC (dS/m)	Organic Carbon (%)	CEC (centimol/kg)	C/N	Bulk Density (g/cm3)	Total Porosity (%)	Water Holding Capacity (%)
M_1	5.10 d	0.80 d	12.66 c	112.62 a	11.40 e	0.31 c	57.88 a	71.15 a
M_2	7.80 b	2.85 b	14.41 a	96.54 d	18.71 a	0.45 b	50.07 c	65.24 d
M_3	7.91 a	2.97 a	14.50 a	100.17 c	16.80 b	0.49 a	48.64 d	62.55 e
M_4	7.70 c	1.89 c	13.29 b	106.07 b	15.10 c	0.44 b	51.86 b	69.49 b
M_5	7.71 c	1.91 c	13.32 b	107.23 b	13.87 d	0.49 a	50.33 c	67.33 c

In each column, averages with at least one common letter are in statistically similar groups, with Duncan's multiple range tests at 1% possibility.

Organic carbon, CEC and C/N ratio

According to Table 2, organic carbon and organic matter in municipal solid waste compost and vermicompost are more than peat moss. Since municipal solid waste compost is obtained directly from the food and organic materials in the waste, it has a high percentage of nutrients. So this organic fertilizer shows a positive effect on the growth of various plants. Rady et al. (2016) also reported that compost could increase soil organic matter and cause positive effects on plant growth. According to the results, the conversion of municipal solid waste compost to vermicompost has reduced organic carbon in this material. It has been added to the CEC of vermicompost. This can be attributed to the particle size distribution and higher fertility of vermicompost compared to compost. The activity of earthworms in vermicompost modulates the particle size of this material compared to compost (Gong et al. 2018). As a result, the distribution of nutrients is better and more accessible in vermicompost, and the plant root uses different elements more willingly. High levels of CEC in municipal solid waste compost and vermicompost have been reported by many researchers, including Gruda et al. (2019) and Gong et al. (2018). Therefore, compost and vermicompost from municipal solid waste are equal to peat moss in food and organic carbon. So, this matter indicates the richness and fertility of these organic materials. Also, by examining the ratio of carbon to nitrogen in these treatments, we find that both organic substances are in good condition in the degree of maturation. In composts, the C/N ratios less than 20 indicate compost maturity (Bernal et al. 1998). So without any worries, these environmentally friendly fertilizers can be used as an organic component of growing media.

Bulk density, porosity, and water holding capacity

By comparing the physical properties studied in the experimental treatments, we find that municipal solid waste compost and vermicompost showed higher bulk density than peat moss. However, the amount of bulk density in compost and vermicompost with increasing the percentage of perlite has shown a significant decrease, which leads to the positive effect of the mineral component of the growing medium on reducing this trait. Besides, the combination of compost and vermicompost of municipal solid waste with 50% perlite has increased the percentage of total porosity and water holding capacity in these substrates compared to the combination of these organic components with 30% perlite. Perlite can absorb water up to several times its weight, and since it does not rot during use in the growing medium, it can help improve water retention in the environment around the plant roots. In general, an optimal growing medium should have 10 to 30 percent space for air conditioning and 45 to 65 percent for water storage (Samadi 2011).

Accordingly, compost and vermicompost are substances that can increase soil porosity and thus lead to the development of the plant root system (Yagi et al. 2003). Also, the high water holding capacity of compost and vermicompost can be another factor in replacing these materials with peat moss. The results of research by Arancon et al. (2004) also showed that compost improved the physical and chemical properties of soil and increased the percentage of nutrients. In contrast, the beneficial and appropriate effects of composts on plant growth can be attributed firstly to adjust the pH and increase water holding capacity in the environment around the roots and secondly to improve the physical, chemical, biological, and microbial properties of soil due to the use of these materials (Mcginnis et al. 2003). The results of Table 2 clearly show that the conversion of compost to vermicompost significantly increased porosity, water holding capacity, CEC, and also decreased pH and EC in this substrate. Therefore, the superiority of vermicompost over compost can be seen in the studied traits. In peat moss, its excellent physical and chemical properties have led to the best results. Based on the results of this study, compost and vermicompost of municipal solid waste showed physical and chemical properties close to peat moss, which could be a reason to replace these materials with peat moss.

Nutrients in growing media

According to Table 3, the highest amounts of nitrogen, phosphorus, and potassium are kept in the control treatment. The high percentage of nutrients, along with the ideal physical and chemical properties in peat moss, are the reasons that have always made this organic matter the perfect substrate for growing various plants.

Similarly, municipal solid waste compost has a high percentage of high-consumption elements required by plants. This material is produced directly from organic matter and food in municipal waste through an aerobic process. Therefore, a high percentage of nutrients are observed in this substrate. On the other hand, the conversion of municipal solid waste compost into vermicompost has also increased the share of nutrients. So the studied elements have a higher rate in vermicompost relative to compost. Also, perlite does not contain any nutrients. Therefore, increasing the volume of organic components from 50 to 70% has increased the percentage of nutrients in M_3 and M_5 treatments compared to M_2 and M_4.

Table 3 Comparison of nutrient concentration average in different substrates

Treatment	N (%)	P (%)	K (%)
M_1	1.21 a	0.98 a	1.03 a
M_2	0.87 d	0.66 c	0.59 d
M_3	0.96 c	0.67 c	0.67 c
M_4	0.98 c	0.75 b	0.68 c
M_5	1.06 b	0.75 b	0.77 b

In each column, averages with at least one common letter are in statistically similar groups, with Duncan's multiple range tests at 1% possibility.

The point about nitrogen in converting municipal solid waste into compost is that high levels of nitrogen in organic waste cause nitrogen loss and an increase in nitrogen gases, resulting in reduced efficiency in compost production (Fukumoto et al. 2003). The lowest decomposition rate among organic fertilizers is the decomposition of materials that composted (Moran et al. 2005). The results of the long-term decay of organic matter show that the amounts of total carbon, total nitrogen, and their proportions decrease during the incubation period because carbon decomposes more rapidly than nitrogen (Quemada 2005). Therefore, the ratio of carbon to nitrogen in compost produced from municipal solid waste is significant for its use in agriculture, has tested in compost and vermicompost to a desirable level. Therefore, the results show that municipal solid waste compost and vermicompost are rich in essential elements for the growth of shoots and roots of plants and can be equal to peat moss. The findings of Gong et al. (2018) and Pant et al. (2011) show that vermicompost can increase plant growth and yield by increasing the percentage of elements necessary for plant growth. This nutrient availability due to the application of municipal solid waste compost has also been reported by researchers such as Gruda et al. (2019) and Sharifi et al. (2011).

Nutrients in plant tissue

Table 4 shows the number of nutrients in plant tissue in different substrates and foliar application of compost tea and vermicompost tea. The highest uptakes of nitrogen, phosphorus, and potassium have been observed in plants planted in 50% peat moss + 50% perlite. This result is directly related to the higher amount of these elements in this substrate. In Table 3, the highest amounts of nitrogen, phosphorus, and potassium belonged to the control treatment.

Table 4 Comparison of nutrient concentration average in the tissue of plants

Treatment	N (%)	P (%)	K (%)
M_1	1.95 a	0.71 a	1.12 a
M_2	1.66 d	0.63 c	0.80 e
M_2S_1	1.78 c	0.65 c	0.86 d
M_2S_2	1.78 c	0.68 b	0.88 d
M_3	1.70 d	0.64 c	0.80 e
M_3S_1	1.79 c	0.65 c	0.85 d
M_3S_2	1.80 c	0.68 b	0.88 d
M_4	1.78 c	0.68 b	0.94 c
M_4S_1	1.88 b	0.71 a	0.98 c
M_4S_2	1.89 b	0.72 a	0.99 b
M_5	1.86 b	0.68 b	0.93 c
M_5S_1	1.95 a	0.72 a	0.96 c
M_5S_2	1.96 a	0.72 a	0.99 b

In each column, averages with at least one common letter are in statistically similar groups, with Duncan's multiple range tests at 1% possibility.

According to Table 2, the higher amounts of nitrogen, phosphorus, and potassium showed in vermicompost. In Table 3, plants planted in vermicompost and perlite (M_4 and M_5) had higher uptake of these elements than compost. Therefore, the conversion of municipal solid waste compost into vermicompost has also increased the number of nutrients in the growing media and their absorption by the plant. The presence of high amounts of nutrients and fiber, along with high water holding capacity in compost, increases overall fertility and soil stability (Rady et al. 2016). When the municipal solid waste compost turns into vermicompost under suitable conditions, the properties of this compost undergo new positive changes due to the activity of earthworms and microorganisms. The resulting vermicompost becomes a peat moss-like substance with porosity, aeration, and drainage, water holding capacity, high microbial activity, and nutrients plants require (Latifah et al. 2009). Also, high amounts of trace and high consumption elements in vermicompost increase nutrient availability and improve soil quality (Jat and Ahlawat 2008). So, it results in modifying the physical, chemical, and microbiological structure of the soil around the roots. By modifying the soil characteristics around the plant roots, access to water and nutrients, microbial activity, essential enzymes, and production of plant growth-promoting substrates are favorably affected (Sahni et al. 2008). Therefore, by converting municipal solid waste compost to vermicompost, the appropriate properties of this compost can be increased in a positive direction. The results of Kaviraj and Sharma's (2003) research also indicate that converting of municipal solid waste into vermicompost increases the percentage of elements such as potassium.

On the other hand, the use of compost tea and vermicompost tea has increased the amount of nitrogen, phosphorus, and potassium in the plant's tissue. As shown in Table 4, foliar application of these two organic substances caused a significant increase in nitrogen concentration in plant tissues. Of course, the effect of vermicompost tea on increasing nitrogen concentration was slightly higher than compost tea, but this difference was not statistically significant. In the case of phosphorus, the use of compost tea and vermicompost tea has increased the concentration of this element. Still, the effect of these organic substances on the concentration of phosphorus is less than the element nitrogen, which can be due to the lower amount of phosphorus in the growing medium and in plant tissue. The amount of potassium increased significantly with foliar application of compost tea and vermicompost tea. The concentration of elements in vermicompost was higher than the compost. So, a foliar application of compost tea and vermicompost tea had a more significant effect on the uptake of macronutrients in these substrates compared to municipal solid waste compost.

During the production of compost tea and vermicompost tea, the nutrients enter the compost tea and vermicompost tea. The use of these substances in the soil improves root growth and increases the absorption of nutrients by the plant. Also, compost tea and vermicompost tea can be used as a foliar application or soil application (Bess 2000). Therefore, according to Table 4, it is concluded that foliar application of compost tea and vermicompost tea can increase the concentration of essential elements in plant tissue. So by applying these organic materials in the substrate of 70% vermicompost + 30 perlite, the amount of nitrogen and phosphorus in plant tissue is equal to the concentration of these elements in 50% peat moss + 5% perlite.

Plant growth indices

Table 5 evaluates the growth indices of *Dracaena marginata* tricolor in the tested substrates and foliar application of compost tea and vermicompost tea. Therefore, first, the effects of substrates and foliar application on these indicators are investigated.

Table 5 Comparison of plant growth indices in different substrates

Treatment	Height (cm)	Number of leaves	Dry weight of aerial organs (g)	Dry weight of roots (g)	Total chlorophyll (mg/gfw)	Anthocyanin (mL/cm)
M_1	58.33 a	42.36 a	7.02 a	3.64 a	0.58 e	0.73 c
M_2	51.97 f	39.06 d	6.66 f	3.49 c	0.58 e	0.71 d
M_2S_1	52.16 f	41.15 c	6.70 e	3.50 c	0.59 d	0.74 c
M_2S_2	52.71 f	41.44 c	6.70 e	3.50 c	0.60 c	0.76 b
M_3	52.44 f	39.12 d	6.61 f	3.47 c	0.58 e	0.70 d
M_3S_1	53.52 e	41.21 c	6.69 e	3.47 c	0.59 d	0.76 b
M_3S_2	53.24 e	42.02 b	6.71 e	3.48 c	0.60 c	0.76 b
M_4	54.93 d	39.40 d	6.77 d	3.57 b	0.60 c	0.73 c
M_4S_1	56.26 c	42.12 b	6.89 b	3.57 b	0.63 b	0.76 b
M_4S_2	57.07 b	42.46 a	6.87 b	3.57 b	0.64 a	0.78 a
M_5	55.29 d	39.11 d	6.77 d	3.55 b	0.60 c	0.73 c
M_5S_1	56.65 c	41.99 b	6.82 c	3.56 b	0.64 a	0.78 a
M_5S_2	57.28 b	42.33 a	6.85 c	3.55 b	0.64 a	0.79 a

In each column, averages with at least one common letter are in statistically similar groups, with Duncan's multiple range tests at 1% possibility.

Plant height

Looking at this Table, the highest plant height is observed in the substrate of 50% peat moss + 50% perlite. Since this substrate has excellent physical and chemical properties for plant growth and the highest uptake of high consumption elements (especially nitrogen) has been seen in this growing medium, the highest change of *Dracaena marginata* tricolor in this substrate seems entirely natural. Examining other growing media, we find that municipal solid waste vermicompost led to plants with higher height than municipal solid waste compost. Therefore, this higher height of plants in vermicompost can be attributed to the better physical and chemical properties and more nutrient uptake in this substrate than compost. Also, combining these organic materials with 50% perlite has shown better results in plant growth than mixing these materials with 30% perlite. Perlite is a substance with no significant nutrients for better plant growth and yield. This mineral matter has a significant effect on maintaining moisture and increasing aeration in the plant growth environment. In general, the organic components of substrates have a high percentage of nutrients and desirable physical and chemical properties. But these materials, without combining with mineral components (in appropriate proportions), cannot be a suitable substrate better growth of the plant. Therefore, the use of perlite mineral in a volume of 50% in combination with compost and vermicompost of municipal solid waste provides more desirable characteristics for these growing media, which results in better plant growth.

Number of leaves

The results of Table 5 on the number of leaves of the plant show that the highest number of leaves produced belongs to the control treatment. There is no significant difference between compost and vermicompost of municipal solid waste in this trait. It is noteworthy that the plants planted in M_2 and M_3 treatments showed lower height compared to M_4 and M_5 treatments. But these treatments produced more leaves at this lower altitude, which resulted in denser and more beautiful plants compared to peat moss and vermicompost. Since municipal solid waste compost is a material with inherently high electrical conductivity, this plant growth (lower height and more leaves) can be attributed to its high electrical conductivity. Similarly, Fitzpatrick (1986) states that the reason for this type of growth in Spathiphyllum and Schefflera plants is the high electrical conductivity in the substrates of these plants.

As in plant height, the combination of compost and vermicompost of municipal solid waste with 50% perlite has produced more leaves in *Dracaena marginata* tricolor, but this difference is not statistically significant. Municipal solid waste compost modifies the physical, chemical, microbial and, biological properties of soil. It promotes further plant growth by providing essential nutrients, microelements, as well as plant growth regulators (Arancon et al. 2004). So, this organic matter with soil improvement and increasing water holding capacity (Haden et al. 2014), and nutrient uptake (Cherif et al. 2009) has a significant effect on better plant performance. The results of many researchers, including Srivastava et al. (2016) and Gruda et al. (2019), also confirm the beneficial effects of this green fertilizer on plant growth. On the other hand, the vermicompost with having the above characteristics can lead to an increase in plant height and number of leaves. Besides, the activity of earthworms and the effects of microorganisms during the production period of vermicompost cause the improvement of compost properties. Therefore, it is possible to see plant growth indices such as height and number of leaves in plants planted in this organic matter. Asciutto et al. (2006) and Yanan et al. (2018) also, in their research on *Impatiens walleranna* and strawberry plants, stated that the vermicompost could positively affect the growth parameters of the plant.

The dry weight of aerial organs and root

The Dracaena plants planted in the substrate of 50% peat moss + 50% perlite had the highest dry weight of aerial organs and roots, because of the higher growth of plants observed in this growing medium. The results of Mohamed's (2018) research also point to the positive effect of peat moss on the fresh and dry weight of aerial organs and the root of the Areca palm. Regarding these two traits, the application of vermicompost significantly increased aerial organs and root dry weight compared to compost in *Dracaena marginata* tricolor, which can be directly related to higher plant growth in M_4 and M_5 treatments. Besides, more dry weight in the aerial organs and roots can be associated with the absorption of potassium and phosphorus. The uptake of potassium can reduce the amount of water used to produce dry matter and overall biomass in the plant. So higher uptake of this essential element has significant effects on the dry weight of the plant shoots. Also, because the element phosphorus plays a vital role in the growth and development of the plant root system (Mengle and Kirkby 1995), increasing the uptake of this element causes a better change of the root and increases its dry weight. Based on these statements and looking at Tables 3 and 4, we find higher amounts of phosphorus and potassium in vermicompost than compost. Therefore, higher absorption of these two essential elements by plants planted in vermicompost can play an essential role in increasing the overall biomass of the plant.

As mentioned earlier, municipal solid wastes compost and vermicompost are obtained from aerobic decomposition of organic matter and have good physical and chemical properties. These organic substances can increase the hormonal activity of the plant and strengthen the root system. So these materials absorb more nutrients and improve plant growth (Alvarez and Grigera 2005). Besides, using these organic fertilizers as a growing medium or in combination with other organic and inorganic materials can also positively effect on soil acidity, microbial population, and soil enzymatic activity (Maheswarappa et al. 1999). The results of Gruda et al. (2019) and Yanan et al. (2018), also point to the positive effect of the municipal solid waste compost and vermicompost on plant growth and its dry weight gain.

Total chlorophyll content

Based on the results of Table 5, the use of municipal solid waste compost causes plants with chlorophyll content equal to peat moss, and the use of vermicompost produces plants with a higher chlorophyll index than peat moss. This increase in chlorophyll content due to the use of these materials can be stated that the application of these organic fertilizers can affect the physical and chemical properties of the growing medium such as porosity and water holding capacity and provide a suitable environment for the system root of a plant. As a result, the plant uses the water and nutrients in the compost more optimally. It shows better growth by increasing the chlorophyll content and improving the efficiency of the photosynthetic system. Also, compost and vermicompost of municipal solid waste have a positive effect on the absorption of microelements such as iron (Mahmoodabadi et al. 2010). These materials can have many beneficial effects on increasing the chlorophyll content of the plant. Therefore, composts have a direct impact on photosynthesis and better growth of plant organs. So compost produces the most storage materials in leaves and also increases water and nutrient uptake from the roots (Sallaku et al. 2009). The results of many researchers, including Rady et al. (2016) and Ayyobi et al. (2013), also indicate an increase in chlorophyll content and improvement of growth indices of *Phaseolus vulgaris* and peppermint plants due to the use of compost and vermicompost.

Anthocyanin content

Based on Table 5, peat moss and municipal solid waste vermicompost have produced plants with equal anthocyanin content. The redness of the leaves in *Dracaena marginata* tricolor is superior to the greenness of the leaves. Also, the increase in anthocyanin content and better coloring of the leaves adds to the marketability and quality of this plant. Therefore, the use of municipal solid waste vermicompost can produce plants with beautiful red leaves. Of course, plants planted in municipal solid waste compost showed high levels of anthocyanin (almost close to peat moss). This matter indicates the high potential of this substrate for replacement with peat moss. It is worth mentioning that the plants in this substrate had a stunning appearance and color due to their lower height and more leaves. Therefore, the use of municipal solid waste compost and vermicompost can improve plant physical and chemical properties. Also, these green fertilizers cause plant access to nutrients, better root system performance, and increase photosynthesis and plant growth. Besides, these organic materials in growing media can produce high-quality plants, such as quality planted in peat moss.

The effect of compost tea and vermicompost tea on the growth indices

On the other hand, compost tea and vermicompost tea had a significant impact on the growth indices. Based on the results, the foliar spraying of these materials significantly increases the height of plants in compost and vermicompost substrates and brings their size closer to plants in the peat moss. The use of compost tea and vermicompost tea has also had positive effects on the number of leaves of plants. So the spraying of vermicompost tea on plants planted in municipal solid waste vermicompost has produced the same number of leaves as the control plants.

As mentioned earlier in Table 4, compost tea and vermicompost tea increase the absorption of nutrients in the plant tissue and can be an essential factor for further plant growth. Therefore, the use of compost tea and vermicompost tea firstly increases the absorption of nutrients by the plant (Bess 2000). Secondly, increasing the activity of microorganisms and plant growth regulators leads to improved plant growth (Edwards et al. 2006). Similarly, Pant et al. (2012) have stated that higher uptake of nutrients such as nitrogen and gibberellin are factors for more plant growth when using compost tea. According to this research, the usage of compost tea and vermicompost tea significantly affected the dry weight of the aerial organs but did not affect the dry weight of the root. Since these substances were not in contact with the roots of the plant, so they could not affect root growth and dry weight gain. Reeve et al. (2010) show the positive effect of compost tea on higher growth and biomass production in the wheat plant.

The use of compost tea and vermicompost tea has a significant effect on the total chlorophyll content and anthocyanin content of the plant. So the use of these substances in all growing media has significantly increased these traits compared to peat moss. These substances contain high amounts of microelements such as zinc and iron, which play an essential role in chlorophyll synthesis (Tejada and González 2009) and thus can lead to better plant growth and more color. The findings of Morales-Corts et al. (2018) on tomatoes also showed that the compost tea from the waste could have a significant effect on the chlorophyll content and overall biomass.

Based on these results, the compost and vermicompost of municipal solid waste are rich in the nutrients and have desirable physical and chemical properties. Therefore, these materials can be used as much cheaper, more accessible alternatives and with appropriate quality for peat moss in the growth of *Dracaena marginata* tricolor plant. Also, foliar application of tea prepared from these materials can significantly affect plant nutrition, increase the anthocyanin content of leaves and the beauty of the plant. These organic materials increase the efficiency of the photosynthetic system and thus improve vegetative growth and quality of this plant. So, by scientifically and accurately processing municipal solid waste and preparing compost and vermicompost from them, the efficient and low- cost substrates in the cultivation of the *Dracaena marginata* tricolor plant can be obtained. Also, the usage of compost tea and vermicompost tea can increase the growth characteristics of the plant in these substrates.

Conclusion

Today, using municipal solid waste compost to cultivate various plants and as a substitute for peat moss has become very important. It has led to good results in multiple types of research. This study showed that the conversion of municipal solid waste compost to vermicompost could improve the physical and chemical properties of this growing medium, increase the nutrients in it and cause more growth of *Dracaena marginata* tricolor. Also, the use of vermicompost of municipal solid waste caused better coloring of plant leaves and the absorption of higher amounts of nutrients in plant tissue than municipal solid waste compost. The combination of 50% of the organic components with the perlite improves the physical and chemical properties of the substrates compared to 70% of these materials. Using 50% vermicompost of municipal solid waste combined with 50% perlite can have similar effects as 50% peat moss + 50% perlite on plant growth. On the other hand, compost tea and vermicompost tea also had a stimulating impact on the development of this plant. Higher absorption of nutrients and increased photosynthesis rate caused more plant growth and increased anthocyanin content, and more marketability. Therefore, based on the findings of this study, compost and vermicompost of municipal solid waste can be used as much cheaper, more accessible, and efficient alternatives to peat moss, and by spraying tea prepared from these organic materials, the plants with the same quality and growth are achieved as the plants planted in peat moss.

Compliance with ethical standards

Conflict of interest The authors declare that there are no conflicts of interest associated with this study.

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