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Short communication

Investigation of the compost of different organic wastes usage combined with zeolite and perlite on the growth of *Codiaeum variegatum* cv. Norma

Farshid Esmaeili[1]

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Abstract

Purpose Nowadays various studies have been carried out on the possibility of using different types of organic waste compost as a much cheaper and more affordable alternative to peat moss. In this research, different rates of peat moss, vermicompost, municipal wastes compost and palm waste compost were used in combination with perlite and zeolite on the growth of *Codiaeum variegatum* cv. Norma.

Methods The physical and chemical characteristics of media, growth indexes of plant and the number of nutritional compounds in the plant were evaluated.

Results The results showed that the highest rate of nitrogen absorption observed in treatment containing peat moss and perlite and combination of this material with zeolite showed better results in the absorption of phosphorus, potassium, iron, and zinc and also had better results in some leaves and dry weight than perlite. Combined treatments of vermicompost with perlite and zeolite, peat moss with perlite and zeolite and also municipal waste compost and perlite showed the best results in different growth indexes of the plant.

Conclusion Based on the results, zeolite can be highly efficient in the substrates due to higher nutrients and desirable physical properties. Also, vermicompost and municipal waste compost due to the availability, desirable characteristics, high nutrient, and lower cost could be the substitute of peat moss for the production of the Croton plant.

Keywords Croton, Palm waste compost, Vermicompost, Municipal waste compost, Zeolite

Introduction

Codiaeum variegatum is one of the most popular grown indoor plants which belongs to the family of Euphorbiaceae and comprised of around 1300 species which are widespread in tropical regions of the world (Robert and Osborne 2009) and foliage beauty of croton is fully depended upon potting media because media plays a vital role in the growth and production of plants (Bugbee 2013). The growth and marketability of this beautiful plant are directly related to its medium. For the production of high quality and marketable plants, we need to use suitable substrates for ornamental plants, which in addition to supplying the nutrients required for plants, have their physical, chemical, and biological properties and they also provide better growth for the plants. Nowadays, in most greenhouse cultivations, plant substrates contain at least two organic and inorganic components (Domingues Salvador and Minami 2004). Peat sphagnum is the main component of soilless substrates in greenhouse cultivation and potted plants, but harvesting it from ecosystems at risk has become a global problem (Vaughn et al. 2011), because the leading peat-production countries are Finland, Ireland, Germany, Sweden, Belarus, Canada, and Russia, which account for 80% of the world's production (Apodaca 2018). So, a comprehensive study has been started for peat's alternative substrates during the past few decades (Benito et al. 2005). Based on this, researchers have been looking for natural, inexpensive and affordable alternatives for peat moss for many years and there has been a lot of research on various materials in this regard. For example, Pritam and Garg (2010) reported that vermicompost can be used as a substitute for the peat moss in the development of Marigold. In another study, Mohamed (2018) investigated the effect of different growing media on Areca palm plant and stated that the mixture medium contained compost + peat moss + perlite produced the tallest plant.

Compost is a general term, describing all organic matter that has undergone thermophile, aerobic decomposition. It represents a bioresource and a sustainable use case for a potential waste material

✉ Farshid Esmaeili
farshid212@rocketmail.com

[1] Department of Horticulture, Science and Research Branch, Islamic Azad University, Tehran, Iran

(Raviv 2017). Palm waste compost, municipal waste compost, and vermicompost are composts that have been used extensively in recent years as substrates in ornamental plants. The palm waste compost including substances that are very similar to cocopeat and the fiber palm tree is obtained. In Iran, there are more than 30 million palm trees that produce large amounts of waste every year and it is incinerated or low level of that is used in the paper industry (Rahbarian and Salehi Sardoei 2014). So, given the high volume of these materials, it can be used in many ways. One of the uses of this material is the usage as an organic component of substrates that can be considered as one of the peat moss substitutes with proper properties. Ali's (2008) investigation in studying and comparing palm waste compost with peat moss as a medium showed that the number of germinated seeds and growth indices of plants in summer leaves compost were equal to or greater than peat moss. Today municipal waste compost is used increasingly in agriculture as soil corrector and organic fertilizer. Application of municipal waste compost can improve plant performance by increasing soil nutrients, improving the activity of microorganisms, soil texture and buffering capacity (Weber et al. 2014). This advantage of using municipal solid waste compost has been reported from many crops, orchards, and pasture products (Ostos et al. 2008). In recent years, the production and use of municipal waste compost in the agricultural sector have been increasing due to the positive effects on the physical, chemical and biological properties of the soil, as well as the high levels of nutrients (especially micronutrients). But one thing to keep in mind is that municipal waste compost can cause plant and human disease and weed infestation if it gets less heat than needed and incomplete processing occurs (Gruda et al. 2016). Vermicompost is one of the useful biofertilizers obtained during a semi-aerobic process from a species of red worm called *Eisenia foetida* (Garg et al. 2006). Much research has pointed to the beneficial effects of vermicompost application on agriculture and improved growth in horticultural crops (Babarabie et al. 2018). Vermicompost is a substance with a high water content that contains the food available to the plant. Also, the microbial metabolites present in this material can act as plant growth regulators (Paul and Metzger 2005).

Perlite is one of the most important and most used mineral components of cultivated media which is widely used in orchards and other horticultural products. Application of perlite in different media enables root development, water retention and improved aeration (Asaduzzaman et al. 2013). Perlite has a very high water-holding capacity, excellent exchange, buffering capacities and aid in aeration and drainage; it is less durable than sand (El-Khateeb et al. 2006). Zeolite is a group of compounds of various types of mineral aluminosilicate hydrated with cations which are mainly alkaline and alkaline earth (Rosalina et al. 2019). Zeolites have a structure that holds nutrients in their holdings and, with their large cavities, causes oxygen to rotate around the plant's root environment (Wang and Peng 2010). Zeolite is one of the natural minerals in Iran and many mines are dedicated to these minerals. Zeolite, as a completely natural material due to its unique properties, such as selective absorption and controlled release of food, can increase the effect of chemical fertilizers and make optimal use of chemical fertilizers. Due to its natural abundance, easy extraction, reasonable prices, as well as desirable properties, this mineral element can be used at various agricultural levels. In a study, Dobrowolska and Żurawik (2016) investigated zeolite as a part of the medium and reported that the application of this material would have beneficial effects on the growth of *Catharanthus roseus* and *Gazania rigens*.

Because of the need to provide the highest quality medium plants in every possible way, as well as what was mentioned above, this research aims to examine the possibility of replacement of palm waste compost, municipal waste compost and vermicompost combination with mineral components of zeolite and perlite as a substitute for imported peat moss which was carried out on an ornamental and beautiful leaf plant, *Codiaeum variegatum* cv. Norma.

Materials and methods

This study was conducted based on a completely randomized design plan with 13 treatments and 3 replications (two pots in each replication) and a total of 78 pots in September 2017 to July 2018. Day and night temperature in a heated glasshouse under natural photoperiod (about 7000 lx) was respectively 24±1°C and 18±1°C and the humidity was set among 60 to 70 percent. For this study 4-liter pots disinfected by 2% sodium hypochlorite were used and in each pot, a rooted cutting of *Codiaeum variegatum* cv. Norma with the 6 cm height was placed. The plants were irrigated to ensure leaching from the pot, with the frequency depending on greenhouse temperature and solar radiation. The plants were fertilized monthly until the end of the experiment with a complete water-soluble fertilizer (Nutrileaf 60, 20–20–20, Miller Chemical and Fertilizer Corp., Hanover, Penn.) to 100 mL of solution per pot (Papafotiou et al. 2007). In this experiment, organic substrates of vermicompost, municipal waste compost, palm waste compost, and peat moss were combined with inorganic components, perlite, and zeolite (from clinoptilolite type), according to the following ratios and Table 1 shows some of the chemical properties of these substances.

1- 50% vermicompost + 25% perlite + 25% zeolite

2- 50% municipal waste compost + 25% perlite + 25% zeolite

3- 50% palm waste compost + 25% perlite + 25% zeolite
4- 50% peat moss + 25% perlite + 25% zeolite
5- 50% vermicompost + 50% perlite
6- 50% vermicompost + 50% zeolite
7- 50% municipal waste compost + 50% perlite
8- 50% municipal waste compost + 50% zeolite
9- 50% palm waste compost + 50% perlite
10- 50% palm waste compost + 50% zeolite
11- 50% peat moss + 50% perlite
12- 50% peat moss + 50% zeolite
13- 100% zeolite

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

Component	pH	EC (dS/cm)	N (%)	P (%)	K (%)	CEC (Centimol/kg)
Peat moss	4.92	0.66	1.99	0.71	0.96	119.28
Vermicompost	7.41	1.44	1.19	0.80	1.38	106.44
Municipal waste compost	7.82	2.70	1.06	0.66	1.12	108.12
Date palm compost	7.55	1.96	1.16	0.73	1.09	113.06
Perlite	7.01	0.13	0	0	0	0.18
Zeolite	8.11	2.93	0.25	0.09	0.88	76.61

Chemical and physical features of substrates were measured at the end of the experiment. For finding the amounts of nutrients in the substrates, nitrogen and phosphorus were determined by Kjeldahl and Olsen methods and potassium was determined by the Flame photometer method (Page et al. 1982). Organic carbon by use of the Walkly and Black (1934) method and CEC by use of Harada and Inoko (1980) method were analyzed. The physical features of substrates were determined by Spomer (1990) and Webber et al. (1999) method and the amount of EC and pH were calculated by Milford (1976) method. Also, nutrient elements, nitrogen with the Kjeldahl method, phosphorus by the Ammonium molybdate-vanadate method (Ryan et al. 2001), potassium by the Flame photometer method and iron and zinc were determined with the atomic absorption device at the end of the experiment; plant growth features, height (with a ruler) and the number of leaves were found monthly and leaf and root dry weight were calculated by placing the samples on oven at 60^{o}C for 24 hours (Rosalina et al. 2019) at the end of the experiment. Data analysis was done by SPSS and the comparison of averages was done by Duncan's multiple range test (DMRT) at 1 or 5 percent possibility level.

Results and discussion

Plant nutrient concentration

Table 2 indicated that the highest concentration of nitrogen was in treatment 50% peat moss + 50% perlite and the highest concentrations of phosphorus and potassium were in the substrate 50% peat moss + 50% zeolite. According to this table, the highest concentrations of zinc and iron in the plant were respectively in treatments 3 and 8. Table 2 showed that substrates containing peat moss (treatments 11 and 4) had a low concentration of iron and zinc. Since these elements have good absorption in 6.5 to 7 pH, the reason for this undesirable result can be attributed to the low pH of peat moss which makes problems in absorbing these metallic elements (Mengle and Kirkby 1995) and on the other hand, complimentary fertilization can solve this defect. The composts when used as a substrate become the sources of fiber, nitrogen, phosphorus, and potassium for plant growth and rooting (Vandecasteele et al. 2018). The results of Rady et al. (2016) research indicate that the application of organic composts increases soil organic matter content and seeks better access to plant root nutrients. Therefore, this experiment also showed that compost's application was able to absorb nutrients from the plant root better and consequently increased the content of nutrients in the plant tissue.

Plant growth index

According to Table 3, treatments 11, 12, 1 and 4 had the best results in the growth index and according to Table 2, all these treatments indicated higher absorption of nitrogen compared to other treatments. Since the highest absorption of nitrogen was in substrates containing peat moss, and because of the role of nitrogen in plant's shoots growth and also appropriate chemical and physical features of peat moss, high growth index in plants of these substrates is not unexpected.

Rady et al. (2016) also reported the better growth of *Phaseolus vulgaris* seedlings as a result of compost application of organic matter to increase soil organic matter utilization and faster decomposition of organic matter and provide more and better nutrients to the plant. Potassium humate in organic compost acts as a natural hormone similar to auxin and cytokinin, affecting plant growth and on the other hand, by stimulating microorganisms, enhancing nutrient uptake and recovery of soil physical properties enable better

Table 2 Comparison of plant nutrient concentration average in different substrates

Treatment	Zn (mg/100gr)	Fe (mg/100gr)	K (%)	P (%)	N (%)
1	51.2 de	341.3 d	1.24 f	0.21 i	2.46 d
2	80.9 b	358.1 d	0.92 k	0.14 j	1.49 k
3	48.8 def	660.8 a	0.92 k	0.30 f	1.70 i
4	40.9 ef	295.3 e	1.58 c	0.57 c	2.73 b
5	53.1 cd	387.8 c	1.03 g	0.21 i	2.04 f
6	85.6 b	466.7 b	0.97 i	0.12 k	1.12 j
7	62.7 c	483.8 b	1.51 d	0.23 h	2.56 c
8	110.1 a	297.9 e	1.45 e	0.21 i	1.95 g
9	63 c	358 d	0.93 j	0.51 d	1.90 h
10	85.1 b	267.1 cd	1.01 h	0.43 e	1.39 l
11	29.2 g	288.5 e	1.65 b	0.59 b	3.76 a
12	46.4 def	354.7 d	1.68 a	0.74 a	2.32 e
13	37.1 fg	364.1 cd	1.03 g	0.27 g	1.71 i

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

Table 3 Comparison of plant growth index in different substrates

Treatment	Leaf dry weight (gr)	Root dry weight (gr)	Leaf number	Plant height (cm)
1	4.06 c	2.44 j	20.77 d	40.52 b
2	2.04 k	2.22 k	17.25 h	32.94 g
3	2.61 i	3.30 d	18.66 g	34.45 ef
4	2.91 d	3.45 b	22.66 c	36.31 d
5	2.49 e	1.84 l	20.02 e	35.88 d
6	1.96 l	1.02 m	13.30 j	34.33 f
7	3.90 d	2.44 i	23.13 c	37.24 c
8	3.11 f	2.91 g	19.88 ef	34.97 ef
9	2.91 h	2.94 f	18.51 g	34.73 ef
10	2.32 j	2.51 h	15.25 i	33.08 g
11	4.38 b	5.30 a	24.97 b	41.77 a
12	4.50 a	3.39 c	26.33 a	40.81 b
13	3.04 g	3.10 e	19.38 f	35.08 e

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

plant growth (Ouni et al. 2014). Therefore, high levels of nutrients and fiber along with high water storage capacity in compost will increase overall fertility and soil stability resulting in better and more plant growth in these growing media (Rady et al. 2016). Nitrogen has an important role in the development of plant shoots and Table 2 shows the most nitrogen absorption in top treatments of these features. On the other hand, since the adequate intake of potassium can decrease water consumption for the production of every single dry matter, the dry weight of leaf can be attributed to absorbed potassium by the plant. The highest dry weight of stem was observed in treatment number 11 and after that treatments number 4 and 12. Mohamed (2018) also concludes in his research that the presence of peat moss in combination with other components of the substrates can enhance the root system of Areca palm. Since phosphorous has a great role in the growth of plants' root (Mengle and Kirkby 1995), we can attribute the high dry weight of roots in top treatments to the high concentration of phosphorus in these plants. In general, and based on the results, Mohamed (2018) also reported in a study on Areca palm that the application of composts and peat moss in growing media increased plant height and fresh and dry weight of the plant. According to the Table 3, one of the reasons for the lower root and leaf dry weight of plants in substrates containing municipal waste compost can be having a high nutrient content, but its inadequate permeability causes that the root doesn't grow well and thus results in less dry weight. In the meantime, the mineral substrates have been able to fix this defect. According to the results, the combination of municipal waste compost with both of the mineral components used in this experiment yielded weaker results than the combination of this material with perlite or zeolite, separately. Looking at Table 3, it can be seen that the combination of municipal waste compost with perlite, except for root dry weight, had better results in other traits compared to the combination of this material with zeolite. The same is true for vermicompost, but the combination of perlite and zeolite yields better results. The combination of palm waste compost with the perlite showed better results than zeolite and the combination of peat moss with perlite and zeolite separately also produced more favorable results than other treatments. Therefore, it can be stated that composts in this study with their distinctive properties have been able to provide better growth and photosynthesis in the plant by increasing their nutrient absorption and availability, thereby improving overall plant growth and biomass. In a study, Grigatti et al. (2007) also obtained the highest dry weight of *Begonia semperflorens* and *Salvia splendens* plants using compost.

As the results show the addition of zeolite to vermicompost and perlite had better results in plant growth and development traits compared to the other two composts and perlite. Adding zeolite to the soil, on one hand, increases soil nutrient content (Rosalina et al. 2019) and on the other hand, it can reduce the fungal complications of soil, plant, and production and also help maintain healthy root and stem health. Research by Munir et al. (2004) showed that zeolites, as fertilizers that slowly feed the plant, by absorbing and trapping nutrients causing leaching problems and consequently contaminating groundwater. Besides, due to this property, they may hurt plant growth, so that if they release high levels of sodium into the growing medium or absorb the nutrients in their channels, they can compete with the roots and can have a reversible effect on plant growth. So in choosing their amounts to be added to the medium, care should be taken. On the other hand, since perlite doesn't have a high cation capacity exchange, it can't provide many nutrients to the plant and zeolite was positioned higher than perlite and yielded better results. Although perlite doesn't contain high amounts of nutrients, it plays a major role in the substrates for water retention and improvement of aeration balance, thus contributing to root development and better plant growth. So when compost is used, perlite may be utilized as a growing medium constituent to increase the drainage and air content of the growing media mix (Gruda et al. 2019).

Chemical properties of substrates

Table 4 shows the number of nutritious elements in substrates and its results have been reported. The most amount of nitrogen before cultivation was observed in treatments 9 and 11. According to Table 2, the most amount of nitrogen absorption in cultivated plants was also seen in this substrate. The most amount of phosphorous before and after cultivation was seen in the substrates containing vermicompost (treatments 1, 5 and 6). Many researchers such as Gong et al. (2018) state that vermicompost can provide nutritious elements like nitrogen, phosphorous and potassium for plants. However, these treatments couldn't have a high absorption of phosphorous.

Table 4 The number of nutritious elements in substrates (before and after cultivation)

Treatment	K (mg/100gr)		P (mg/100gr)		N (%)	
	After	Before	After	Before	After	Before
1	155	270	395	197	0.31	0.37
2	196	400	243	45	0.32	0.45
3	206	406	384	70	0.25	0.74
4	187	342	382	33	0.44	0.56
5	65	170	449	478	0.49	0.43
6	148	312	459	246	0.12	0.22
7	142	428	302	175	0.60	0.56
8	163	352	231	86	0.31	0.30
9	97	296	434	110	0.31	1.63
10	174	348	96	87	0.08	0.37
11	73	18	420	81	1.01	1.54
12	166	294	293	27	0.15	0.33
13	158	328	34	42	0.003	0.01

he most amount of potassium before cultivation was observed in treatment number 3 and treatments that contain municipal waste compost (substrates 2, 7 and 8) and this nutrient production by municipal waste compost has been reported by researchers like Gruda et al. (2019). On the other hand, potassium absorption in all treatments with zeolite has been high and low potassium absorption was seen in substrates that contain the only perlite in their inorganic component (except for substrate number 7). Since the levels of nutrients in perlite are very low, we can't expect too much of this mineral component of the growing media to supply the plant with the nutrients it needs. So, zeolite has had a positive effect on providing and absorption of potassium. Treatment with 50% peat moss + 50% perlite showed low potassium absorption at the beginning and the end of the trial, but high potassium absorption was seen in plants cultivated in this treatment. This can be attributed to fertilization with complete fertilizer which has removed this shortcoming. Treatments 3 and 10 showed a high amount of potassium at the end of the trial, but they didn't have enough absorption. It should be noted that the amount of nutrient in treatments which contain palm waste compost didn't differ significantly with substrates with peat moss at the beginning of the trial, they even were slightly higher than these substrates, and this matter shows that this substrate can replace peat moss. Rahbarian and Salehi Sardoei (2014) got the same result in their research on replacing palm waste compost with peat moss. According to Table 4, the addition of zeolite to vermicompost and peat moss has shown higher potassium values in treatments 1 and 3 compared to treatments 7 and 9, which indicates the zeolite used has high levels of potassium. Since perlite contains no food, the addition of zeolite to the medium can partially offset this perlite defect. Adding zeolite to the substrates also increases the content of potassium, calcium, and magnesium (Rosalina et al. 2019). It also shows a slightly alkaline reaction that can be combined with mineral fertilizers to preserve the soil's buffering properties and indirectly regulate soil pH (Milosevic and Milosevic 2009). Rosalina et al. (2019) reported that zeolite, due to its high cation exchange capacity, increases soil organic matter; thereby promoting plant growth.

According to Table 5, substrates number 11, 4, 12 showed the least amount of pH because of the acidic nature of peat moss as might be expected, and the most amount of pH was seen in treatments number 10 and 6. Navas et al. (1998) stated that the effect of compost on the soil pH is related to its origin and since these matters mostly have acidic pH, long term use of them makes soil pH acidic. As it was stated before, the least amount of iron and zinc concentration was seen in treatments which have peat moss as a central component (because of the low pH of this matter). The application of zeolite can increase the pH of the substrates because, since the zeolite is capable of exchange between cations, it can increase the pH of the substrate by adsorption of H ions (Rosalina et al. 2019). This argument is consistent with the results of Mahboub Khomami (2011) in replacing zeolite instead of perlite in the *Ficus Benjamina* medium and increasing the pH of the compounds of the culture medium.

Table 5 Comparison of chemical properties in different substrates

Treatment	OC (%)	C/N Ratio	CEC (Centimol/kg)	(dS/cm) EC	pH
1	31.6 a	101 bc	113.3 a	2.7 e	7.09 f
2	19.3 b	58.3 cde	103.3 b	5.7 a	7.06 fg
3	15.3 d	60.1 bcd	44.6 f	1.4 h	7.49 d
4	15.0 d	33.9 de	69.6 cd	2.2 f	4.76 i
5	16.6 c	33.7 de	55.0 e	2.8 d	7.04 g
6	11.3 fg	88.4 bc	23.3 g	1.5 g	7.66 b
7	11.0 g	17.2 de	36.0 f	3.3 c	7.23 e
8	12.6 e	39.6 de	62.3 de	4.1 b	7.22 e
9	11.3 fg	35.2 de	14.6 a	1.0 i	7.61 c
10	9.30 h	104 bc	15.0 g	0.7 j	7.78 a
11	11.6 f	10.6 e	111.6 ab	1.2 i	4.02 j
12	16.8 c	107.1 b	76.0 c	1.6 g	5.23 h
13	2.90 i	871.2 a	66.0 d	0.6 j	7.07 fg

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

The highest levels of cation exchange capacity were observed in treatments number 1, 11 and 2, and better growth of cultivated plants in treatments 1, 4, 11 and 12 can be attributed to a higher amount of nutrients in these treatments. Particle-size distribution and fertility were superior in the vermicompost-based media than in the conventional compost-based media. The compost-based media showed an approx. 2.2 higher coarseness index than the vermicompost medium that possessed more fine particles as compost, due to the effect of earthworms (Gong et al. 2018). The least amount of organic carbon was seen in treatment 13 and because of its low amount of organic carbon and nitrogen, the highest ratio of C/N was seen in this substrate. This treatment also showed a high cation exchange ratio which this CEC in natural zeolite was reported by many researchers such as Rosalina et al. (2019). It is seen in other treatments that the application of zeolite in comparison with perlite increased the C/N ratio. Also, the composting process has many advantages including sanitation, mass, bulk reduction, and also a decrease of C/N ratio (Rady et al. 2016). The highest amount of EC was observed in treatment 50% municipal waste compost + 25% perlite + 25% zeolite and this high level of EC can be one of the reasons that caused the cultivated plants in this substrate not to be able to grow appropriately. Besides, the biggest challenge facing municipal waste composting is its high electrical conductivity (Gruda et al. 2019), which can increase soil salinity over time. In terms of plant height, treatment 12 statistically followed treatment with 50% peat moss + 50% perlite, but with a lower height could produce more leaves and plants cultivated in this substrate which had a more beautiful and denser appearance compared to treatment 11. The reason of this matter may be a higher level of EC in this treatment compared to treatment 11 because Fitzpatrick (1986) reported that when potted plants, *Spathiphyllum* and *Schefflera*, which are salt-sensitive, were cultured by more soluble salt, the result was significantly smaller plants which were significantly bigger than control plants.

Physical properties of substrates

According to Table 6, substrate 1 had the highest pores. The high amount of pores in this treatment can be attributed to its high amount of organic matter because by increasing organic matters in a substrate, pores will be increased, too. Treatments 9 and 11 showed the maximum amount of water holding capacity and both were placed in the same statistic group. It should be noted that these two treatments had much higher volume compared to other treatments (because of the high volume of peat moss and palm waste compost); but treatment 9, having more humidity, couldn't be a good substrate for plants since porosity leads to moisture loss. This sharp reduction of humidity was also seen in other treatments that had palm waste compost. This problem affected growth indexes of plants and caused poor results in these substrates. It seems that substrates with more capacity for keeping water make better growth conditions for the plant by providing enough water and nutrients. These conditions were seen in treatments number 11, 12, 8, 4, 1 and 13. The highest bulk density was seen in treatment 6 and the lowest particle porosity was seen in treatment 11. The results of Table 6 showed that the addition of zeolite to the growing media increased the bulk density and the particle porosity loss compared to perlite. Treatments 13 and 9 were substrates which had respectively the highest and the lowest total porosity. In general, 10 to 30 percent of the space of a substrate is allocated to the areas required for plant ventilation and 45 to 65 percent of the space required for plant water (Samadi 2011).

Table 6 Comparison of physical properties in different substrates

Treatment	Bulk density (g/cm^3)	Particle porosity (g/cm^3)	Total porosity (%)	Water holding capacity (%)
1	0.50 fg	1.13 d	56.65 b	8.446 e
2	0.69 d	1.11 d	38.94 l	4.14 j
3	0.55 ef	1.16 d	52.50 c	5.35 i
4	0.52 fg	0.77 e	41.13 k	10.21 c
5	0.44 g	0.89 e	45.55 g	5.39 hi
6	0.86 bc	1.71 a	50.07 d	5.45 h
7	0.44 g	0.86 e	42.88 i	8.25 f
8	0.92 ab	1.62 ab	43.31 h	10.26 c
9	0.21 i	0.51 f	54.62 a	15.46 a
10	0.79 c	1.32 c	42.14 j	8.15 g
11	0.30 h	0.46 f	47.87 f	15.45 a
12	0.62 de	1.31 c	49.32 e	11.21 b
13	0.96 a	1.51 b	37.48 m	9.02 d

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

Therefore, the percentage of total porosity, water holding capacity, percentage of air porosity, density and particle size distribution are the most important physical properties of a growing media. According to the results, treatments 2, 6 and 10 couldn't show acceptable growth. The reason for these poor results can be low capacity for keeping humidity, high C/N and low CEC ratio in treatments 6 and 10, high EC of treatment number 2, and low absorption of macronutrient especially nitrogen. Because peat moss had a unique peculiarity and an appropriate physical and chemical property, composts are a good substitute for this material with physical and chemical properties similar to peat moss (Sanchez- Monedero et al. 2004). It can be stated that high water retention, good porosity and appropriate cation exchange capacity in a substrate can promote better root system growth of the plant and increase plant growth and yield in these substrates.

Treatment 100% zeolite, having little amounts of nitrogen and phosphorous and high amount of potassium for the plant, couldn't have a high absorption of elements and obtained no impressive result chemically and physically; but it was not among poor result treatments because of high CEC and good humidity holding capacity. It also showed good results in most of the growth indexes. The reason can be used for complementary fertilizers which could make up deficiencies. Treatments containing zeolite showed more humidity compared to the perlite that indicates that zeolite can keep humidity. In this study, the addition of zeolite to a combination of vermicompost, municipal waste compost and peat moss with perlite increased bulk density and particle density compared to treatments 5, 7 and 9. This increase can be due to the presence of minerals zeolite with a weight gain in comparison with perlite. The results of Kolar et al. (2010) showed that with increasing granulation of zeolite in the peat moss substrate in a Geranium plant, Bulk density also increases. Zeolites can ameliorate the adverse effects of drought in plants; similar results about the effect of zeolite on soil moisture have been reported by other researchers (Dhanda et al. 2004).

As it was expected, common substrate for keeping house plants (50% peat moss + 50% perlite) showed good results and plants cultivated in this substrate grew pretty well. Treatment containing 50% peat + 50% perlite was better than treatment 11 in properties such as absorption of phosphorous, potassium, iron, zinc and also leaf dry weight, and this shows that zeolite has natural mineral ability to replace perlite. Treatments 1, 4, 7 and 11 were the best substrates in this trial, and treatments 5 and 8 were ranked after the aforementioned treatments. Concerning the chemical and physical properties of used substrates, the common element in these treatments was nitrogen. However, top treatments in this study were not the best treatments in some chemical and physical properties, all (top treatments) showed the high percent of nitrogen absorption and this influenced plant growth and brought the best result for these substrates. Treatments with poor function showed low absorption of this important element by plants, so that growth indexes didn't have a satisfactory result. Such a result has brought up the matter of complementary fertilization along with complete fertilizers and demonstrates its effective role in plant yield. This way, low absorption of elements will be compensated. Also, some chemical and physical problems of substrates which prevent absorption and better growth of the plant will be removed. Besides, on the other hand, the release of inorganic minerals from organic compost decay improves plant photosynthetic pigments and increases plant nutrient levels resulting in better plant growth in these mediums (Rady et al. 2016). Therefore, the combination of these characteristics with favorable physical and chemical properties can improve the growth of *Codiaeum variegatum* cv. Norma planted on these substrates.

Conclusion

Nowadays, research on finding new, inexpensive, environmentally friendly substrates with physically and chemically important features is necessary for the agricultural sector. Composted from palm waste, vermicompost, and municipal waste can, if properly processed, be suitable alternatives for imported peat moss and are subject to extinction. In the end, it can be mentioned that zeolite as an inorganic component in combination with other organic matters can be used instead of perlite. The combination of peat and zeolite is better than a combination of this matter and perlite in some features. Also, pure zeolite can be used as a plant substrate with the application of complete fertilizer. Since treatments which contain 50% vermicompost + 25% perlite + 25% zeolite and 50 % municipal waste compost + 50% perlite showed satisfactory results; by studying these treatments (and after them treatments which contain 50% vermicompost + 50% perlite and 50% municipal waste compost + 50% zeolite) and with due attention to the low cost of vermicompost and municipal waste compost compared to peat moss, they can be used as cheap, high quality and available superseded of imported peat moss in cultivating *Codiaeum variegatum* cv. Norma is a potted plant and other ornamental house plants.

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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