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The Effect of *Azolla*, Peanut Shell, and Tea Waste Composts on the Growth and Nutrient Uptake of Common Ivy (*Hedera helix*)

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Abstract

The effect of different substrates was studied on the growth of common ivy (*Hedera helix*) in a pot experiment based on a completely randomized design with five treatments and three replications in a research greenhouse in the Ornamental Plants Research Center of Lahijan. The experimental treatments were composed of five substrates including (B1) 50 % *Azolla* compost + 40 % peanut shell compost + 10 % perlite, (B2) 50 % *Azolla* compost + 40 % peanut shell compost + 10 % zeolite, (B3) 30 % *Azolla* compost + 30 % peanut shell compost + 30 % tea waste compost + 10 % perlite, (B4) 30 % *Azolla* compost + 30 % peanut shell compost + 30 % tea waste compost + 10 % zeolite, and (B5) 80 % peat + 20 % perlite. The results showed that the plant height, leaf number, auxiliary branch number and diameter, the number of nodes, and leaf chlorophyll content, which are the decorative traits of climbing evergreen plants like the common ivy, were the highest in substrate B3. The highest root and shoot dry matter and leaf N, K, and Zn contents were obtained from the plants grown in substrate B3. The highest leaf carotenoid and the longest roots were related to substrate B5. B1 was the most successful substrate in increasing leaf Fe. So, substrate B3 is recommended as the best substrate for the growth of the common ivy.

Keywords: Composting, Invasive plant, Organic matter, Plant residue, Waste management.

INTRODUCTION

The substrate is one of the most critical inputs in the cultivation of ornamental plants. Peat is the most common substrate in floriculture, which is usually applied in combination with minerals like perlite, vermiculite, zeolite, and so on. Peat sources are limited in Iran, so floriculturists and researchers have put their efforts to find a natural and cheap alternative for it in recent decades due to environmental and economic constraints on its production (Mohammadi Torkashvand *et al*., 2014; Kaushal and Kumari, 2020).

The collection and disposal of agricultural and horticultural crop production waste are serious challenges in all countries, but with sound management, this waste can be returned to the production cycle and optimally used. Composting crop residues or waste for substrate production is one of the most economic and best methods of waste management (Omidi *et al*., 2017).

Peanut shells constitute a significant part of peanut cultivation waste. These shells have a fibrous structure and are used in the substrates of horticultural crops to increase porosity, improve soil physical and chemical characteristics, and provide a source of nutrients (Hanik *et al*., 2021; Omidi *et al*., 2017). By composting peanut shells, in addition to using them in the substrate as an alternative for peat, the environmental problem of peanut shell accumulation in nature can be solved largely (Mahboub Khomami, 2015). There are reports about the positive effect of peanut shells on the growth of *Dendrobium* sp. (Hanik *et al*., 2021), sweet violet and marigold (Mahboub Khomami, 2015), and *Begonia rex* (Mahboub Khomami *et al*., 2019).

The process of tea production and processing has also a huge amount of waste whose disposal is time-consuming and costly. A research study reported that the application of tea waste as the substrate stimulated root and shoot growth and increased fruit yield (Fazel Tehrani and Ilkaei, 2018). Composting improves the characteristics of tea waste. For example, by composting, the beneficial microorganisms of tea compost become more active, and their activity enhances nutrient availability to plants (Fazel Tehrani and Ilkaei, 2018). However, tea waste compost should be applied to the substrate of salinity-sensitive plants cautiously because of its high EC (Mastouri *et al*., 2005). The positive effect of tea waste compost has been reported on the growth and yield of lettuce (Mastouri *et al*., 2005) and basil (Fazel Tehrani and Ilkaei, 2018).

Azolla is a fast-growing water-floating plant that is an expanding environmental issue in the paddies and wetlands of Guilan province, Iran. In symbiosis with *Anabaena*, *Azolla* can fix nitrogen. This invasive plant is used as an organic or biological fertilizer in most countries. It is also used in the pharmaceutical industry, animal and poultry feeding, human feeding, and biogas generation (Rajabi Islamic *et al*., 2015; Farahpour-Haghani, 2019). *Azolla* compost is a proper substrate containing nutrients required by plants, and its application in the substrate can improve the physical and chemical characteristics of the soil (Rafati *et al*., 2019). The increased growth of *Pedilanthus tithymaloides* (Omidi *et al*., 2019), *Populus deltoids* (Rafati *et al*., 2019), and *Ficus benjamina* (Mahboub Khomami and Padasht Dehkaei, 2010) have been reported with the application of *Azolla* compost as their substrates.

The common ivy (*Hedera helix*) is an evergreen climbing shrub from the family of Araliaceae that has medicinal properties in addition to ornamental and greenspace applications. The leaves compose the medicinal part of the plant. The leaf extract of the common ivy has antioxidant, anti-spasm, antimicrobial, pain-killing, anti-inflammatory, anti-tumor, and liver-protecting activities. The plant is used in traditional medicine to cure many diseases, such as respiratory system diseases and infections, chronic cough, and skin diseases. Its leaf extraction is also used in the modern pharmaceutical industry to produce various anti-cough syrups and in the cosmetic industry to produce shampoos, creams, and lotions (Lutsenko *et al*., 2010; Li *et al*., 2021).

Given the importance of the common ivy as an ornamental-medicinal plant and the need for substituting peat with cheap and available organic matter, this research aimed to compare the effect of substrates composed of different percentages of *Azolla* compost, tea waste, and peanut shell with the conventional substrate in the floriculture industry (peat + perlite) and its effect on vegetative growth and nutrient uptake by the common ivy.

MATERIALS AND METHODS

The effect of different substrates on the growth and development of common ivies was studied in a pot experiment based on a completely randomized design with five treatments (substrates) in 3 replications, 15 plots, and 3 plants per plot. The experimental treatments were composed of five substrates containing different ratios of composted organic matter and minerals. Table 1 presents the characteristics and compositions of the substrates.

Table 1. The description of the substrates used in the research.

Treatments	Composition
B1	50% *Azolla* compost + 40% Peanut shell compost + 10% Perlite
B2	50% *Azolla* compost + 40% Peanut shell compost + 10% Zeolite
B3	30% *Azolla* compost + 30% Peanut shell compost + 30% Tea waste compost + 10% Perlite
B4	30% *Azolla* compost + 30% Peanut shell compost + 30% Tea waste compost + 10% Zeolite
B5	80% Peat + 20% Perlite (control)

The research was conducted using plastic pots with a height of 40 cm and a mouth diameter of 25 cm containing 4.5 kg of the substrate in a greenhouse with standard conditions in the Ornamental Plants Research Center of Lahijan, Guilan province in March-April 2018. Fifty-cm-tall common ivy plants were purchased as pot plants from a greenhouse in Mazandaran, Iran in March 2018 and were transferred to the target substrates. The composts were purchased from an authentic biofertilizer institution, and their physicochemical characteristics were examined before consumption (Table 2). The experiment took five months from the initiation of the vegetative growth to the end of the growth period.

Table 2. The physicochemical characteristics of the substrates used.

Substrates	B1	B2	B3	B4	B5
Porosity (%)	91.38	99.95	90.73	88.20	86.52
Water capacity (%)	58.57	70.00	72.47	71.35	38.76
Aeration porosity (%)	32.81	18.26	25.99	16.85	47.75
Particle density (g/cm^3)	0.75	0.90	0.80	0.77	0.42
Bulk density (g/cm^3)	0.25	0.34	0.63	0.41	0.10
Nitrogen (%)	0.78	1.56	2.10	2.57	2.63
Phosphorous (ppm)	25.00	12.50	12.50	75.00	6.00
Potassium (ppm)	250	200	275	575	125.00
Organic carbon (%)	7.80	15.60	20.80	25.40	26.30
Organic matter (%)	13.45	26.89	34.61	43.78	45.34
Zinc (ppm)	3.85	5.75	5.55	5.35	0.90
Iron (ppm)	7.47	10.42	10.70	8.52	0.65
pH	5.43	5.89	5.95	6.29	3.43
EC (mS/cm)	1.80	1.90	2.30	2.20	2.50

Measurement of the traits

Vegetative traits

The number of leaves, the number of auxiliary branches, and the number of internodes were counted at the end of the experiment. The length of the internode and the length of the auxiliary branch were measured with a caliper. To determine the plant height, it was measured with a ruler from the ground in two steps – first at the beginning and then at the end of the experiment. Finally, the two figures were subtracted to yield the plant height. To measure the length of the longest root and the root and shoot dry matter, the plant was uprooted and its roots and shoots were cut from the crown. After cleaning the mud and soil of the roots, the length of the longest root was measured with a ruler, and the root and shoot fresh weight was determined with a 0.01-g digital scale. Then, the samples were oven-dried at 75 °C for 72 hours, and their fresh weight was measured. The root and shoot dry matter were, finally, calculated by the following equation:

$$\text{Root or shoot dry matter} = \frac{\text{Root or shoot dry weight}}{\text{Root or shoot fresh weight}} \times 100$$

Leaf pigments

To measure leaf chlorophyll and carotenoid contents, the leaves of the second, fourth, and sixth nodes were sampled. The chlorophyll content was determined with an Eijekel Lamp CL01 chlorophyll meter (the Netherlands). To find out the carotenoid content, 0.5 g of the fresh leaf was extracted with acetone 80 %. Then, the pigments in the resulting extract were read at 440, 645, and 663 nm with an APEL PD-103UV spectrophotometer, and the carotenoid content was calculated in $\mu g\ g^{-1}$ FW by the following equation:

$$\text{Petal carotenoid} = 4.69 \times A_{440} - 0.268 \times (20.2) A_{645} + (8.02) A_{663}$$

Minerals

To measure the concentrations of iron (Fe), zinc (Zn), phosphorous (P), and potassium (P), 2 g of the dry leaf was converted to ash in an electrical furnace at 550 °C for 5 hours. The resulting ash was added with 10 mL of 2N hydrochloric acid and was dissolved well. Then, it was heated up in a Bain-marie for 10 minutes. After cooling down, it was infiltrated through a Whatman filter paper, and its volume was adjusted to 50 mL with distilled water. The amount of nitrogen (N) was measured with the Kjeldahl method, the Fe and Zn contents with an atomic absorption device, the amount of P by the spectrophotometry method, and the K content by the flame-photometry method (Rengel and Romheld, 2000).

Statistical analysis

The SPSS19 software suite was used for data analysis, and the means were compared by the LSD test at the $P < 0.05$ level. The graphs were drawn in MS-Excel.

RESULTS

The analysis of variance showed that the substrate influenced all recorded traits significantly ($P < 0.01$), except for shoot dry matter and leaf N, P, and Zn contents (Table 3).

Table 3. The results of the analysis of variance for the common ivy traits.

SoV	df	Plant height	Leaf no.	Auxiliary branch no.	Stem diameter	Longest root length	Internode distance	Internode no.	Shoot dry matter	Root dry matter
Replication	2	1.97	76.76	0.002	0.002	0.2	0.09	36.48	8.26	0.8
Substrate	4	41.42**	900.53**	1.10**	1.36**	60.08**	0.84**	21.81**	3.56ns	7.1**
Error	8	2.073	14.94	0.002	0.002	0.2	0.156	28.01	7.26	0.3
CV (%)		9.65	26.02	18.22	13.06	21.52	26.25	20.34	7.39	5.26

** and ns: significant at $P < 0.01$ and insignificant based on the LSD test, respectively.

Table 3. Continued

SoV	df	Chlorophyll	Carotenoid	Nitrogen	Phosphorus	Potassium	Zinc	Iron
Replication	2	2.29	0.001	0.013	0.2	1.88	0.001	0.211
Substrate	4	21.35**	1.38**	0.011ns	25.25ns	0.12**	0.001ns	0.299**
Error	8	2.29	0.001	0.002	0.2	1.41	0.001	0.018
CV (%)		26.86	76.33	56.46	38.40	39.19	32.50	34.69

** and ns: significant at $P < 0.01$ and insignificant based on the LSD test, respectively.

Plant height

The comparison of the means revealed that the use of the substrates containing *Azolla*, tea waste, and peanut shell composts increased the plant height versus “peat + perlite”. Fig. 1 displays that B3 and B4 were related to the highest plant heights of 42.03 and 40.99 cm, respectively. They did not differ from one another significantly. The lowest plant height was recorded by B5 (34 cm) and B1 (34.25 cm), not differing significantly (Fig. 1).

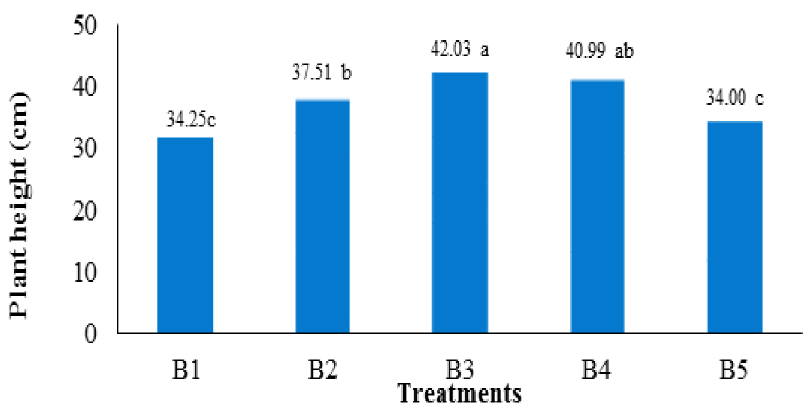

Fig. 1. The effect of different substrates on the plant height of common ivy (B1: 50% *Azolla* compost + 40% peanut shell compost + 10% perlite; B2: 50% *Azolla* compost + 40% peanut shell compost + 10% zeolite; B3: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% perlite; B4: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% zeolite; B5: 80% peat + 20% perlite).

Leaf number

The comparison of the means revealed that the leaves were the fewest in the two substrates of B2 and B5. The most number of leaves (95.98 leaves) was recorded by the treatment of B3, which did not differ from B4 and B1 significantly (Fig. 2).

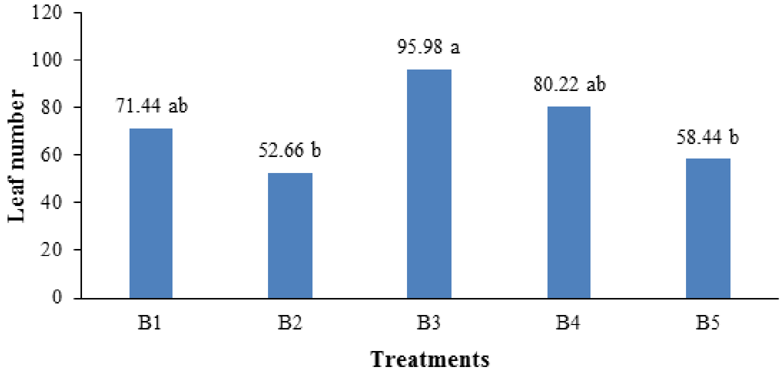

Fig. 2. The effect of different substrates on the leaf number of common ivy (B1: 50% *Azolla* compost + 40% peanut shell compost + 10% perlite; B2: 50% *Azolla* compost + 40% peanut shell compost + 10% zeolite; B3: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% perlite; B4: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% zeolite; B5: 80% peat + 20% perlite).

Auxiliary branch number and diameter

Fig. 3 depicts that the plants grown in substrates B3 and B1 produced the highest number of auxiliary branches and the thickest stem, respectively. The lowest number of auxiliary branches was related to B2 (2.44) and B5 (2.55), and the lowest stem diameter was recorded by B5 (3.84 mm) (Fig. 3).

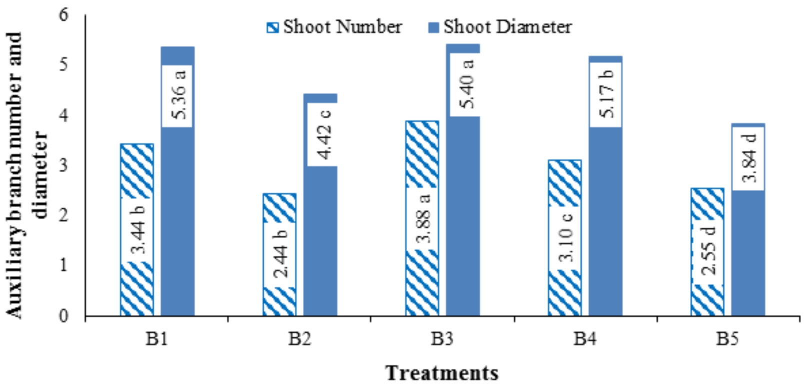

Fig. 3. The effect of different substrates on the auxiliary branch number and diameter of common ivy (B1: 50% *Azolla* compost + 40% peanut shell compost + 10% perlite; B2: 50% *Azolla* compost + 40% peanut shell compost + 10% zeolite; B3: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% perlite; B4: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% zeolite; B5: 80% peat + 20% perlite).

Internode number and length

As the comparison of means showed, substrates B3 and B4 had the highest number of internodes (58) and internode length (2.93 mm), respectively. The lowest internode number (37) and length (1.46 mm) were related to substrate B5 (Figs. 4 and 5).

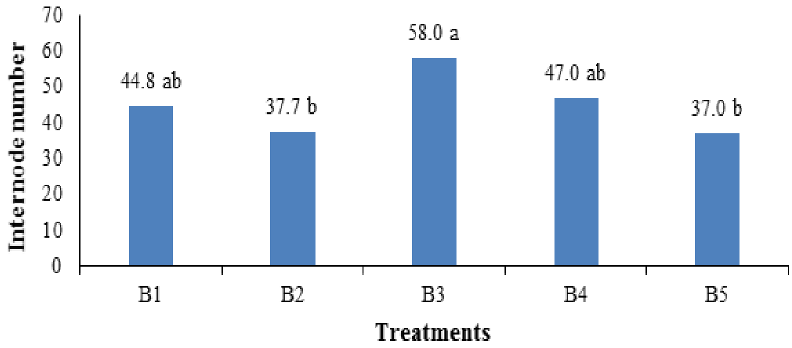

Fig. 4. The effect of different substrates on the internode number of common ivy (B1: 50% *Azolla* compost + 40% peanut shell compost + 10% perlite; B2: 50% *Azolla* compost + 40% peanut shell compost + 10% zeolite; B3: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% perlite; B4: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% zeolite; B5: 80% peat + 20% perlite).

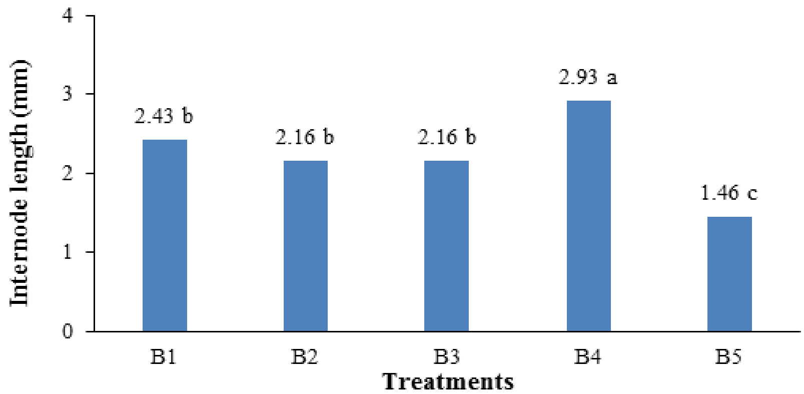

Fig. 5. The effect of different substrates on the internode length of common ivy (B1: 50% *Azolla* compost + 40% peanut shell compost + 10% perlite; B2: 50% *Azolla* compost + 40% peanut shell compost + 10% zeolite; B3: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% perlite; B4: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% zeolite; B5: 80% peat + 20% perlite).

Longest root length

The results showed that substrates B5 and B2 had the longest and shortest roots (26.3 and 14.13 cm), respectively (Fig. 6).

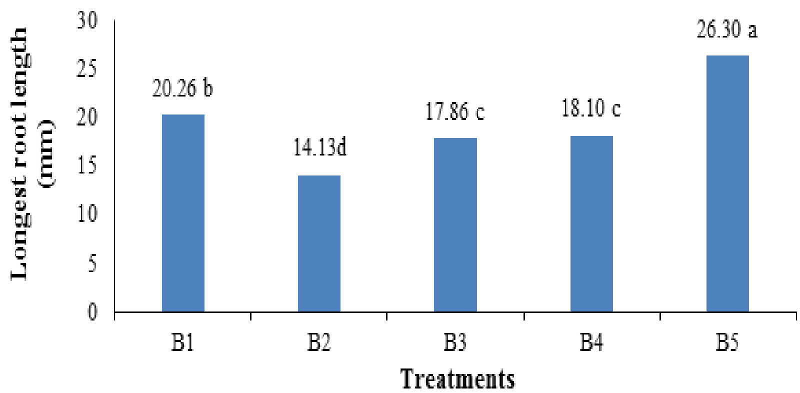

Fig. 6. The effect of different substrates on the longest root length of common ivy (B1: 50% *Azolla* compost + 40% peanut shell compost + 10% perlite; B2: 50% *Azolla* compost + 40% peanut shell compost + 10% zeolite; B3: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% perlite; B4: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% zeolite; B5: 80% peat + 20% perlite).

Shoot and root dry matter

It was found by the comparison of means that the highest shoot dry matter was related to substrates B3 and B5. The plants grown in substrate B3 had the highest root dry matter (31 %), which was significantly higher than the other treatments. Substrate B4 was associated with the lowest shoot and root dry matter (Fig. 7).

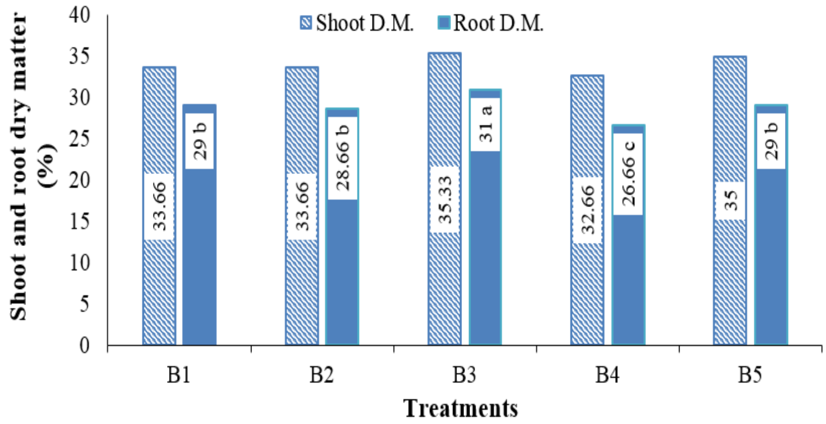

Fig. 7. The effect of different substrates on the shoot and root dry matter of common ivy (B1: 50% *Azolla* compost + 40% peanut shell compost + 10% perlite; B2: 50% *Azolla* compost + 40% peanut shell compost + 10% zeolite; B3: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% perlite; B4: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% zeolite; B5: 80% peat + 20% perlite).

Chlorophyll content

Leaf chlorophyll content was significantly ($P < 0.01$) increased with the application of organic matter compost compared to the commercial substrate of "peat + perlite" (Table 1). According to the comparison of the means, B3 was the most successful substrate in preserving and increasing the chlorophyll content. The plants grown in substrates B5 and B1 had the lowest chlorophyll content (Fig. 8).

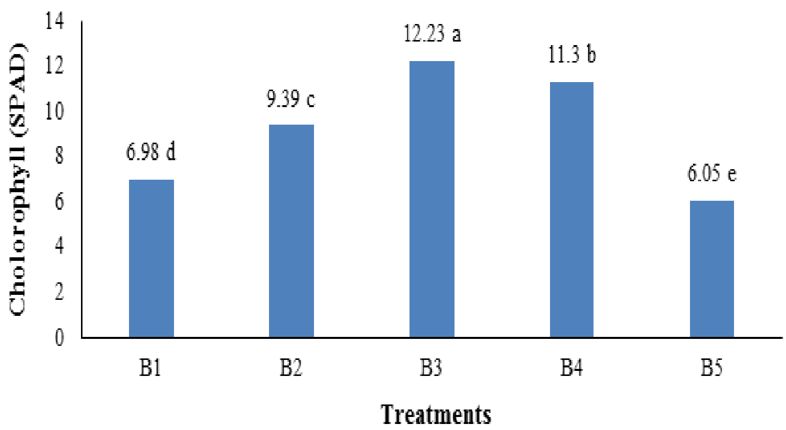

Fig. 8. The effect of different substrates on the leaf chlorophyll content of common ivy (B1: 50% *Azolla* compost + 40% peanut shell compost + 10% perlite; B2: 50% *Azolla* compost + 40% peanut shell compost + 10% zeolite; B3: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% perlite; B4: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% zeolite; B5: 80% peat + 20% perlite).

Leaf carotenoid

Fig. 9 shows that substrate B5 had the highest leaf carotenoid content (1.84 µg g^{-1} F.W.), whereas substrates B2 and B1 had the lowest ones (0.273 and 0.296 µg g^{-1} F.W., respectively).

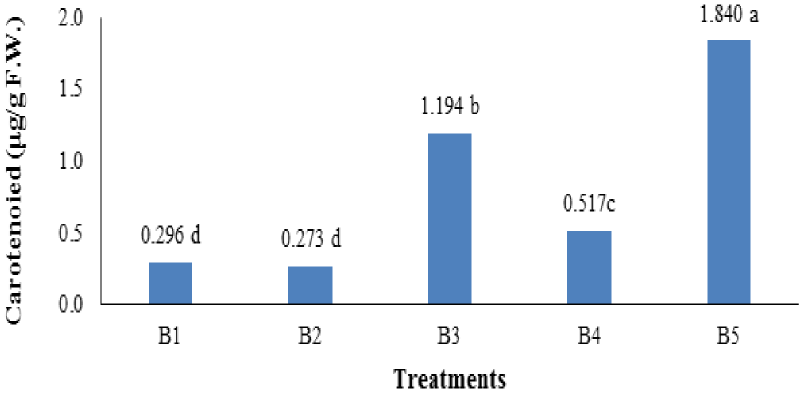

Fig. 9. The effect of different substrates on the leaf carotenoid content of common ivy (B1: 50% *Azolla* compost + 40% peanut shell compost + 10% perlite; B2: 50% *Azolla* compost + 40% peanut shell compost + 10% zeolite; B3: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% perlite; B4: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% zeolite; B5: 80% peat + 20% perlite).

Minerals

It was revealed by the comparison of means that the highest N and Zn contents in the leaves were obtained from substrate B3. The leaf K content was the highest in substrates B3 and B2, respectively. The plants grown in substrate B1 exhibited the lowest leaf K content and the highest leaf P and Fe contents (Table 4).

Table 4. The comparison of means for the effect of substrate on the leaf minerals of common ivy.

Substrate	Nitrogen (%)	Phosphorus (ppm)	Potassium (ppm)	Zinc (ppm)	Iron (ppm)
B1	0.086 a	0.034 a	0.90 b	0.043 a	1.403 a
B2	0.096 a	0.033 a	3.16 a	0.036 a	1.296 a
B3	0.120 a	0.033 a	3.26 a	0.056 a	1.065 a
B4	0.110 a	0.030 a	2.77 b	0.036 a	0.876 b
B5	0.083 a	0.031 a	2.85 b	0.040 a	0.886 b

Means with similar letter(s) in each column show the lack of a significant difference at the $P < 0.05$ level based on the LSD test. B1: 50% *Azolla* compost + 40% peanut shell compost + 10% perlite; B2: 50% *Azolla* compost + 40% peanut shell compost + 10% zeolite; B3: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% perlite; B4: 30% *Azolla* compost + 30% peanut shell compost + 30% tea waste compost + 10% zeolite; B5: 80% peat + 20% perlite.

DISCUSSION

Tea and peanut are two major crops in Guilan province, but they leave significant waste from the production to the processing steps. *Azolla* is also an invasive plant in this province whose control is expensive and time-consuming. The processing of crop wastes and residues is an effective and cheap way for substrate production and a useful method for waste recycling and the prevention of environmental problems caused by waste accumulation. Composts as substrates act as a rich source of organic matter, nutrients, and water, contribute to soil aeration, and generally improve the physical and chemical structure of the soil (Ramesh *et al.*, 2009; Sanati *et al.*, 2011). In the present research, the substrates containing the composts of *Azolla*, peanut shells, and tea waste, along with the minerals of zeolite or perlite, increased soil porosity, water capacity, particle density, bulk density, P, K, Zn, Fe, and pH and decreased EC when compared to "peat + perlite". They also improved the physical and chemical characteristics of the substrate.

Previous research has already shown that the composts of plant residues or crop wastes, which have physical and chemical characteristics like peat, can be a good alternative for this expensive endangered material in the substrates of ornamental plants. There is evidence that, unlike peat, composts contain plant growth regulators and outperform peat (Mohammadi Torkashvand *et al.*, 2014). The present research also showed that composts could be a proper alternative for "peat + perlite" in the cultivation of the common ivy. The best results for plant height, leaf number, auxiliary branch number and diameter, root and shoot dry matter, and leaf N, K, Zn, and chlorophyll contents were obtained from substrate B3 (30 % *Azolla* compost + 30 % peanut shell compost + 30 % tea waste compost + 10 % perlite).

The compost of *Azolla* is one of the best composts used as a rich source of organic matter or biological fertilizer in addition to a substrate (Cheng *et al*., 2010; Mahboub Khomami and Padasht Dehkaei, 2010). The compost of *Azolla* improves the physical and chemical characteristics of the soil. It releases nutrients needed by plants slowly and supplies them to plant roots (Rafati *et al.*, 2019). It has been reported as a proper substrate for *Ficus benjamina* (Mahboub Khomami and Padasht Dehkaei, 2010), daffodil (Mohammadi *et al*., 2021), and *Pedilanthus tithymaloides* (Omidi *et al*., 2019).

By improving nutrient availability, creating proper pH, and reducing the C:N ratio, peanut shell compost provides a suitable substrate for the growth of ornamental plants and is an appropriate alternative for peat (Mohammadi Torkashvand *et al*., 2015). Hanik *et al.* (2021) reported that peanut shell compost contained high amounts of nutrients and provided good conditions for the growth of Dendrobium. Mahboub Khomami (2015) reported that the application of 25-50 % peanut shell compost enhanced the growth of *Viola tricolor* and marigold. In another study, Mahboub Khomami *et al*. (2019) found that the replacement of peat with 25% peanut shell compost increased the growth factors of *Begonia rex*.

Tea waste compost is a proper medium for the activity of beneficial soil-borne microorganisms and provides favorable conditions for nutrient availability to plants, thereby improving their vegetative growth and yield (Fazel Tehrani and Ilkaei, 2018). There are reports about the effect of tea waste compost on increasing leaf number, fresh and dry weight, chlorophyll, and N content (Fazel Tehrani and Ilkaei, 2018) and increasing the growth and yield of lettuce (Mastouri *et al*., 2005).

Researchers have attributed the effectiveness of peanut and *Azolla* composts in improving the growth and development of different plants to the presence of humic material and growth regulators in these substrates (Mahboub Khomami, 2015; Mahboub Khomami and Padasht Dehkaei, 2010). Amiri *et al.* (2017) state that composting organic matter or plant residue increases the uptake of nutrients, e.g., Zn, by plants. Zn, in turn, increases vegetative growth by influencing growth hormones, like auxin. As well, Mohammadi *et al.* (2021) reported that the increased availability and uptake of N in compost-containing substrates increased chlorophyll pigments in the leaves of daffodils.

As expressed in the Results, the leaves of the plants grown in different substrates differed in their minerals. The leaves of the plants grown in B3, which was found to be the best substrate for the growth of the common ivy, had higher contents of all evaluated elements than those of the plants grown in "peat + perlite". In general, composts contain high amounts of absorbable nutrients. On the other hand, composting organic matter increases the activity of beneficial soil-borne microorganisms in the root zone and improves the uptake and storage of these elements in plant organs by increasing their availability to the roots (Mohammadi *et al*., 2021). Increases have been reported in the N content in the leaves of *Begonia rex* with the application of peanut shell compost (Mahboub Khomami *et al*., 2019) and in the K content of English daisy with the application of *Azolla* compost (Ramenzanzadeh *et al*., 2014). Mohammadi Torkashvand *et al*. (2014, 2015) state that the application of compost provides ideal conditions for increasing root growth. With the increase in root growth and volume, the plant's uptake area increases, so more nutrients are absorbed and stored by the plants. In the present study, substrate B3 was related to the greatest accumulation of N, K, and Zn in the leaves of the common ivy. At the same time, this substrate exhibited the best performance in improving vegetative traits and chlorophyll. However, researchers argue that nutrient concentration is not a reliable parameter to explain plant growth due to the dependence of the concentration of nutrients in plant shoots on the growth rate, ion competence, and the precipitation of elements (Mohammadi Torkashvand *et al*., 2014, 2015).

CONCLUSION

According to the results, the substrate composed of 30% *Azolla* compost + 30 % peanut shell compost + 30 % tea waste compost + 10 % perlite (B3) performed well in improving vegetative growth, preserving leaf pigments, and enhancing nutrient uptake, so it is recommended as a proper alternative for "peat + perlite" for the growth of the common ivy.

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