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RESEARCH PAPER

Investigation of the Usage Possibilities of Leonardite as a Growing Medium

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Abstract

Growing medium is very important as it affects both the germination of the seed and the growth of the seedling. The most used growing medium for seedling growth in the world is peat. Because peat deposits contain a significant amount of carbon, growing mediums that can be used as an alternative to peat are gaining importance in terms of climate change. In this study, the possibilities of using leonardite 100% and its mixtures with different materials as a seedling growing medium for melon were investigated. As a result of the study conducted under greenhouse conditions, it was observed that the germination rate decreased when 100% leonardite was used as a growing medium. The highest plant height, stem length, leaf number, plant fresh weight, and dry weight were obtained from the use of 100% peat material. The highest stem diameter was obtained from 50% peat + 25% vermiculite + 25% perlite, and the highest root length was obtained from 50% peat + 50% perlite. There was no difference between the growing medium in terms of fresh root weight and dry root weight. As a result, it has been determined that it is not suitable to use 100% leonardite as a growing medium. However, it was observed that growing mediums 33% leonardite + 33% vermiculite + 33% perlite, 50% leonardite + 50% vermiculite, and 25% leonardite + 25% peat + 25% vermiculite + 25% perlite could compete with seedling growing mediums without leonardite.

1. Introduction

The growing medium is important for seed germination. The growing medium used in seedling cultivation affects the growth of the underground and above-ground parts of the seedling as well as seed germination. The growing medium functions not only as a growing area but also as a source of nutrients for plant growth (Bhardwaj, 2014). Peat is a high-quality substrate used as a growing medium in horticulture. (Kern et al., 2017). The volume used annually as a growing medium is about half of the fuel peat (IPS, 2023). Sphagnum peat has been the most important growing medium component for decades (Schmilewski, 2008). Germany and Canada account for more than half of horticultural peat extraction. Other important peat producing countries are the Baltic countries, Finland, Ireland, and Sweden, as well as Chile and Argentina (IPS, 2023).

Peatlands are carbon-rich ecosystems that constitute the largest terrestrial carbon store. The protection of peatlands is recognized as a fundamental component based on nature in combating climate change on a global scale (Lourenco et al., 2023). Due to climate impacts, some European countries have developed national strategies to reduce peat use (Hirschler et al., 2022). Kern et al. (2017) reported that unsustainable peat extraction damaged peatland ecosystems, disappear in Central and Southern Europe. They also emphasized that degraded peatlands have become a source of greenhouse gases due to drainage and excavation. Authorities and many non-governmental organizations advocate reducing peat use (Michel, 2010). Rozas et al. (2023) reported that peat extraction has a global impact due to greenhouse gas emissions and has a significant impact on the local ecosystems from which it is obtained. Česonienė et al. (2023) reported that a large number of saplings are currently grown for blueberry fields and that it is important to conduct studies on the use of various organic and inorganic components in the lower layers to reduce the amount of excavated peat. Environmental concerns have increased the demand for alternative growing media to replace Sphagnum peat. However, growing medium formulations are still dependent on peat and alternatives are limited (Steiner and Harttung, 2014). In addition, the import of peat is an important cost element for countries that do not have sufficient peat resources. Heiskanen (2013) reported that as a result of increasing costs and environmental incentives, seedling growers are seeking more local growing medium components such as compost.

The use of different materials as growth media in seedling cultivation is an important subject due to both increasing costs and environmental concerns regarding the extraction of peat. Replacement of peat is possible using alternative growing medium components based on biomass (Hirschler et al., 2022). It is necessary to be careful when choosing an alternative growing medium for peat. Schmilewski (2008) stated that producers and users of growing medium will be exposed to a high risk if a significant amount of potentially unsuitable ingredients are included in the product.

There are some studies on different growing medium and their mixtures that can be used as an alternative to peat. Osman and Rady (2014) detected the highest rate of germination in a mixture of peat, vermiculite, and perlite in the ratios of 0-35-65, where humic acid was not applied to both eggplant and tomato transplants. Akbaşak and Koral (2014) obtained the lowest value in terms of all seedling characteristics, except for seedling germination rate, from the seedling growing medium consisting of 100% unground rice hull. Polat et al. (2017) used peat, peat+perlite (1:1), grape marc, and soil materials as growth medium for watermelon. Chrysargyris et al. (2019) mixed peat with different biochar materials as a growth medium for cabbage seedlings. Steiner and Harttung (2014) examined the growth of sunflowers in different growing mediums such as biochar, perlite, clay granules, Sphagnum peat and, peat mixed with biochar. Peng et al., (2018) researched the potential of using biochar as a container substrate component to replace peat moss to produce horticultural crops. Kern et al., (2017) reported that biochar can play an important role in replacing peat in the growing medium when biochar is available, meets quality needs, and is economically feasible to use. Fascella and Zizzo (2004) reported that perlite/coir dust caused more flowers and longer stems than pure perlite in open-cycle soilless rose cultivation in the greenhouse. El-Naggar and El-Nasharty (2009) reported that the use of different growing mediums in Amaryllis (*Hippeastrum vittatum*, Herb.) significantly affected most vegetative growth characteristics, flowering parameters, bulb productivity and, leaf chemical composition. In this study, maximum beneficial effect was obtained from the application of N, P and K (19:19:19) complete fertilizer at the rate of 5 g per plant grown on composted leaf medium or its mixture with sand (1:1 v/v) in terms of vegetative growth characteristics, flowering and bulb and bulblet production.

Rozas et al. (2023) examined growing medium mixtures based on the combination of compost, biochar and, peat. Growing media based on the combination of compost, biochar and peat maintained most of the *Lactuca sativa* L. (Oak Leaf variety) seedling traits obtained in the growing media based on only peat.

Leonardite is a stratified material as a result of the fragmentation, degradation, humification, oxidation, and metamorphosis of plant and animal remains deposited in lake environments and swamps in prehistoric times over millions of years under the influence of volcanism movements under pressure, temperature, and anaerobic conditions (Pekcan et al., 2018). Leonardite materials obtained from different regions may have different properties. Pekcan et al. (2018) determined that 28 leonardite samples obtained from different sources had different physical and chemical properties (pH, EC, organic matter, total humic+fulvic acid, carbon/nitrogen ratio, cation exchange capacity) and contents (macro plant nutrients and micro plant nutrients and heavy metals). The physical and chemical properties of leonardite affect its quality. Leonardite materials, which contain high amounts of organic matter, humic, and fulvic acid and and low amounts of $CaCO_3$ and moisture, can be used in agriculture. In addition, the heavy metal content of leonardite should be low. Leonardite is used in agriculture for purposes for improve soil properties, increasing plant nutrition status, yield and quality.

This study was planned to determine the possibilities of using leonardite 100% and its different mixtures with peat, vermiculite and perlite as a growing medium in melon seedling cultivation. Another purpose is determine the possibility of using leonardite as an alternative to peat as a growing medium in seedling cultivation in countries that have important leonardite deposits and can obtain leonardite at low cost.

2. Materials and Methods

2.1. Description of the study site

This study was carried out GAP International Agricultural Research and Training Center in Diyarbakır province of Türkiye in greenhouse conditions in 2023. The coordinates of the greenhouse where the study was carried out are 37°56'33.51" north meridian and 40°15'27.17" east longitude. During seedling growth in the greenhouse, the temperature was set at 25°C, and the humidity was set at 80%.

2.2. Materials

Melon (*Cucumis melo* L.) was used as plant material in this study. Some properties of leonardite was shown in Table 1.

The peat used in the study contains 25.86% organic matter and 1.29% $CaCO_3$. In addition, the pH value was determined as 5.33 and the EC value as 1.88 mmhos cm^{-1} of the peat used.

2.3. Experimental design

The study was carried out according to the randomized plot design with 3 replications. There were 5 plants in each replication.

2.4. Treatments

In this study, it was aimed to investigate the possibilities of using pure and different leonardite mixtures as seedling growing media and their comparison with different growing media. Seedling growing mediums examined in the study; 1: 100% leonardite; 2: 33% leonardite + 33% vermiculite + 33% perlite; 3: 100% peat; 4: 33% peat + 33% vermiculite + 33% perlite; 5: 50% peat + 50% perlite; 6: 50% leonardite + 50% perlite; 7: 50% leonardite + 25% vermiculite + 25% perlite; 8: 50% peat + 25% vermiculite + 25% perlite; 9: 50% peat + 50% vermiculite; 10: 50% leonardite + 50% vermiculite; and 11: 25% leonardite + 25% peat + 25% vermiculite + 25% perlite.

The growing media prepared in the determined proportions were filled in the seedling trays. Seeds were planted by hand on March 12, 2023. Seedling trays were watered after seed planting. Then, irrigation was continued by giving equal amounts of water to the root area every 2 days. Measurements were made on seedlings 45 days after seed planting. Germination rate, plant height, stem length, stem diameter, leaf number, plant fresh weight, plant dry weight, root length, fresh root weight, and dry root weight measurements were made in seedlings. Dry plantand root weights data were determined keeping fresh plants and roots at a temperature of 70°C for 24 hours in drying oven.

2.5. Statistical analysis

The data obtained from this study were evaluated by analysis of variance. Treatment means were compared by LSD Test at a 0.05.

3. Results and Discussion

This study, the parameters of germination rate, plant height, stem length, stem diameter, and actual leaf number, plant fresh weight, plant dry weight, root length, fresh root weight, and dry root weight were examined in seedling growing mediums.

It can be seen that growing mediums are important in terms of germination rate, plant height, stem length, stem diameter, and leaf number parameters (Table 2). Germination rate is very important in seedling cultivation. In this study, it is

Table 1. Some properties of leonardite used in the experiment.

Properties	Unit	Content
Organic matter	%	75.05
Humic+Fulvic acid	%	95.46
EC (1:10 distilled water)	mmhos cm^{-1}	1.94
pH (1:10 distilled water)	-	5.76
Moisture	%	35.00
$CaCO_3$	%	2.27
Total N	%	1.30
Total P	%	0.45
Total K	%	0.07
Total S	%	6.12
Total Na	%	0.90
Total Ca	mg kg^{-1}	14 569
Total Mg	mg kg^{-1}	2 825
Total B	mg kg^{-1}	37.00
Total Fe	mg kg^{-1}	9273.00
Total Cu	mg kg^{-1}	4.76
Total Ma	mg kg^{-1}	26.67
Total Cr	mg kg^{-1}	44.65
Total Mo	mg kg^{-1}	10.72

Table 2. Germination rate, plant height, stem length, stem diameter, and leaf number of seedling growing mediums.

Growing mediums	Germination rate (%)	Plant height (cm)	Stem length (cm)	Stem diameter (mm)	Leaf number (number)
1 (100% leonardite)	60.00 d	4.86 cd	2.36 d	2.43 d	3.05 bc
2 (33% leonardite + 33% vermiculite + 33% perlite)	100.00 a	5.66 ac	2.60 cd	2.58 bd	3.20 bc
3 (100% peat)	100.00 a	6.73 a	3.73 a	2.71 ad	3.93 a
4 (33% peat + 33% vermiculite + 33% perlite)	100.00 a	5.00 bd	2.26 d	2.60 bd	3.06 bc
5 (50% peat + 50% perlite)	93.00 ab	4.40 d	2.00 d	2.62 bd	3.06 bc
6 (50% leonardite + 50% perlite)	66.00 bc	4.91 bd	2.08 d	2.54 bd	3.16 bc
7 (50% leonardite + 25% vermiculite + 25% perlite)	66.00 bc	6.11 ab	3.41 ab	2.72 ad	3.28 bc
8 (50% peat + 25% vermiculite + 25% perlite)	66.00 bc	4.83 cd	2.27 d	3.05 a	2.85 c
9 (50% peat + 50% vermiculite)	100.00 a	4.86 cd	2.06 d	2.84 ab	3.00 bc
10 (50% leonardite + 50% vermiculite)	100.00 a	5.80 ac	3.06 bc	2.81 ac	3.40 b
11 (25% leonardite + 25% peat + 25% vermiculite + 25% perlite)	100.00 a	6.00 ac	3.00 bc	2.49 cd	3.33 bc
CV	19.46	13.01	13.35	7.49	9.34
LSD	28.66*	1.18**	0.60**	0.33*	0.52*

*: $p<0.05$, and **: $p<0.01$, CV: Coefficient of variation, LSD: Least significant difference.

Table 3. Plant fresh weight, plant dry weight, root length, fresh root weight, and dry root weight of seedling growing medium.

Growing mediums	Plant fresh weight (g)	Plant dry weight (g)	Root length (cm)	Fresh root weight (g)	Dry root weight (g)
1 (100% leonardite)	0.93 b	0.58 bc	10.37 bc	0.58	0.32
2 (33% leonardite + 33% vermiculite + 33% perlite)	0.86 bd	0.60 bc	13.50 ab	0.60	0.38
3 (100% peat)	1.26 a	0.84 a	10.40 bc	0.77	0.47
4 (33% peat + 33% vermiculite + 33% perlite)	0.73 bd	0.60 bc	11.45 bc	0.60	0.28
5 (50% peat + 50% perlite)	0.92 bc	0.55 b-d	15.30 a	0.55	0.35
6 (50% leonardite + 50% perlite)	0.87 bd	0.69 ab	12.05 bc	0.69	0.40
7 (50% leonardite + 25% vermiculite + 25% perlite)	0.95 b	0.60 bc	11.84 bc	0.60	0.34
8 (50% peat + 25% vermiculite + 25% perlite)	0.63 d	0.47 cd	10.26 c	0.47	0.23
9 (50% peat + 50% vermiculite)	0.66 cd	0.37 d	10.45 bc	0.43	0.30
10 (50% leonardite + 50% vermiculite)	0.90 bc	0.64 bc	10.60 bc	0.64	0.36
11 (25% leonardite + 25% peat + 25% vermiculite + 25% perlite)	0.96 b	0.63 bc	12.31 bc	0.63	0.27
CV	17.04	16.66	13.19	16.94	26.60
LSD	0.24**	0.16**	3.00*	n.s.	n.s.

ns: non-significant *: $p<0.05$, and **: $p<0.01$, CV: Coefficient of variation, LSD: Least significant difference.

seen that growing medium effect on the germination rate. The germination rate of pure leonardite was found to be lower than other growing medium. It was observed that the highest plant height was in growing medium number 3 (100% peat), and the lowest plant height was in growing medium number 5 (50% peat + 50% perlite). The highest stem length was obtained from growing medium number 3 (3.73 cm), and the lowest stem length was obtained from growing medium number 5 (2.00 cm). The proximate value to the growing medium number 3 in terms of stem length was obtained from the growing medium number 7 (50% leonardite + 25% vermiculite + 25% perlite). 100% leonardite was statistically in the same group as growing medium number 5. It has been observed that growing mediums also greatly affect stem diameter. While the stem diameter was the highest (3.05 mm) in the growing medium number 8 (50% peat + 25% vermiculite + 25% perlite), it was the lowest (2.43 mm) in the growing medium number 1 (100% leonardite). Growing mediums also affected the leaf number of the seedlings. The leaf number in growing medium number 3 (100% peat) was found to be highest (3.93) in other growing mediums. It was determined that the leaf number was lowest (2.85) in the growing medium number 8 (50% peat + 25% vermiculite + 25% perlite).

Although the germination rate is 60% when pure leonardite is used as a seedling growing medium, it has been determined that the germination rate is higher in growing mediums where leonardite is used as a mixture. All of the seeds germinated in growing mediums 2, 10 and, 11, in which leonardite was used as a mixture. Plant height was found to be higher in seedling growing mediums numbered 2, 6, 7, 10, and 11, in which leonardite was used as a mixture, compared to growing medium number 5 (50% peat + 50% perlite). Positive results were obtained in terms of the stem diameter of seedling growth mediums numbered 7 and 10, where leonardite was used as a mixture, and the stem length of seedling growing medium number 7. The highest leaf number after 100% peat was obtained from seedling growing medium number 10. Table 3 shows the plant fresh weight, plant dry weight, root length, fresh root weight, and dry root weight parameters of the seedling growing medium. When Table 3 is examined, it was seen that there were differences between the growing environments in terms of plant fresh weight, plant dry weight, and root length, but there is no difference in terms of fresh and dry root weights. The highest fresh weight (1.26 g) was obtained from 100% peat and the lowest (0.63 g) weight determined on 50% peat + 25% vermiculite + 25% perlite. Plant dry weight was found to be highest (0.84 g) in growing medium number 3 (100% peat) and lowest (0.37 g) in growing medium number 9 (50% peat + 50% vermiculite). It was determined that the root length was the highest (15.30 cm) in the growing medium number 5 (50% peat + 50% perlite). The growing medium with the lowest (10.26 cm) root length was growing medium number 8 (50% peat + 25% vermiculite + 25% perlite).

Although the seedling growing mediums in which leonardite was used as a mixture were found to be lower than 100% peat material in terms of plant fresh and dry weight, they were higher than the seedling growing mediums numbered 5, 8, and 9, in which leonardite was not used. Similarly, root length in all applications where leonardite was used as a mixture was statistically better or classified in the same group as growing medium 3, 4, 8, and 9, in which leonardite was not used.

It was determined that the peat and leonardite materials used in this study have similar properties in terms of organic matter, pH and electrical conductivity. However, it has been observed that pure peat material is a better growing medium than pure leonardite material in this study. The effects of growing medium on seedling germination and seedling growth have been investigated in different studies. Polat et al. (2017) in which different growing mediums in watermelon were examined, the highest actual number of leaves, stem length, stem diameter, plant fresh weight, plant dry weight, root fresh weight, and root dry weight were obtained from peat material. As a result of the study, the best results were obtained from peat and peat: perlite (1:1) mixture media. Yılmaz et al. (2018), the highest seedling height and root length were obtained from 100% peat application in tomato. As in these references, positive results were obtained from peat material in this study. 100% peat application was in the highest statistical group among seedling growing media in terms of germination rate, plant height, stem length, leaf number, plant fresh weight, and plant dry weight. The lowest values in terms of germination rate, stem length, and stem diameter were obtained from 100% leonardite medium. Compared to pure leonardite, higher values were obtained in terms of germination rate, plant height, stem length, stem diameter, leaf number, plant dry weight, and root length from the seedling growing media which leonardite was used as a mixture. In a study conducted by Pertuit et al. (2001) reported that adding 1/64 leonardite (v/v) to sand medium increased tomato root and shoot growth compared to plants produced with fertilizer only. Growth increased linearly from 0% to 25% with increasing leonardite levels, but 50% leonardite inhibited growth. Unal (2013) examined the effect of different organic media on the growth of vegetable seeds. As a result of the study, lower hypocotyl height, seedling height, and seedling root length were obtained from the peat-stable manure-prunings (2:1:1) mixture with leonardite added (5 g kg^{-1}) in tomato plants compared to other mixtures without leonardite. Erdal et al. (2024) examined the effects of different growing media (cocopeat, perlite, leonardite, vermicompost, and peat) and their mixtures on growth and yield in tomato plants and reported that vermicompost and its mixtures with peat were generally the most effective growth media on leaf and fruit nutrient concentrations.

As a result, it was understood that 100% peat material is a growing medium that positively affects the growth of seedlings. It has been determined that 100% leonardite material is not a suitable growing medium. However, better results were obtained from seedling growing mediums where leonardite was used as a mixture, compared to 100% leonardite. It was observed that all the seeds germinated in growing mediums 2, 10, and 11, in which leonardite was used as a mixture. In addition, it was determined that growing mediums 2, 10, and 11 could compete with seedling growing mediums without leonardite in terms of other parameters examined.

4. Conclusions

It was determined that growing mediums are very important in terms of germination rate and growth of seedlings in this study. Important results were obtained from this study that related the use of leonardite as a growing medium. 100% leonardite gave the lowest statistical group in terms of germination rate, plant height, stem length, leaf number, and root length parameters. For this reason, it is not recommended to use pure leonardite as a seedling growing medium. 100% germination rate, highest plant height, stem length, actual leaf number, plant fresh weight, and plant dry weight values were obtained in growing medium number 3, in which pure peat was used. However, higher values were obtained in terms of germination rate, plant height, and stem length, stem diameter, actual leaf number, plant dry weight, and root length in a seedling growing medium which leonardite was used as a mixture, compared to pure leonardite. In addition, seedling growing mediums using leonardite were able to compete with seedling growing mediums without using leonardite. As a result, it was determined by this study that the best seedling growing medium is 100% peat and it is not suitable to use 100% leonardite as a seedling growing medium. Although the results were not as good as the seedling growing medium using 100% peat material, it was determined that leonardite could be used in seedling growing medium mixtures as an alternative to the use of peat. Considering the 100% germination rate and other parameters, it was determined that growing mediums 33% leonardite + 33% vermiculite + 33% perlite, 50% leonardite + 50% vermiculite, and 25% leonardite + 25% peat + 25% vermiculite + 25% perlite could compete with seedling growing mediums without leonardite.

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