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Research Article

Effects of Different Growing Media on Growth Parameters of Zinnia (*Zinnia elegans*)

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Abstract: Growth media have important effects on the development of ornamental plants. Many organic and inorganic materials are used in the as growing media (GM) of plants. The present study was carried out in Atatürk University controlled greenhouses condition. In the study, 11 different media created with sand, soil, peat, perlite, and coconut peat and their different mixtures were used as growing media. Mixing medium on a volumetric basis (V:V), respectively: Mix 1: coconut peat+perlite+peat (1:1:1), mix 2: coconut peat + perlite+ soil (1:1:1), mix 3: coconut peat + peat + soil (1:1:1), mix 4: coconut peat + sand + soil (1:1:1), mix 5: perlite + sand + soil (1:1:1), mix 6: peat + sand+soil (1:1:1). Our results showed that GM had a positive effect on the plant growth and flower parameters (flower number, stem diameter, flower stem length, flower diameter, flower stem thickness, plant wet and dry weight, flower wet and dry weight, root length parameters), chlorophyll reading value (SPAD), and chemical properties of plant leaves. In the study, it was determined that the plant growth and development were better by using peat + sand + soil (1:1:1) mixtures that can be suggested as useful growth media for *Zinnia elegans* plants.

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Kirli Hanım Çiçeği (*Zinnia elegans*) nin Büyüme Parametreleri Üzerine Farklı Büyüme Ortamlarının Etkileri

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Anahtar Kelimeler

Hindistan cevizi kabuğu,
Ortam,
Perlite,
Kum,
Zinnia elegans

Öz: Süs bitkilerinin gelişimi üzerinde büyüme ortamlarının önemli etkileri vardır. Bitkilerin yetiştirme ortamı (BYO) olarak birçok organik ve inorganik malzeme kullanılmaktadır. Çalışma Atatürk Üniversitesi kontrollü sera koşullarında gerçekleştirilmiştir. Çalışmada yetiştirme ortamı olarak kum, toprak, turba, perlit ve hindistancevizi turbası ve bunların farklı karışımları ile oluşturulan 11 farklı ortam kullanılmıştır. Karışım ortamları hacimsel esasa göre (V:V) sırasıyla: Karışım 1: hindistan cevizi turba+perlit+turba (1:1:1), karışım 2: hindistan cevizi turba+perlit + toprak (1:1:1), karışım 3: hindistan cevizi turba + turba + toprak (1:1:1), karışım 4: hindistan cevizi turba + kum+toprak (1:1:1), karışım 5: perlit+kum+toprak (1:1:1), karışım 6: turba+ kum +toprak (1:1:1) şeklindedir. Sonuçlarımız, BYO'nun bitki büyüme ve çiçek parametreleri (çiçek sayısı, gövde çapı, çiçek sap uzunluğu, çiçek çapı, çiçek sap kalınlığı, bitki yaş ve kuru ağırlığı, çiçek yaş ve kuru ağırlığı, kök uzunluğu parametreleri), bitki klorofil okuma değeri (SPAD) ve kimyasal özellikleri üzerinde olumlu bir etkiye sahip olduğunu göstermiştir. Çalışmada, *Zinnia elegans* bitkileri için faydalı büyüme ortamı olarak turba+kum+toprak (1:1:1) karışımlarının kullanılmasının bitki büyüme ve gelişiminin daha iyi olduğu tespit edilmiştir.hardness, adhesiveness, resilience and cohesiveness values of the meatball samples. However, the frying method did not have a significant effect on the springeness ($p>0.05$). The frying number caused a decrease in all texture parameters except the gumminess value.

1. Introduction

Zinnia elegans is a common ornamental plant of the Asteraceae family. These plants are of American origin with Central America and Mexico origin. The plant has 20 varieties as annual and perennial. The genus Zinnia and *Zinnia elegans* are the most widely known among them (Dole and Wilkins, 2005). It has got an impressive range of flower colors and persistent bloom. It is one of the seasonal plants. It is grown by sowing seeds in the spring. Zinnia flowers exhibit bright, uniform colors, sturdy stems with disease resistant plants, and along with vase life (Sardoie et al., 2015). Zinnia flowers have different colors such as white, light green, yellow, orange, red, purple, and lilac (Salem et al., 2003). It has different usage areas as landscape land arrange. Long varieties of zinnia are used for cut flower production, while shorter varieties are used as annual garden, window, and pot plants (El-Nashar and Aboelsaadat, 2020). Since it is a temperate climate plant, it is not resistant to frosts and extreme cold. There are many varieties with dwarf, tall, plain and layered flowers. Many types of zinnia are used in cut floriculture. Leaves are lanceolate, and their length varies between 15 cm and 1 meter. Its leaves are light green in color and are arranged in an oval or heart shape on the stem (Burlec et al., 2019). Zinnia is valuable for landscape works due to its resistance to drought and temperature and its long flowering period (Ebrahimzadeh and Seifi, 1999; Taherpazir and Hashemabadi, 2016).

Drought-resistant *Zinnia elegans* are widely used in landscaping in many parts of the world. *Zinnia elegans* began gaining popularity in 1790 by being recognized in Europe as a landscape plant (Burlec et al., 2019). Zinnia is tolerant of different soil types except for intense moisture and poorly ventilated soils that can cause root rot. With drip irrigation, leaves remain dry, and the spread of disease that can be transmitted from leaf to leaf or from plant to plant is reduced (Johnson and Kessler, 2008).

Growth media (GM) have important effects on the development of the plant. Today, producers prefer growth media that will allow the plant to grow rapidly and do not cause much labor, time, and money loss. Many organic and inorganic materials are used in the GM of plants. For this purpose, different media such as sand, soil, perlite, coir were used as GM for the growing of ornamental plants. Soil conditioners and the mixture of the substrate of growing media are important parameters that affect the plant height, the number of leaves, the number and diameter of florets per spike, yield, and the longevity of the plants provided proper aeration, water holding capacity, and adequate nutrient supply. It has been reported that the optimum amount of nutrient and environmental factors affect the plant growth, development, and flowering of the plant (Alvarez et al., 2018).

Perlite is a volcanic material heated to (850 °C), it is light weight, chemically inert, pH neutral, sterile and odorless, and its particles create tiny air tunnels, which allow moisture and oxygen to flow freely to roots (Sharbazhery and Gareeb, 2016). Due to the porous structure of sand, they have features such as low cation exchange capacity, low water holding capacity, and scarcity of nutrients. In addition, since it has large pores (macro pores), the nutrients found are lost due to rapid washing. If it is to be used as a growth medium, it needs intensive fertilization and irrigation. For these reasons, it is not preferred by growers as a single planting medium (Rosalina et al., 2019).

Peat is an organic soil type formed as a result of the decrease in the water level in the lake beds, the prominence of plant activities, the death of the plant due to the increase of the water level in winter, and the continuous repetition of this naturalness. Peat has important functions for the plant. It holds water and nutrients due to its high water holding and aeration capacity. Peat can hold 20 times its own weight in water. It is easy to carry because of its light weight, it is sterile, and does not contain foreign matter (Fascella, 2015). Peat is a good substrate used as a growing medium in vegetable and ornamental plants seedling cultivation due to its optimum quality properties (Noordegraaf et al., 2014).

Coir growth medium is widely used as a medium for the production of potted ornamental plants. İt is one of the most preferred media in plant breeding due to its physical and chemical properties such as pH, EC, bulk density, high water holding capacity (Ilahi and Ahmad, 2017). Coir is the substrate obtained from the shell of the coconut and used in soilless agriculture. İn addition, it can be used as a plant growing medium alone or as a mixture due to its high pore number, high water holding capacity, low bulk density, and slow biodegradation (Cahyo et al., 2019). Coir can be used as a plant growth medium alone or as a component. In a study, it was found that cucumber grown under salt stress is more effective on the growth and yield of t.he plant than rock wool and perlite (Cahyo et al., 2019). The better performance of coir may be due to its higher water and nutrient holding capacity. It has also been reported that coir has a cation exchange capacity 50-100 times higher than perlite; in this case, it affects the pH and nutrient intake (Usanmaz and Abak, 2019). In another study, after the use of coir as a planting medium, balanced fertilization was recommended to provide nutrients not found in cocoa (Cahyo et al., 2019).

This study was carried out to compare the effects of different growth media such as sand, soil, perlite, coir and their different mixture forms on zinnia growth parameters.

2. Materials and Methods

2.1. Plant material and growth conditions

The potting study was conducted in controlled greenhouse conditions at Atatürk University Faculty of Agriculture between May 2019 and July 2019 in Erzurum province in the northeastern Anatoli region of Turkey.

Growing media (GM) such as soil, perlite, sand, peat, and coir were used as a single and mix in the study. The experimental layout is randomized as sand, soil, peat, perlite, coir, Mix 1 (coir + perlite + peat), Mix 2 (coir + perlite +soil), Mix 3 (coir + peat + soil), Mix 4 (coir+sand + soil), Mix 5 (perlite+sand+soil), Mix 6 (peat+sand+soil) (Table 1). Coir (PC) has been used as a reference medium because it is known as a growing medium for ornamentals and outdoor plants.

Table 1. Potting media combination

Growing Media	Growing Media	Ratio
Sand	SD	1
Soil	SO	1
Peat	PT	1
Perlite	PR	1
Coir	CP	1
Coir + Perlite + Peat	Mix 1	1:1:1
Coir + Perlite +Soil	Mix 2	1:1:1
Coir + Peat + Soil	Mix 3	1:1:1
Coir+ Sand+ Soil	Mix 4	1:1:1
Perlite+ Sand + Soil	Mix 5	1:1:1
Peat+ Sand+ Soil	Mix 6	1:1:1

The experiment was applied in 3 replicates in a random block design. Zinnia seeds were firstly sown into the multi-celled trays filled with peat. About two months later, the homogenous and healthy seedlings were transferred into 2.5 L pots as a seedling for each pot. The fertilizer (18-18-18, NPK+TE) was applied to all pots as 100 cc two-week intervals.

The study was carried out in controlled greenhouses of Erzurum Atatürk University Faculty of Agriculture. During the study period, the average minimum temperature of the greenhouse was 14.4 °C, and the average maximum temperature was 32.9 °C, while the average air humidity was 25 ± 5%. The study was carried out in 99 pots with 11 different growing media.

2.2. Growth and yield parameters

Harvest was made after 60 days of transplanting. After harvest, 2 samples were taken from each pot and prepared for various analyses. Plant flower number, stem diameter (mm), flower stem length (cm), flower diameter (mm), flower stem thickness (mm), plant fresh and dry weight (gr), flower fresh and dry weight (gr), chlorophyll reading value (SPAD), root length parameters (cm) were examined. The plant samples for dry weight were kept in an oven at 65 °C for 48 h. Leaf chlorophyll reading value was determined with a portable chlorophyll meter (SPAD-502). Since the plants used in the experiment were initially selected in equal size, no measurements were made. Afterward, measurements were made in 2 different periods as flowering and harvesting periods.

2.3. Medium chemical analysis

In the study, various analyzes were made on soil samples taken from growth media. Experimental samples were air dried, crushed and passed through a 2mm sieve prior to chemical analysis. The Kjeldahl method (Bremner, 1996) was used to determine total N while plant available whereas P concentrations were determined by using the sodium bicarbonate method of Olsen et al. Electrical conductivity (EC) was measured in saturation extracts according to Rhoades. Samples pH were determined in 1:2 extracts, and calcium carbonate concentrations were determined according to McLean. Soil organic matter was determined using the Smith-Weldon method according to Nelson and Sommers. Ammonium acetate buffered at pH 7 (Thomas 1982) was used to determine exchangeable cations. Available Fe, Mn, Zn, and Cu in the soils were determined by DTPA extraction methods (Lindsay and Norvell, 1978). Available B was analyzed for extractable B using the azomethine-H extraction of Wolf. Some physical and chemical properties of mediums used in the study Table 2. *Zinnia elegans* leaves and roots were ground after being dried at 68 ºC for 48 h in an oven. Determination of the total N was achieved by the Kjeldahl method using a Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Konigswinter, Germany). An inductively coupled plasma spectrophotometer (Optima 2100 DV, ICP/OES; Perkin-Elmer, Shelton, CT) was used to determine tissue P, K, Ca, Mg, Fe, Cu, Mn, Zn, B, Cl, and Cd (Mertens, 2005a and 2005b).

Table 2. Some physical and chemical properties of the medium used in the study

Growth Medium	pH	EC (dS m^{-1})	Lime (g kg^{-1})	Organic Matter (%)	Total N (%)	Soluble P (mg kg^{-1})	Soluble K (mg kg^{-1})	Soluble Ca (mg kg^{-1})
CP	6.5±0.2	0.82±0.05	0.32±0.02	6.5±0.1	0.37±0.04	0.6±0.02	90±15	455±5
PR	6.8±0.3	0.79±0.08	0.77±0.04	0.2±0.2	0.002±0.06	0.08±0.03	40±1.5	390±4
PT	6.9±0.2	0.97±0.04	0.54±0.03	20.5±0.2	0.005±0.74	0.72±0.04	174±1.6	750±7
SD	6.8±0.3	0.88±0.06	0.11±0.020	0.2±0.3	0.010±0.21	0.05±0.05	22±1.4	300±3
SO	7.3±0.3	1.0±0.05	1.90.±0.52.	1.3±0.2	0.030 ±0.05	2.41±0.03	114±,31.7	1050±8
Mix 1	6.9±0.20	1.05,6±0.03	0.7±0.05	6.9±0.1	0.35±0.06	0.53±0.040	96±2.2	715±3
Mix 2	6.7±0.2	0.92±0.06	0.68±0.07	2.1±0.3	0.19±0.05	0.50.±0.32	93±1.8	670±6
Mix 3	6.8±0.3	0.88±0.08	0.6±0.05	6.6±0.3	0.27±0.03	0.59±0.02	83±1.4	477±4
Mix 4	7.2±0.2	0.96±0.09	0.63±0.02	4.3±0.2	0.14±0.07	0.56±0.02	69±1.6	430±5
Mix 5	6.8±0.2	0.87±0.04	0.75±0.06	0.5±0.3	0.025±0.08	0.05±0.04	29±1.5	355±3
Mix 6	7.1±0.2	1.07±0.07	0.42±0.08	6.3±0.2	0.32±0.06	0.56±0.02	62±1.2	390±7
Growth Medium	**Mg (mg kg^{-1})**	**Na (mg kg^{-1})**	**Available B (mg kg^{-1})**	**Available Cu (mg kg^{-1})**	**Available Fe (mg kg^{-1})**	**Available Zn (mg $kg^{-1)}$)**	**Available Mn (mg kg^{-1})**	
CP	20.3±0.5	11.4±1.1	0.07±0.02	0.1±0.05	0.5±0.02	0.07±0.01	0.08±0.01	
PR	16.5±0.6	23.9±1.0	0.06±0.02	0.14±0.03	0.3±0.02	0.07±0.020	0.09±0.01	
PT	26.5±0.7	9.54±1.2	0.02±0.01	0.15±0.03	0.6±0.01	0.2±0.02	0.09±0.01	
SD	8.4±0.4	3.3±0.5	0.05±0.03	0.13±0.05	0.4±0.03	0.05±0.020	0.03±0.02	
SO	40.5±0.5	11.1±40.6	0.06±0.02	0.32±0.02	1.2±0.01	0.30.±0.03	0.01±0.01	
Mix 1	25.4±0.5	8.59±0.8	0.03±0.02	0.14±0.03	0.5±0.02	0.15±0.01	0.09±0.02	
Mix 2	20.5±0.5	9.45±0.9	0.02±0.03	0.17±0.02	0.4±0.01	0.15±0.02	0.08±0.02	
Mix 3	19.6±0.3	8.77±0.5	0.02±0.01	0.15±0.03	0.6±0.03	0.13±0.02	0.07±0.01	
Mix 4	29.4±0.6	9.56±0.4	0.04±0.03	0.16±0.02	0.5±0.03	0.12±0.01	0.06±0.02	
Mix 5	22.7±0.7	9.43±0.6	0.03±0.02	0.17±0.02	0.4±0.02	0.12±0.02	0.07±0.03	
Mix 6	19.6±0.4	8.3±0.3	0.04±0.03	0.14±0.03	0.3±0.01	0.14±0.02	0.06±0.02	

CP: coir, PR: pearlite, PT; Peat, SD: sand, SO: Soil, Mix 1: coir + perlite + peat (1:1:1), Mix 2: coir + perlite + soil 1:1:1), Mix 3: coir + peat + soil1:1:1), Mix 4: coir + sand+Soil (1:1:1), Mix 5: perlite + sand + soil (1:1:1), Mix 6: Peat + Sand + Soil (1:1:1).

2.4. Statistical analysis

The data obtained from the study results were subjected to variance analysis, and the differences of the means were determined by the Duncan multiple comparison test (SPSS, 2010).

3. Results and Discussion

Our results showed that different growth medium applications significantly affected the plant growth parameters such as the number of flowers, plant height, pedicle length, pedicle diameter, plant fresh weight, plant dry weight, root fresh weight, root dry weight, root length of *Zinnia elegans* plants (Table 3). Number of flowers, plant height, pedicle length, pedicle diameter, plant fresh weight, plant dry weight, root fresh weight, root dry weight, root length**,** chlorophyll reading (SPAD) of *Zinnia elegans* plant differed significantly among treatments. The highest numbers of flowers per plant and pedicle length were recorded in soil treatment, followed by Mix 6 treatment. The least flower number per plant was found in CP treatment. Soil medium increased flower per plant and pedicle length by 81.96 and 78.13%, respectively, compared to the CP. CP has been used as a reference medium because it is known as a growing medium for ornamentals and outdoor plants. The highest plant height, plant fresh weight, plant dry weight, root fresh weight, root dry weight, root length, and chlorophyll reading were obtained from Mix 6 application. Mix 6 applications increased plant height, plant fresh weight, plant dry weight, root fresh weight, root dry weight, and root length reading by 183%, 108%, 57.32%, 236%, and 31.53%, respectively, compared to the CP. On the other hand, the highest chlorophyll reading values were obtained from SD and followed by Mix 5, Mix 6 applications, the lowest values were found in CP treatments (Table 3). Mix5 and Mix 6 treatment increased the chlorophyll reading values by 52.88% and 50,92%, respectively, compared to the PC.

These results are supported by the findings of various researchers. Awan and Ismail (1997); Riaz et al. (2008) found that *Zinnia elegans* and marigold produced more flowers when grown in a coconut-containing media, but in this case, coconuts failed to produce these effects when used alone.

In a study, different media were used for the growth performance of *Ficus benjamina*, *Padanus sanderi*, *Rosmarinus officinalis* plants. In the study, the highest average stem length was determined in 50% peat moss + 25% sand + 25% perlite and 50% peat moss + 25% sand + 25% perlite (Sardoei and Rahbaria, 2014). In a study, saffron was grown in soil + sand (control), soil + sand + fertilizer, soil + sand + onion, and soil + sand + fertilizer + nitfojip-K, and the effect of hydration on plant growth was examined. The best media in the study was determined as soil + sand + fertilizer environment (Turhan et al., 2007). Younis et al. (2007) Dahlia coccinia plant in different growth media (coconut coir, compost, silt, leaf manure, manure mix (silt 1+sand 1+leaf manure 1), compost mix (compost 1+sand 1+silt 1), coconut coir mix (coconut coir 1+silt 1+sand 1), silt+normal) the effects of the plant on flower quality, flower size and germination were investigated. As a result of the research, it has been proven that the fertilizer leaf manure application of the plant is a much better growing media than other applications. In a study, volumetric mixtures such as peat + sand (2:1), peat + perlite (2:1), and soil + farmyard manure + sand (2:1:1) were investigated on the seedling characteristics and leaf nutrient content of *Alnus orientalis* plant of different growing media its effects have been researched. As a result of the research, the highest values on plant seedling length, stem diameter, number of leaves, number of side shoots, stem and root length, and dry weight were recorded for seedlings grown on a mixture of soil + fertilizer + sand (2: 1: 1) (Kösa and Karaguzel, 2012). On the growth and flowering of *Zinnia elegans* plant, coconut compost, silt, soil loam, foliar fertilizer, (foliar + silt; 2:1), (coconut compost + soil loam; 1:1) and silt; 2: 1), (coconut compost + soil loam; 1: 1) and (leaf manure + soil loam + silt; 1:1:1), the effects of seven different growing media on the growth parameters of the plant were evaluated. In this study, it was determined that maximum vase life and flower diameter increased significantly in both media using foliar fertilizer and mixture (coconut compost + soil tone; 1:1) (Sardoei et al., 2014). The effects of different potting media on plant growth parameters of chrysanthemum variety Punjab Anuradha were examined, and differences were observed between environments. As a result of the study, it was determined that the medium containing Coir + Sand + farmyard manure (FYM) + Vermicompost showed maximum values for plant height, plant spread, number of branches per plant, flowering duration, flower weight, spray length and number of flowers per plant. However, the maximum flower diameter was obtained from the combination of Soil + Sand + FYM + Vermicompost (2:1:0.5:0.5) (Kameswari et al., 2014).

Many studies emphasize the importance of growing media as well as the availability of nutrients for optimum plant growth (Brito et al., 2015). However, besides the presence of nutrients, the pH and EC values of the environment are also important factors (Caballero et al., 2007). , The ph of growing environments, affects the availability of plant nutrients. Increases and decreases in pH levels directly affect plant growth parameters. Awang et al. (2010) stated that the best pH range is in the range 5.9-7.0, and the plants show the best growth and development in this range. Our results range from 6.5-7.1 (Table 2). This shows that the pH value of all growth media is suitable. Electrical conductivity (EC) allows measurement of dissolved salts in soil affects plant growth (Bustamante et al., 2008). EC higher than 4dS/m generally depresses plant growth (Ribeiro et al., 2002; Riaz et al., 2008) EC values of the environments in the study ranged between 0.82-1.07 (Table 2).

The present study showed that different growth medium applications significantly affected on leaf and root nutrient content such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), zinc (Zn), iron (Fe), manganese (Mn), copper (Cu) and boron (B) leaf and root content of *Zinnia elegans* plant differed significantly among treatments. The highest leaf N, P, Ca, Mg, Zn, Fe, Cu, and B content of *Zinnia elegans* were recorded in PT treatment, followed by SD treatment. While the highest K was found in SD treatment. PT medium increased N, P, Ca, Mg, Zn, Fe, Cu and B by 51.54%, 79.63%, 47,85%, 23,63%, 106.8%, 58.86%, 44.08% and 1454.8% respectively, compared to the PC (Table 4).

The highest root N, P, Zn, Cu, and B content of *Zinnia elegans* were recorded in PT treatment, followed by SD treatment. While the highest K, Ca, Fe, and Mn were found in SD treatment. PT medium increased N, P, Zn, Cu, and B by 52.38%, 79.51%, 112.54%, 44.29%, and 145.21%, respectively, compared to the PC (Table 5). SD treatment increased K, Ca, Fe, and Mn by 57.59%, 49.77%, 65.08%, and 51.25%, respectively.

Results from various studies revealed that the suitability of using peat in plant cultivation in terms of providing plant nutrients had been demonstrated (Ceglie et al., 2015; Dhen et al., 2018). Stamps and Evans (1997) reported that the use of coconut instead of moss peat for the plant dieffenbachia (*Diffenbachia maculata*) gives better results for growth index and visual performance. In a study conducted, Stok (*Matthiola incana* L. 'Midseason Merry White') and zinnia (*Zinnia elegans* Jacq. "Benary's Giant Deep Red") plants were grown in different environments. These environments; It is in the form of peat, coconut and traditional substrate (soil + silt + leaf mildew, 1: 1: 1, v / v / v). As a result of the study, it was determined that the NPK content of the peat medium was higher than the other medium (Saleem et al., 2015). Al-Ajlouni et al. (2017) found that there is no linear relationship between the mineral element presence of the growing environment and the mineral element concentration in the above-ground parts of the plant. They determined that the effects of different media (coconut, palm peat, and perlite) used in tomato cultivation on the nutrient concentration of the fruit such as N, P, K in the greenhouse were not significant (Ghehsareh et al., 2011). A study with lily plants revealed that the increase in N concentration in the plant might cause an increase in Ca absorption (Marin et al., 2011). Similarly, in our study, the amount of Ca increased in parallel with the increase in the amount of N in the plant (Table 4). Hajizadeh et al. (2016) explained that the reason for the growth of the upper parts more than the roots is the presence of more N in the upper parts of the plants. In our study results, it was revealed that the N content of the plants' upper part is higher than the root part (Table 3-4). In our study, it has been shown that single sand and peat media contain more Mn than other single media (Table 3). Similarly, it was determined that Mn content increased in rose cultivation in coconut peat environments (Roosta et al., 2015). In a greenhouse study, the effect of palm and coconut habitats on lily plant growth and nutrient was investigated. As a result of the research, when the effect of different growing media in terms of plant nutrient content was evaluated with the control group, some elements (K, Ca, Cu and Mn) were compared to other elements (N, Mg, and Fe) (Heidari et al., 2021).

Table 3. Effect of different growing medium on growth parameters of *Zinnia elegans*

Growth Medium	Number of Flower (per plant)	Plant height (cm)	Stem diameter (mm)	Pedicle length (cm)	Pedicle diameter (mm)	Flower diameter (mm)
CP	1.83±0.29 d	20.75±1.64 c	4.90±0.80 ns	7.18±1.07 cd	2.75±0.36 d	50.74±6.83 ns
PR	2.33±0.58 bcd	20.74±2.16 c	4.89±0.18	8.29±1.14 bcd	3.05±0.22 cd	50.78±9.42
PT	2.67±0.29 a-d	25.83±0.88 a	6.57±0.81	12.79±0.90 a	3.25±0.20 a-d	57.19±2.29
SD	2.93±0.55 abc	22.50±1.80 abc	5.99±1.64	7.90±1.15 bcd	3.04±0.31 cd	45.98±12.83
SO	3.33±2.29 a	24.37±1.26 ab	5.69±0.48	6.33±0.76 d	3.15±0.13 bcd	56.81±5.71
Mix 1	2.50±0.50 a-d	23.83±0.88 abc	5.44±0.34	9.48±0.23 bc	3.54±0.36 abc	59.73±6.01
Mix 2	2.50±0.49 a-d	23.53±1.71 abc	5.69±0.05	8.50±2.18 bcd	3.83±0.16 a	59.25±8.66
Mix 3	2.50±0.48 a-d	23.83±2.75 abc	5.90±0.66	8.99±1.57 bc	3.78±0.73 ab	58.73±13.21
Mix 4	2.00±0.50 cd	21.83 ±1.57bc	5.65±0.10	9.78±1.34 b	3.50±0.35 abc	53.79±4.11
Mix 5	2.67±0.58 a-d	24.25 ±1.64ab	5.98±0.31	9.56±1.39 bc	3.51±0.34 abc	63.62±4.71
Mix 6	3.17±0.76 ab	25.42±2.16 a	6.13±0.41	12.37±1.43 a	3.60±0.24 a	54.05±8.35

	Plant fresh weight (g plant^{-1})	Plant dry weight (g plant^{-1})	Root fresh weight (g plant^{-1})	Root dry weight (g plant^{-1})	Root length (cm)	Chlorophyll reading value (SPAD)
CP	9.34±0.75 d	2.84±1.22 e	17.60±6.54 bc	1.21±0.85 c	32.50±3.40 ab	18.40±1.22 f
PR	13.30±2.51 cd	3.51±0.77 de	18.60±6.23 bc	2.23±0.99 bc	27.37±1.93 b	26.30±1.65 a-d
PT	24.490±0.50 ab	6.80±1.05 a	15.60±2.51 bcd	3.01±1.29 ab	23.42±3.16 b	27.03±1.60 abc
SD	13.08±5.39 cd	3.23±0.86 de	8.30±2.47 d	1.03±0.61 c	28.58±2.32 b	29.17±2.63 a
SO	14.82±2.73 cd	3.99±0.49 cde	14.10±3.61 cd	1.08±0.32 c	23.92±0.14 b	27.77±0.31 ab
Mix 1	18.62±1.74 bc	4.11±0.22 cde	27.12±2.78 a	2.76±0.35 b	33.17±1.38 ab	23.63±1.53 de
Mix 2	20.941.35 ab	4.59±0.52 bcd	16.55±1.99 bc	1.75±0.20 bc	34.58±3.56 ab	23.97±1.76 cde
Mix 3	23.17±5.35 ab	5.39±1.11 abc	23.16±2.13 ab	2.39±0.28 bc	42.75±1.39 a	23.03±2.06 e
Mix 4	12.05±4.59 d	3.61±0.56 de	14.90±2.41 cd	1.70±0.65 bc	31.58±0.52 ab	24.60±0.95 b-e
Mix 5	13.94±1.19 cd	5.19±0.63 bc	20.38±2.08 abc	2.07±0.33 bc	33.75±1.64 ab	28.13±2.68 a
Mix 6	26.45±4.12 a	5.92±1.03 ab	27.69±6.81 a	4.07±1.04 a	42.75±1.50 a	27.77±0.25 ab

CP: coir, PR: pearlite, PT; Peat, SD: sand, SO: Soil, Mix 1: coir + perlite + peat (1:1:1), Mix 2: coir + perlite + soil 1:1:1), Mix 3: coir + peat + soil1:1:1), Mix 4: coir + sand+Soil (1:1:1), Mix 5: perlite + sand + soil (1:1:1), Mix 6: Peat + Sand + Soil (1:1:1).

Table 4. Effect of different growing medium on leaf macro and micro nutrient content of *Zinnia elegans*

Growth Medium	N (%)	P (mg kg^{-1})	K (mg kg^{-1})	Ca (mg kg^{-1})	Mg (mg kg^{-1})	Na (mg kg^{-1})
CP	0.97±0.07 e	837.61±14.11 e	7127.44±307.77 cde	2197.21±88.89 f	830.59±69.38d	240.28±19.86 ns
PR	1.06±0.16de	852.42±161.79 e	6701.95±978.35 de	2399.31±269.36 ef	887.73±88.97 bcd	260.54±8.89
PT	1.47±0.08 a	1504.66±63.13 a	9817.12±300.04 ab	3248.63±130.70 a	935.75±101.36 bcd	215.62±17.96
SD	1.30±0.04 bc	1333.88±78.56 ab	10472.91±757.20 a	3169.74±168.65 ab	1026.88±72.48 ab	251.54±35.86
SO	1.18±0.07 bcd	1058.37±38.62 cde	8215.46±736.40 bcd	2767.47±210.30 b-e	988.77±60.21 abc	213.16±10.55
Mix 1	1.23±0.03 bc	1164.84±233.34 bc	9113.41±166.70 abc	2725.48±197.31 cde	942.56±32.12 bcd	220.90±7.22
Mix 2	1.29±0.02 bc	1323.53±55.41 ab	10759.52±77.21 a	2978.22±45.63 abc	1016.73±55.76 ab	253.96±30.33
Mix 3	1.15±0.01 cd	1048.86±184.91 cde	7854.17±156.84 cd	2557.81±264.31 def	886.45±57.75 bcd	259.23±70.26
Mix 4	1.19±0.08 bcd	1107.92±31.45 bcd	7440.34±302.16 cde	2770.62±123.93 b-e	1008.18±61.85 abc	243.06±31.87
Mix 5	1.04±0.11 de	886.76±78.22 de	5863.78±549.81 e	2282.11±133.94 f	869.50±114.65 cd	263.47±55.25
Mix 6	1.34±0.13 ab	1187.81±235.71 bc	8398.67±204.32 bcd	2909.40±470.59 a-d	1083.38±60.84 a	268.65±23.78

	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})	B (mg kg^{-1})
CP	6.290.63 f	29.27±1.18 de	10.13±0.84 e	10.57±0.52 cd	2.66±0.27 ef
PR	7.10±0.73 ef	33.98±6.52 bcd	11.07±2.33 de	10.26±1.30 cd	2.88±1.07 ef
PT	13.01±0.67 a	46.50±3.16 a	14.62±2.15 abc	15.23±1.43 a	6.53±0.90 a
SD	11.54±1.09 ab	46.49±1.34 a	14.74±0.64 ab	13.13±1.06 b	5.16±0.50 bc
SO	9.09±1.40 cde	40.08±3.56 abc	12.66±1.12 a-e	12.38±1.37 bc	3.90±0.21 cde
Mix 1	9.52±1.66 bcd	40.83±6.65 ab	13.57±1.97 a-d	12.16±1.36 bc	4.53±1.23 bcd
Mix 2	11.53±0.38 ab	45.37±2.11 a	15.08±0.41 a	12.59±0.74 bc	5.45±0.80 ab
Mix 3	8.04±2.44 def	32.10±6.90 cde	12.04±1.92 cde	11.70±0.78 bcd	3.33±1.02 def
Mix 4	9.17±0.73 b-e	36.70±1.15 bcd	12.28±0.18 b-e	11.69±1.50 bcd	3.48±0.05 def
Mix 5	6.97±0.13 ef	25.41±0.77 e	11.00±0.30 de	9.54±0.62 d	2.13±0.36 f
Mix 6	11.08±2.05abc	39.81±5.85 abc	14.61±2.15 abc	11.37±1.80 bcd	3.82±0.94 cde

CP: coir, PR: pearlite, PT: Peat, SD: sand, SO: Soil, Mix 1: coir + perlite + peat (1:1:1), Mix 2: coir + perlite + soil (1:1:1), Mix 3: coir + peat + soil (1:1:1), Mix 4: coir + sand+Soil (1:1:1), Mix 5: perlite + sand + soil (1:1:1), Mix 6: Peat + Sand + Soil (1:1:1). Data followed by a different letter were significantly different according to Duncan's Multiple Range Test ($p<0.01$).

Table 5. Effect of different growing medium on root macro and micro nutrient content of *Zinnia elegans*

Growth Medium	Total N	P (mg kg-1)	K (mg kg-1)	Ca (mg kg-1)	Mg (mg kg-1)	Na (mg kg-1)
CP	0.42±0.03 f	356.11±6.00 e	3077.78±132.90 de	948.80±38.38 e	358.66±29.96 d	103.34±8.58 ns
PR	0.48±0.07 ef	370.97±70.41 de	3006.07±438.82 de	1076.17±120.82 de	398.180±39.90 be	116.86±10.27
PT	0.64±0.04 a	639.27±26.84 a	4239.24±129.56 b	1402.82±56.44 ab	404.07±43.77 b-e	93.10±7.76
SD	0.58±0.01 ab	580.50±34.19 ab	4850.56±339.63 a	1421.08±75.65 a	460.59±32.51 ab	112.82±16.09
SO	0.53±0.03 cd	460,60±16.81 cde	3684.94±330.30 bcd	1241.31±94.32 bcd	443.50±27.01 abc	95.61±4.73
Mix 1	0.55±0.02 bc	522.47±104.66 bc	4087.70±747.58 bc	1222.47±88.50 cd	422.27±14.41 a-d	99.07±3.24
Mix 2	0.58±0.06 ab	593.65±24.85 ab	4808.54±747.58 a	1335.84±20.47 bc	456.04±25.01 abc	113.91±13.61
Mix 3	0.48±0.01 def	445.92±78.62 cde	3313.00±661.77 cde	1078.93±111.49 de	373.18±24.36 de	109.34±29.64
Mix 4	0.50±0.03 cde	471.04±13.37 cd	3138.47±127.46 de	1168.69±52.28 cd	425.27±26.09 bcd	102.52±13.44
Mix 5	0.44±0.04 ef	377.00±33.26 de	2473.45±231.92 e	962.63±56.50 e	366.77±48.36 de	111.13±23.30
Mix 6	0.58±0.02 ab	505.00±100.21 bc	3626.72±882.31 bcd	1256.34±203.21 bcd	467.83± 26.27a	116.01±10.27
	Zn (mg kg-1)	Fe (mg kg-1)	Mn (mg kg-1)	Cu (mg kg-1)	B (mg kg-1)	
CP	2.71±0.27 g	12.63±0.51 e	4.37±0.37e	4.56±0.23 cd	1.15±0.12 ef	
PR	3.18±0.34 efg	15.24±2.92 cd	4.96±1.05cde	4.60±0.58 cd	1.29±0.48 ef	
PT	5.62±0.29 a	20.07±0.58 ab	6.31±0.93ab	6.58±0.62 a	2.82±0.39 a	
SD	5.17±0.49 b	20.85±1.41 a	6.61±0.29a	5.89±0.48 ab	2.32±0.22 abc	
SO	4.07±0.63 cde	17.97±1.59 abc	5.67±0.50 a-d	5.55±0.61 bc	1.75±0.09cde	
Mix 1	4.27±0.74 de	18.31±2.98 abc	6.08±0.88abc	5.45±0.60 bc	2.03±0.55 bcd	
Mix 2	5.17±0.17 b	20.35±0.95 ab	6.76±0.18 a	5.64±0.33 ab	2.44±0.36 ab	
Mix 3	3.38±1.03 efg	13.54±2.91 de	5.07±0.81 cde	4.93±0.63 bcd	1.40±0.43 def	
Mix 4	3.86±0.31 cdef	15.48±0.49 cd	5.18±0.08 bcde	4.93±0.32 bcd	1.47±0.02 def	
Mix 5	2.94±0.06 fg	13.88±0.33 de	4.63±0.13 de	4.02±0.26 d	0.89±0.15 f	
Mix 6	4.78±0.87 c	17.19±2.53 bc	6.31±0.93 ab	4.90±0.78 bcd	1.64±0.40 de	

CP: coir, PR: pearlite, PT: Peat, SD: sand, SO: Soil, Mix 1: coir + perlite + peat (1:1:1), Mix 2: coir + perlite + soil (1:1:1), Mix 3: coir + peat + soil (1:1:1), Mix 4: coir + sand+Soil (1:1:1), Mix 5: perlite + sand + soil (1:1:1), Mix 6: Peat + Sand + Soil (1:1:1). Data followed by a different letter were significantly different according to Duncan's Multiple Range Test ($p<0.01$).

4. Conclusions

In conclusion, different growth medium applications significantly affected on plant growth parameters and nutrient content of *Zinnia elegans* plants, and the application of peat + sand + soil 1:1:1 mixtures have been determined as the most suitable environment in terms of plant growth, nutrient uptake, development parameters and aesthetic and marketing point of view. This medium was the most convenient for the economic and sustainable cultivation of *Zinnia elegans* plants. It has been determined that the peat environment is very effective in terms of the macro and micro element content of the plant. It is seen that the growth parameter values of plants grown in Mix 6 application medium are higher than those grown in other application mediums. The reason for the very high plant growth in the Mix 6 application medium can be explained by the better uptake of plant nutrients by the plant from the growth medium. It was determined that the plants in the Mix 6 medium absorb more nutrients. It has been revealed that the mixture medium of peat + sand + soil (1:1:1) in *Zinnia elegans* plants is an ideal environment to obtain the maximum yield.

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