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Interactive effects of organic materials and electrical conductivity in the growing medium on the vase life of cut lisianthus flowers

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Abstract: This study was conducted to determine the effects of certain organic materials added to the growing medium prior to harvest on the vase life of cut lisianthus (*Eustoma grandiflorum*) flowers. Nine different growing media were prepared by supplementing a peat+perlite mixture with varying proportions of thyme compost, leonardite, vermicompost, and humic acid. In addition, the electrical conductivity (EC) of the growing media was adjusted to two levels: 1.1 dS m^{-1} and 2.2 dS m^{-1}. Vase life was evaluated using a visual scoring system to assess deterioration symptoms in leaves and flowers. As a result, the longest vase life (22.0 days) was obtained from the application of 20% thyme compost + EC 2.2. This treatment was followed by applications of 10% and 20% vermicompost + EC 2.2, and 10% thyme compost + EC 2.2. The shortest vase life (8.33 days) was recorded in the control group containing only peat + perlite. The findings revealed that the use of thyme compost and vermicompost in combination with high EC levels significantly extended the vase life of lisianthus flowers. It has been determined that applications of humic acid and leonardite also exhibit positive effects on vase life. This result indicates that the application of organic materials in combination with appropriate EC levels during the pre-harvest period enhances the postharvest longevity of cut flowers.

Keywords: Humic acid, leonardite, thyme compost, vermicompost.

Yetiştirme ortamındaki organik maddeler ve elektriksel iletkenliğin kesme lisianthus çiçeklerinin vazo ömrüne etkileşimli etkileri

Öz: Bu çalışma, hasat öncesi yetiştirme ortamına eklenen bazı organik materyallerin kesme lisianthus (*Eustoma grandiflorum*) çiçeklerinde vazo ömrü üzerine etkilerini belirlemek amacıyla yapılmıştır. Yetiştirme ortamı olarak torf + perlit karışımına farklı oranlarda kekik kompostu, leonardit, vermikompost ve humik asit ilave edilerek hazırlanan 9 farklı ortam kullanılmıştır. Ayrıca, yetiştirme ortamlarında elektriksel iletkenlik (EC) seviyeleri 1.1 dS m^{-1} ve 2.2 dS m^{-1} olacak şekilde iki farklı düzeyde ayarlanmıştır. Vazo ömrü, yaprak ve çiçeklerdeki bozulma semptomlarına dayalı olarak, görsel skorlama yöntemiyle belirlenmiştir. Sonuç olarak en yüksek vazo ömrü 22.0 gün ile %20 kekik kompostu + EC 2.2 uygulamasından elde edilmiştir. Bu uygulamayı, %10 ve %20 vermikompost + EC 2.2 ve %10 kekik kompostu + EC 2.2 uygulamaları takip etmiştir. En düşük vazo ömrü 8.33 gün ile yalnız torf + perlit içeren kontrol grubunda belirlenmiştir. Elde edilen sonuçlar, kekik kompostu ve vermikompost organik materyallerinin yüksek EC düzeyi ile birlikte kullanıldığında lisianthus çiçeklerinin vazo ömrünü önemli ölçüde uzattığını ortaya koymuştur. Humik asit ve leonardit uygulamalarının da vazo ömrü üzerinde belirli düzeyde olumlu etkiler gösterdiği belirlenmiştir. Bu sonuç, organik materyallerin hasat öncesi dönemde uygun EC seviyeleri ile uygulanmasının, kesme çiçeklerin hasat sonrası dayanıklılığını artırabileceğini ortaya koymaktadır.

Anahtar kelimeler: Humik asit, leonardit, kekik kompostu, vermikompost.

1. Introduction

Lisianthus is among the most prominent species in the global ornamental plant market, with its silky-textured yet highly durable flowers in vivid and pastel tones. Due to its extended postharvest longevity, lisianthus ranks among the top ten most popular cut-flower species worldwide (Harbaugh, 2007; Hutchinson, 2011; Bertoldo et al., 2015; Özkan, 2017). While tall cultivars are primarily used for cut-flower production in open

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fields and greenhouses, dwarf and multi-branched varieties are commonly cultivated as potted ornamental plants (Harbaugh & Zhanao, 2006; Hanks, 2014; Menge, 2019).

Vase life, a critical quality attribute for the commercial viability and success of cut flowers, greatly influences both consumer satisfaction and market demand (Onozaki et al., 2001). Flowers cultivated under optimal environmental conditions have a longer vase life and higher quality. It is well established that pre-harvest practices significantly affect vase life.

The vase life of cut flowers is influenced by the plant's genetic structure, preharvest growing conditions, cultural practices, harvest-time applications, and postharvest handling procedures (Mengüç, 1991; Fanourakis et al., 2012; Kazaz, 2015). During the preharvest stage, genetic traits and cultivation conditions are the primary determinants of vase life. Ensuring optimal environmental conditions and understanding genotype–environment interactions are critically important for maximizing postharvest longevity (Van Meeteren et al., 2005; Fanourakis et al., 2012). Environmental factors and cultural practices such as irrigation, fertilization, and pest–disease management positively affect vase life by enhancing dry matter accumulation and increasing stem thickness (Balas et al., 2006). One of the key factors affecting vase life is the timing of harvest and the condition of the cutting surface. Studies have shown that flowers achieve optimal quality when harvested early in the morning or during the cool hours of the evening (Crow, 1970). Following harvest, cut flowers undergo a series of processes including grading, leaf removal, bunching, recutting, hydration, treatment with preservative solutions, packaging, precooling, storage, and transportation. During these stages, factors such as xylem blockage, ethylene production, leaf yellowing, geotropism, and improper storage and transport conditions significantly reduce vase life. Harvested flowers are graded according to cultivar standards and stem length. Graded flowers are expected to have straight, upright stems, be free of mechanical damage, and show no symptoms of pests or diseases (Kazaz et al., 2003).

Vase life is determined by genetic and environmental factors, and optimizing these interactions enhances flower longevity (Fanourakis et al., 2013). Short vase life remains a major issue encountered in cut flowers and directly affects consumer preferences (Ghosh et al., 2015). The short vase life observed in species such as carnations, roses, and lisianthus is attributed to carbohydrate depletion (Ketsa, 1989), water stress (Sankat & Mujaffar, 1993), microbial contamination (Van Doorn & Witte, 1991), and ethylene-induced senescence (Meng & Wang, 2004), varietal differences, seasonal variability, and environmental conditions (Dole & Wilkins, 1999; Farokhzad et al., 2005; Hojjati et al., 2007).

Although ornamental plants are not intended for human consumption, the widespread use of chemical inputs, such as pesticides and fertilizers, in agricultural production has adverse effects on human health and the environment. Therefore, organic and sustainable agricultural techniques have gained attention as environmentally friendly alternatives for producing ornamental plants without harming the environment and health (Tütüncü, 2024).

Among local and renewable materials suitable for use in the growing environment, plant-derived organic waste is particularly noteworthy (Dede & Özdemir, 2018). The use of organic waste as fertilizer or growing medium contributes to sustainable agriculture and offers an important recycling opportunity for the country's economy (Çıtak et al., 2006; Çiçek, 2021). In this context, returning organic matter to the soil enhances soil fertility and facilitates waste management for producers (Özenç et al., 2019; Najafi et al., 2019).

Vermicompost, which is particularly relevant in this context, is a microbiologically active, nutrient-rich material produced by the decomposition of organic matter through the activities of earthworms and microbes. Its low C:N ratio, high water-holding capacity, and porosity have been shown to improves both the physical and chemical properties of the growth substrate (Kahsnitz, 1992; Hidalgo & Harkess, 2002; Domínguez, 2004; Hidalgo et al., 2006). Additionally, humic and fulvic acids, which constitute a large portion of soil organic matter, directly influence both soil structure and plant physiological processes (Schnitzer, 1992; Pal & Biswas, 2005). Leonardite, one of the important sources of these compounds, is a completely natural material with high economic value due to its high humic acid content (O'Donnell, 1973).

However, there are few studies in the literature examining the effects of pre-harvest applications of organic material on vase life, particularly in cut-flower species. Therefore, the use of organic waste and soilconditioning organic materials in cut-flower production may represent a promising strategy, particularly for growers engaged in soilless cultivation systems. In this study, the effects of various pre-harvest organic fertilizer treatments on the vase life of cut lisianthus plants were investigated to inform the development of sustainable ornamental horticultural practices.

2. Materials and Methods

2.1. Materials

In this study, the plant material consisted of the 'Advantage Purple' cultivar of lisianthus (*Eustoma grandiflorum*). The seedlings used in the experiment were obtained from Seçkin Tarım Company, located in Yalova, Türkiye. Thyme compost was obtained from the Cemre facility in Tokat/Merkez. Fresh vermicompost was provided by a producer operating in Turhal, Tokat. Leonardite and humic acid were acquired from commercial suppliers.

2.2. Methods

The lisianthus cv. 'Advantage Purple' seedlings (4-6 leaf) used in the study were planted in pots with a volume of 5.5 liters (25 cm in diameter, 20 cm in height). The growing medium consisted of a mixture of Finnish peat and perlite, selected for its high water-holding capacity and optimal pH range (5.5-6.0). The base substrate was prepared in a 2:1 volumetric ratio (4 parts peat to 2 parts perlite) to form the base growing medium, which was then filled into the pots and prepared for planting. To enrich the growing medium, thyme compost, vermicompost, and leonardite were incorporated into the peat-perlite mixture at 10% and 20% (v/v) by volume prior to planting. Additionally, a liquid humic acid fertilizer was applied directly to the soil at concentrations of 500 and 1000 ppm; this application was initiated at planting and repeated every 15 days at 200 mL per pot.

The water and nutrient requirements of all plants were met using a standard Hoagland nutrient solution (Hoagland & Arnon, 1950) via a drip irrigation system. These treatments aimed to evaluate the effects of both environmental conditions and organic amendments on plant growth and flower quality.

2.2.1. Preparation and Application of Humic Acid

In each plot, liquid humic acid fertilizer was applied to the soil at predetermined doses (500–1000 ppm) during planting and subsequently at 15-day intervals, at a rate of 200 mL per pot using a beaker (Table 1).

2.2.2. Preparation and Application of Vermicompost

Vermicompost at 10% and 20% doses was incorporated into the potting media, based on pot volume ratio, prior to planting (Table 2).

Table 1. Composition of liquid humic acid used

Content of Liquid Humic Acid	Content
Total (Humic + Fulvic Acid) (%)	15
Organic Matter (%)	15
Water-Soluble K_2O (%)	3
pH	8

2.2.3. Preparation and Application of Leonardite

Leonardite at 10% and 20% doses was applied by mixing into the pots according to volume ratio prior to planting (Table 3).

2.2.4. Preparation and Application of Thyme Compost

Prior to planting, thyme compost was incorporated into the pots at volumetric ratios of 10% and 20% (Table 4).

Table 2. Some physical and chemical properties of the vermicompost used

Property	Content
pH (1-14)	7.2-7.6
Humidity (%)	35-40
Organic Matter (%)	37.84
Total Nitrogen (%)	1.10
K (%)	7.19
P (%)	1.11
Zn (ppm)	86.41
Mn (ppm)	657.82
Fe (ppm)	885.90
Cr (mg kg-1)	0.04
Ni (mg kg-1)	36
Cu (ppm)	15.65

2.3.5. Preparation and Application of the EC and Hoagland Solution

In the study, two EC levels (1.1 dS m^{-1} and 2.2 dS m^{-1}) were applied to determine whether similar results could be achieved using organic materials as a growing medium while reducing the use of synthetic fertilizers. A total of 570 lisianthus seedlings were used in the experiment, and the applications were carried out for a period of 80–90 days.

Table 3. Some physical and chemical properties of the leonardite used

Property	Content
Organic Matter (%)	50
Total (Humic + Fulvic Acid)(%)	50
Maximum Humidity (%)	35
pH	5-7

During the preparation and application of fertilizers, two nutrient solutions with different electrical conductivity levels (EC: 1.1–2.2 dS m^{-1}) formulated according to Hoagland and Arnon (1950) were applied to plants cultivated in pots containing varying proportions of organic amendments. These nutrient solutions were prepared based on the Hewitt (1966) and Steiner (1984) formulations widely cited in the literature, and the applications were carried out in accordance with the specifications of these formulations (Table 5).

Table 4. Some physical and chemical properties of the thyme compost used

Property	Content
Humidity (%)	4.15
Organic Matter (%)	65.11
pH	7.59
EC	2.82
N (%)	2.79
K (%)	1.87
Cu (ppm)	2.40
P (%)	294
Ca (%)	6.02
Mg (%)	0.47
Fe (ppm)	0.08
Mn (ppm)	157
Zn (ppm)	90

EC: Electrical conductivity

During nutrient solution preparation, two tanks with a capacity of 1000 L each were used. The electrical conductivity level of the first tank was adjusted to 1.1 dS m^{-1}, while that of the second tank was set to 2.2 dS m^{-1}. No organic material was applied in the control and NPK treatments; in the control treatment, plants were supplied with water only. The pH and EC values were regularly monitored using a Hanna pH/EC meter. Depending on greenhouse conditions, fertigation was performed every 2 or 3 days, and fertilization continued from planting through harvest.

Table 5. Nutrient solution formulations to be used in the study.

Nutrient Element	(mg/L)
N	170
P	50
K	210
Mg	40
Ca	140
S	40
Fe	3
Mn	0.5
B	0.5
Cu	0.5
Zn	0.5
Mo	0.1

2.3.6. Determination of the vase life of flowers

Harvested (17 August 2023) lisianthus plants (Figure 1) were immediately subjected to water uptake for 30–45 minutes under greenhouse conditions, after which they were kept in a vehicle for approximately 30 minutes and subsequently transported to the Laboratory of the Department of Horticulture, Faculty of Agriculture, Tokat Gaziosmanpaşa University. Upon arrival at the laboratory, the flower stems were recut diagonally to facilitate water uptake and subsequently placed in vases with an approximate length of 40 cm. The flowers were then placed in vase solutions prepared in advance using tap water. The vase solutions were prepared in 1000 mL glass vases, each containing 500 mL of solution; no supplements were added to these solutions during the experiment, and the solutions were not replaced.

Vase life is defined as the period from the day the harvested flowers are placed in vases containing pure water to the day the first signs of deterioration, such as wilting of the petals and bending of the stems, are observed (Ichimura et al., 1999; Lu et al., 2010) (Figure 2).

A visual assessment was used to determine the vase life of the flowers, with three parameters considered: leaves, flowers, and leaves + flowers. The vase life assessment was terminated when any of the following criteria were observed:

1. Yellowing observed in at least 50% of the leaves,

2. At least 50% of the open flowers showing signs of wilting, darkening, or closing,

3. Both yellowing in at least 50% of the leaves and wilting, darkening, or closing in at least 50% of the open flowers occur simultaneously.

In accordance with these criteria, each flower sample was monitored daily, and the vase life period was recorded.The vase life experiment was set up with three replicates for each cut flower, with three cut flowers placed in each vase. The experiment was conducted at a room temperature of 22-24°C and 56% humidity.

Figure 1. Appearance of plants ready for harvest in a greenhouse environment.

2.2.5. Statistical analysis

The study was conducted according to a factorial experiment in a randomized complete block design. The results were evaluated using one-way ANOVA in SPSS. Significant differences between treatments were determined using Duncan's multiple range test.

3. Results and Discussion

According to the findings, the longest vase life of 22.0 days was recorded in the 20% thyme compost + EC 2.2 application (Table 6). This was followed by applications of 10% vermicompost + EC 2.2 and 10% thyme compost + EC 2.2, which yielded a vase life of 19.33 days. In the EC 1.1 group, the longest vase life was again achieved with thyme compost applications, with 18.33 days for 20% thyme compost and 16.33 days for 10% thyme compost. Similar positive effects were observed with vermicompost applications: in the EC 1.1 group, vase life was 14.00 days with 10% VC and 15.67 days with 20% VC, whereas in the EC 2.2 group, it was 19.33 days at both doses. This indicates that an increase in vermicompost dosage leads to an increase in vase life. When evaluating Leonardite applications, the vase life in the EC 2.2 group was 16.00 days at a 20% dose and 15.33 days at a 10% dose, whereas in the EC 1.1 group it was 14.33 days at both doses. It was observed that the increase in the ratio did not significantly contribute to vase life in Leonardite applications. In humic acid applications, vase life was 17.67 days at a 1000 ppm dose and 17.00 days at a 500 ppm dose in the EC 2.2 environment; in the EC 1.1 environment, it was 15.33 days for both doses. These results indicate that humic acid applications generally increase vase life, but increasing the dosage does not yield additional benefits. The lowest vase life, 8.33 days, was observed in the control group (where no fertilizer or additive was applied). In contrast, vase life in plants treated with chemical fertilizer (NPK) alone ranged from 10.67 to 16.33 days, indicating that the use of organic materials alone or in combination with chemical fertilizer significantly extended vase life. Overall, organic material applications (HA, thyme compost, VC, leonardite) showed statistically significant ($p<0.01$) positive effects on vase life both alone and at high EC levels (Table 6). The EC 2.2 group provided longer vase life than the EC 1.1 group in all organic applications. These data suggest that applying organic materials such as thyme compost and vermicompost at high EC levels could be an effective strategy for extending the marketing period of lisianthus cut flowers. Alkaç et al. (2024) reported the longest vase life of lilies (14.14 days) in growing media containing 40% compost with an EC of 0.75 dS m^{-1}. However, the 40% compost application affected only vase life, whereas it limited overall plant growth. Although fertilization is an important practice in lily cultivation, an EC level exceeding 2.0 dS m^{-1} in the growing medium is considered undesirable. Significant improvements in vase life were observed with increased doses of organic materials such as thyme compost and humic acid. Humic acid and vermicompost applications increased the vase life of lilies by 10.23-11.34 days. The longest vase life was observed in the 150 ppm HA + VK combination, corresponding to a 9% increase compared to the control group. However, increasing the HA dose reduced vase life by 12%. These applications also affected the full flowering period, ranging from 71.67 to 74.00 days; the longest period was observed with the 900 ppm HA + VK application, but this increase was only 1% relative to the control group (Tuncel et al., 2024). As a result of humic acid and vermicompost applications, the vase life of the "Dynasty" tulip cultivar ranged from 5.25 to 9.00 days. The longest vase life was observed only in the vermicompost treatment (9.00 days), representing a 38% increase compared to the control group (Tuncel et al., 2025). Additionally, the literature reports that humic acid delays flower senescence and prolongs vase life in various ornamental plants (Kumar et al., 2003; Nikbakht et al., 2008; Khenizy et al., 2013; Khodakhah et al., 2014; Yazdani et al., 2014).

Figure 2. A view of the vase life experiment setup

Table 6. Effect of humic acid, thyme compost, leonardite, and vermicompost applications on the vase life of the lisianthus cv. 'Advantage purple' (day)

Growing media	1.1 dS m^{-1}	2.2 dS m^{-1}	Mean
Control	8.33±1.15g	8.33±1.15g	8.33 f
NPK	10.67±0.58f	16.33±1.53cde	13.50 e
%10 Thyme	16.33±0.58cde	19.33±0.58b	17.83 b
%20 Thyme	18.33±0.58bc	22.00±1.00 a	20.17 a
%10 Leonardite	14.33±0.58 e	15.33±0.58 de	14.83 de
%20 Leonardite	14.33±1.15 e	16.00±1.73cde	15.17 cd
%10 VC	14.00±2.00 e	19.33±1.15b	16.67 bc
%20 VC	15.67±1,15 de	19.33±3.21b	17.50 b
500 ppm HA	15.33±0.5 de	17.00±1.00bcd	16.17 bcd
1000 ppm HA	15.33±1.15 de	17.67±1.53bcd	16.50 bc
Mean	14.27 b	17.07 a	
Significance level	EC:*** Growing media :*** EC x Growing media :**		

The difference between the means indicated by different letters in the same column is significant. **: p<0.01, ***: p<0.001, EC:electrical conductivity, HA: Humic acid, VC: Vermicompost.

The effects of compost on the vase life of cut flowers have been indirectly supported by previous studies. For example, in a study of tuberose (*Polianthes tuberosa*), a mixture of sand and leaf compost yielded the highest flower diameter, number of flowers, and vase life (Ikram et al., 2012). In the studies in which humic acid (FHA) obtained from compost was sprayed on chrysanthemums, increases in chlorophyll content, photosynthetic rate, soluble sugar, and protein content were observed, and vase life was significantly extended (Fan et al., 2014). FHA spraying increased vase life by 61% compared to distilled water and by 33% compared to NPK fertilizer. Similarly, a combination of 1.25 mL FHA (8%) + 10 g/m^2 NPK (17:17:17) increased flower yield and vase life in Triumph-type gladioli (Ali et al., 2014). Additionally, worm tea (vermiwash), cow urine, and GA_3 applications caused significant increases in vegetative growth, flowering, and vase life in *Gladiolus grandiflorus* "Candyman" (Tamrakar, 2016).

Jamali and Asil (2021) reported that the application of 450 mg/L gibberellic acid combined with 400 mg/L humic acid was the most effective treatment for improving growth, flowering, and vase life traits in lilies. Rahmani et al. (2020) investigated the effects of compost and humic acid applications. Their results indicated that the longest vase life was obtained with 100% compost combined with 500 mg/L humic acid, whereas the shortest vase life was observed in the control group and in the treatment without humic acid (0 mg/L). Bice et al. (2025) reported that humic acid applications reduced vase life in lilies compared with the control. However, some studies have reported contrasting results regarding the effect of humic acid on vase life. Al-Gubouri and Al-Saad (2020) demonstrated that the application of humic acid significantly enhanced plant growth in gladiolus. In particular, the highest vase life (10.48 days) was achieved with a 2 g/L application of humic acid. In Gerbera, Nikbakht et al. (2008) found that a 1000 mg/L humic acid treatment prolonged vase life. Humic acid also exhibited auxin-like activity, enhancing nutrient uptake and thereby extending the vase life of cut stems (Baldotto and Baldotto, 2013). Fan et al. (2014) investigated the physiological mechanisms by which foliar-applied humic acid fertilizer influenced the postharvest vase life of cut chrysanthemum flowers. The study concluded that foliar application of humic acid extended the vase life of cut chrysanthemum flowers. Eskandari and Abdusi (2016) studied the effects of vermicompost (%0, 10, 20, 40, and 80) and three levels of humic acid (0, 500, and 1000 mg/L) on the vase life of *Rosa hybrida* cv. “Polar Star” cut flowers. The longest vase life (11.2 days) was achieved with 10% vermicompost application. However, increasing the proportion of vermicompost from 10% to 80% adversely affected these traits.

4. Conclusion

The effects of adding various organic materials, such as thyme compost, leonardite, vermicompost, and humic acid, at different ratios to a peat-perlite growing medium on the vase life of lisianthus were investigated. The findings revealed that all organic material applications contributed positively to vase life to varying degrees. The longest vase life was obtained with the application of 20% thyme compost at an EC of 2.2 dS m^{-1}, followed by treatments with 10% and 20% vermicompost at an EC of 2.2 dS m ^{1}. Moreover, humic acid and leonardite were found to extend vase life. In conclusion, the controlled and optimized use of organic amendments holds significant potential for sustainable horticulture from both economic and ecological perspectives. Further studies are needed to evaluate the combined effects of organic amendments on other cut flower species.

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Authorship Contribution

F.O.: Conducting the experiment and writing, reviewing and editing of article. M.G.: Planning the experiment, reviewing and editing of article.

Conflict of Interest

The authors declare no conflicts of interest.

Ethical Statement

There is no need to obtain ethics committee approval for this study.

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