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Effects of Vermicompost on the Growth and Development of the 'Advantage Pink' Lisianthus Cultivar

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ABSTRACT

This study investigated the effects of different doses of liquid vermicompost (SG) on the growth and development characteristics of the "Advantage Pink" Lisianthus cultivar. Liquid vermicompost was prepared at four different concentrations, namely 0 (control), 300, 600, and 900 ppm, and applied to the growing medium. Applications were carried out at two-week intervals, with 250 mL applied to each pot. A mixture of peat and perlite (2:1, v/v) was used as the growing medium, and the electrical conductivity (EC) level was adjusted to 1.00 dS m^{-1} during fertilization. The effects of the treatments were evaluated through phenological observations and the measurement and recording of morphological traits.The results indicated that increasing SG doses led to improvements in several morphological parameters, including stem length, stem thickness, plant height, branch weight, root length, and root fresh weight. The highest values for most measured parameters were generally recorded at 600 and 900 ppm SG applications. However, flowering time and flower number were negatively affected by higher doses, while the highest flower number was obtained at the 300 ppm SG treatment. Structural traits such as flower diameter and node number showed positive responses with increasing doses. On the other hand, differences among certain yield parameters, including flower number, branch number, and leaf number, were found to be statistically insignificant ($p > 0.05$). Overall, the findings suggest that liquid-applied SG positively influences the growth performance of Lisianthus; however, increasing doses may exert adverse effects on generative development. Therefore, the optimum application dose should be carefully determined.

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Introduction

The role of organic fertilizers in soil fertility and healthy plant development has been increasingly investigated. The application of organic fertilizers to soil notably enhances soil organic matter content and nitrogen levels (Okur et al., 2008). The increase in organic matter stimulates the activity of soil microorganisms, accelerating microbiological cycles and thereby contributing to the improvement of soil health (Chaturvedi et al., 2008). Simultaneously, organic fertilizers improve soil structure, facilitating the maintenance of air–water balance and enhancing water-holding capacity. This, in turn, supports root development and leads to positive outcomes in both growth and yield (Akan et al., 2015). It is frequently emphasized that organic fertilizers provide a more sustainable function within the soil ecosystem compared to chemical fertilizers, offering long-term benefits without disrupting the natural balance. Recently, among various types of organic fertilizers, Vermicompost (VC) has attracted particular attention.

VC is a high-quality organic fertilizer obtained through the digestion of plant and animal organic wastes by earthworms such as *Eisenia fetida* (Krishnaswamy et al., 2022; Cao et al., 2021; Yılmaz & Kurt, 2018). This fertilizer not only enriches the organic matter content but also enhances the bioavailability of essential nutrients for plants. Applications on diverse species, including grapevine seedlings, basil, daffodil, and various outdoor ornamental plants, have demonstrated that VC positively affects plant growth (Bademkıran et al., 2018; Şenyiğit et al., 2021; Eker, 2016; Açıkbaş & Bellitürk, 2016). During the digestion of organic matter, earthworms induce transformation of materials through physical, chemical, and biological processes (Suthar, 2010). They incorporate nitrogenous waste, mucus, enzymes, and dead tissue into their gut system, thereby increasing nitrogen concentration within the digestive tract (Suthar, 2007). This mechanism facilitates greater accessibility of nitrogen in the compost for plant uptake. In Turkey, the production and use of VC

have rapidly expanded in recent years. This fertilizer is obtained by passing organic wastes through the digestive system of earthworms, resulting in rapid humification and detoxification (Tutar, 2013; Edwards & Bohlen, 1996). The biological activities occurring during the earthworm digestion process accelerate the decomposition of organic matter and promote the formation of humus-like substances, which lead to significant improvements in the physical, chemical, and biological properties of the soil. VC enriches the soil microflora through its content of symbiotic and asymbiotic microorganisms, mycorrhizal fungi, and actinomycetes (Demir et al., 2010; Edwards, 1998). Additionally, earthworm secretions are rich in biologically active compounds such as growth hormones (auxins and gibberellins), various enzymes, vitamins, and amino acids (Sinha et al., 2013; Edwards & Bohlen, 1996). These components help suppress pathogens and pests, enhance beneficial microbial populations, and support nutrient uptake by plants (Tutar, 2013; Çıtak et al., 2011; Arancon et al., 2006; Arancon et al., 2005). Improvements in soil porosity and water-holding capacity, along with positive changes in chemical and biological properties, directly support plant growth, resulting in increased yield and nutrient acquisition (Açıkbaş & Bellitürk, 2016; Çıtak et al., 2011; Gutiérrez-Miceli et al., 2007; Edwards et al., 2004; Atiyeh et al., 2001).

Lisianthus (*Eustoma grandiflorum*), a member of the Gentianaceae family, is an important ornamental plant generally cultivated as an annual (Yeşil, 2017). In Turkey, lisianthus ranks tenth in production after carnation (*Dianthus caryophyllus*), rose (*Rosa* spp.), gerbera (*Gerbera jamesonii*), lily (*Lilium* spp.), chrysanthemum (*Chrysanthemum morifolium*), gladiolus (*Gladiolus* spp.), daffodil (*Narcissus* spp.), tulip (*Tulipa* spp.), and gypsophila (*Gypsophila paniculata*). The crop was first cultivated in France in 1984. Native to South America, lisianthus is now widely grown worldwide. Its rose-like, multi-layered flowers in bright and pastel tones make it highly valued in the cut-flower industry. The plant is appreciated for its long vase life and aesthetic qualities, with bluish-green leaves, single or branched stems, and flowers reaching approximately 5 cm in diameter (Yeşil, 2017).

In the literature, most studies on the effects of liquid vermicompost have been largely limited to vegetable cultivation, and information regarding cut-flower species is quite scarce. Evaluating the effects of liquid vermicompost on an important ornamental plant such as lisianthus (*Eustoma grandiflorum*) is important for understanding its potential impacts on plant growth and flower characteristics. This study aims to investigate the effects of liquid vermicompost on plant growth and quality parameters in lisianthus cultivation.

Materials and Methods

Greenhouse Conditions

This study was conducted between 2023 and 2024 in a 450 m² glass greenhouse at the Agricultural Research and Application Center of Tokat Gaziosmanpaşa University, which lacked heating and cooling systems and was ventilated through the roof. Lisianthus plants were grown in pots measuring 25 × 20 × 14 cm. Liquid vermicompost (VC) applications were planned at doses of 0, 300, 600, and 900 ppm, with 250 mL applied to each pot per application. The experiment was arranged according to a randomized complete block design with three replications, each containing six plants. Observations and measurements were conducted on a total of 72 plants, with one plant per pot. A substrate mixture of peat and perlite (2:1 v/v) of Finnish origin, with high water-holding capacity and a pH range of 5.5–6.5, was used as the growing medium. Seedlings were transplanted in the third week of May, and pinching was performed 14 days after transplanting. During this period, only Hoagland nutrient solution was applied to the plants. Following the pinching treatment, liquid vermicompost applications were initiated and administered at 10-day intervals throughout the cultivation period, resulting in a total of nine applications. Hoagland solution was continuously supplied according to the irrigation requirements of the plants until harvest. Harvesting was carried out on 25 August, six days after the final liquid vermicompost application. The liquid vermicompost (Wormbomb) used in this study was supplied by Senta Tarım, located in Tokat, Türkiye, and the product composition is presented in Table 1.

Table 1. Analysis results of the liquid vermicompost used in the study

Parameter	Liquid VC
Organic Matter (w/w)	15
(Humic+Fulvic) Acid (w/w)	1.5
Total N (w/w)	1.5
Nem (%)	-
pH	4.5-6.5
Max EC	5
P (%)	0.75
K (%)	1.90
Ca (ppm)	7942
Mg (ppm)	1070
Fe (ppm)	1062
Cu (ppm)	9.52
Zn (ppm)	3.70
Mn (ppm)	21.0

PlantMaterial

In the study, the lisianthus cultivar ‘Advantage Pink’ of *Eustoma grandiflorum* Raf. (Shinn.), characterized by pink, double flowers, was used as the plant material (Figure 1A). Seedlings used in the experiment were obtained from Yalova Seçkin Tarım, and the transplanting was carried out in May.

Preparation and Application of the Hoagland Solution

During the preparation and application of fertilizers, a nutrient solution prepared according to the Hoagland & Arnon (1950) formula was applied to plants grown in pots containing different rates of vermicompost. The electrical conductivity (EC) of the applied solutions was adjusted to 1.0 $dS \cdot m^{-1}$, taking into account the formulations developed by Hewitt (1966), Steiner (1984), and Kılınç (2005) for solution preparation. The nutrient solutions were prepared using a 500 L water tank.

Measurements, Weighing, and Observations

Flowering duration (days): Recorded as the period from planting until 50% of the plants were ready for harvest.

Stem length (cm): Measured from the cutting point to the flower head.

Stem thickness (mm): Determined using a digital caliper at the middle section of the stem, between the 5th and 6th nodes from the top (Marfa et al., 1989) (Figure 1C).

Shoot weight (g): Measured immediately after harvest by weighing the stem + leaves + flower head on a precision balance.

Plant height (cm): Measured from the soil surface to the tip of the plant.

Root length (cm): Determined using a measuring tape as the distance from the base of the longest root to its tip after harvest.

Fresh root weight (g): Measured on harvested plants using a precision balance.

Number of shoots (count): Determined by counting the shoots per plant after harvest and calculating the average per replication.

Number of leaves (count): The total number of leaves per plant was counted for each treatment.

Number of flowers per shoot (count/shoot): Counted as the total number of fully opened flowers and buds on a single shoot.

Flower diameter (mm): Measured with a digital caliper at the widest point of the bud when the color of the flower bud became visible for each plant in each plot (Figure 1B).

Number of nodes (count): Determined by counting the nodes from the cutting point to the tip of the harvested flower stems.

A B C

Figure 1. Lisianthus; A. General view, B. Flower diameter (mm), C. Stem thickness (mm) measurement

Experimental Design and Statistical Analysis of Data

The experiment was arranged as a randomized complete block design with three replications. The obtained data were analyzed using analysis of variance (ANOVA) in SPSS 26.0 statistical software. Duncan's multiple range test was applied to determine the significance of differences among treatments.

Results and Discussion

The effects of different vermicompost application rates on lisianthus cultivation are presented in Tables 2, 3, and 4.

The longest flowering duration was observed in the control group (75.66 days), whereas this period decreased to 61.66 days under the 900 ppm VC application, indicating that VC may accelerate the generative development process. Additionally, the values obtained for stem length, stem thickness, and shoot weight (46.66 cm, 5.22 mm, and 22.34 g, respectively) demonstrate the positive effects of VC applications on plant growth parameters. These findings are consistent with the results reported by Ulusu & Şahin (2020), who noted earlier emergence and flowering with increased organic fertilizer applications and suggested that liquid vermicompost accelerates phenological development. When considered together with increases in biomass-related parameters, such as stem and shoot growth and root weight, the data suggest that VC application may enhance photosynthetic activity, thereby supporting overall plant biomass production. However, it should also be noted that accelerated generative development may not always yield positive outcomes; in particular, high-dose applications may shorten the flowering period to an extent that could limit flower quality and yield. This highlights the critical importance of dose optimization in VC applications to balance both vegetative and generative development.

The effects of different doses of liquid vermicompost (VC) on the number of shoots in lisianthus were found to be statistically non-significant ($p > 0.05$). However, the results indicate that VC applications particularly support vegetative growth, as increases were observed in morphological parameters such as plant height, stem thickness, and shoot weight. These findings are consistent with those reported by Komnenić et al. (2020) in lavender, where VC and other organic fertilizer applications increased plant height and the number of flowering shoots, with the lowest values recorded in the control group. Furthermore, analysis of the VC used in this study revealed that it is rich in humic and fulvic acids, which may have contributed to the observed increases in plant height and stem length by promoting root development and nutrient uptake. Similarly, Sahu et al. (2020) reported that VC, when applied together with microbial fertilizers, significantly enhanced plant height, flower number, and bud number in *Dendranthema grandiflora*. On the other hand, the absence of statistically significant differences in shoot number among treatments in the present study suggests that VC does not affect all growth parameters to the same extent.

Additionally, Çiçek & Yücedağ (2021) emphasized that morphological improvements in ornamental plants reflect not only aesthetic value but also the plant's adaptation to healthy environmental conditions.

In the present study, the lowest mean flower number was observed in the control group and the 600 ppm SG treatment (4.00 flowers/plant), while the highest value was recorded in the 300 ppm SG treatment (6.00 flowers/plant). These results indicate that SG may stimulate generative development at low to moderate doses, whereas its effect may be limited at higher doses. Chamani et al. (2008) reported similar findings in *Petunia hybrida*, where SG initially promoted flower and leaf development, but its effect diminished with increasing doses, and in some cases, values even decreased. Similarly, Widnyana et al. (2023) reported that liquid organic fertilizer mixtures increased flower number by 246% in *Tagetes erecta*, though they suggested that this effect could be due to other organic components applied alongside SG, and that the effect of SG alone depends on dose, plant species, and environmental conditions. Bademkıran et al. (2018) reported that the effect of SG on flower number in *Narcissus* was limited but could increase flower number by up to 20%. According to the literature, liquid SG has been shown to enhance flower crown diameter, number of flowers and buds, and aesthetic traits in species such as *Rosa* sp. (Koca, 2014), marigold (Sardoei et al., 2014), and *Verbena officinalis* (Çiçek & Yücedağ, 2023). Pritam et al. (2010) reported the largest flower diameter in marigold with 40% SG, while Ataklı et al. (2021) achieved a 16% increase in lily flower diameter with humic acid application, and Bademkıran et al. (2018) reported an 8% increase in flower diameter in *Narcissus* with SG. Considering the observed reduction in flowering duration in the present study, it is suggested that SG may also influence generative developmental processes. Ulusu & Şahin (2020) similarly reported that SG and other organic fertilizers shortened flowering duration and accelerated developmental stages. Bademkıran et al. (2018) indicated that the best growth and quality traits in *Narcissus* were obtained in groups treated with liquid SG, with positive effects on leaf number, stem thickness, and flower diameter. Likewise, Karagöz et al. (2019) reported that autoclaved SG combined with rhizobacteria provided the highest values for flower number and fresh flower weight in gladiolus, demonstrating a synergistic bio-stimulatory effect.

However, some studies have reported contradictory results regarding SG application. For instance, Atiyeh et al. (2000) observed a 40% decrease in flower number in tomato seedlings treated with SG, whereas Hidalgo et al. (2006), Gajalakshmi & Abbasi (2002), and Arancon et al. (2004) reported increased flower numbers with SG in marigold, *Crossandra undulaefolia*, and strawberry, respectively. These findings indicate that the effects of SG are species-specific and dose-dependent.

Pritam et al. (2010) also reported the largest flower diameter in marigold with 40% SG addition to the growing medium. Conversely, Lazcano & Dominguez (2010) reported that high-dose SG application (25%) in *Viola tricolor* and *Viola wittrockiana* caused 20% plant mortality and reduced leaf biomass and flower production.

Table 2. Effects of vermicompost (VC) doses on flowering duration, stem length, stem thickness, and shoot weight of the 'Advantage Pink' lisianthus cultivar

Dose (ppm)	Flowering duration (days)	Stem length (cm)	Stem thickness (mm)	Shoot weight (g)
0	75.66+2.08a [x]	31.66+3.51d	2.89+0.75c	14.43+2.97c
300	70.00+1.00b	40.33+2.51c	4.57+0.03ab	19.04+0.61bc
600	66.66+1.52cd	42.33+2.51bc	4.81+0.25ab	20.99+2.25abc
900	61.66+1.52e	46.66+1.52ab	5.22+0.51a	22.34+0.53ab
Mean	68.50***	40.24***	4.38***	19.2**

*** Significant at $P \leq 0.001$; ** : Significant at $P \leq 0.01$

Table 3. Effects of vermicompost (VC) doses on plant height, root length, fresh root weight, and number of shoots of the 'Advantage Pink' lisianthus cultivar

Dose (ppm)	Plant height (cm)	Root length (cm)	Fresh root weight (g)	Number of shoots (count)
0	36.66+6.42c[x]	6.00+1.00d	3.02+1.64c	1.00+0.00
300	47.33+3.05b	11.00+2.00c	6.52+0.82b	1.00+0.00
600	51.00+2.64b	14.00+2.64bc	6.41+0.64b	1.00+0.00
900	53.00+2.64ab	20.33+2.51a	10.18+1.51a	1.33+0.57
Mean	47.00***	12.83***	6.53***	Ns.

*** Significant at $P \leq 0.001$; Ns : Not significant

Table 4. Effects of vermicompost (VC) doses on leaf number, flower number, flower diameter, and number of nodes of the 'Advantage Pink' lisianthus cultivar

Dose (ppm)	Number of leaves (count/plant)	Number of flowers (count/plant)	Flower diameter (mm)	Number of nodes (count)
0	23.66+2.51c[x]	4.00+1.00b	41.00+6.8c	10.33+3.51c
300	29.33+3.05ab	6.00+1.00a	53.26+4.51ab	13.33+1.52abc
600	30.66+3.05a	4.00+0.00b	51.81+2.73b	14.66+0.57ab
900	27.66+4.50bc	3.66+0.57c	60.6+9.63a	17.00+1.73a
Mean	Ns.	Ns.	51.67***	13.83*

*** Significant at $P \leq 0.001$; *: Significant at $P \leq 0.05$; Ns: Not significant

This underscores the importance of determining the optimum dose for SG applications. Sardoei (2014) reported that stem diameter in *Calendula officinalis* varied depending on SG dose, with the widest and narrowest diameters observed at 50% and 30% SG, respectively. Finally, Padhiyar et. al (2017) reported that SG enhanced vegetative growth, extended flowering duration, and increased flower yield in chrysanthemum, supporting the observed increases in stem and branch development in the present study. Overall, the present study and existing literature indicate that SG applications exert variable effects on morphological and generative traits in lisianthus and other ornamental plants, depending on species, dose, and environmental conditions. Observed increases in flower diameter, node number, and stem characteristics suggest that SG can positively influence certain morphological traits; however, high-dose applications may reduce generative performance, highlighting the importance of optimizing application rates.

Conclusion

In this study, the effects of different doses of liquid vermicompost (SG) on the morphological and generative development parameters of the *Advantage Pink* lisianthus cultivar were examined in detail. The findings revealed that increasing SG doses led to statistically significant improvements in certain morphological traits, including stem length, stem thickness, plant height, root development, and biomass accumulation. These results indicate that liquid vermicompost is an important organic input that supports vegetative growth in plant production. Conversely, high-dose SG applications exhibited negative effects on generative development parameters such as flowering duration and flower number. The longest flowering period was observed in the control group (75.66 days), whereas a significant reduction was recorded at 900 ppm (61.66 days). Similarly, the highest mean flower number (4.00 flowers/plant) was achieved at the moderate dose of 300 ppm, while higher doses showed a declining trend. These findings suggest that the positive effects of SG on generative development are maintained only up to a certain threshold, beyond which the plant's flowering capacity may decrease. Structural traits such as flower diameter and node number generally improved with increasing doses, supporting the regulatory effect of SG on plant morphogenesis. However, the differences in mean values for branch number, leaf number, and flower number were statistically insignificant ($p > 0.05$), indicating that the effects of liquid SG on these yield parameters may be limited or indirect. Overall, liquid vermicompost appears to have a dual effect on lisianthus, promoting vegetative growth while potentially suppressing generative development at high doses. This highlights the critical importance of dose optimization in organic fertilizer applications. Therefore, determining an appropriate SG dose is essential for maintaining balanced plant growth as well as preserving flower yield and quality.

Declarations

Ethical Approval Certificate

This study did not require ethical approval.

Author Contribution Statement

The authors declare that they contributed equally to the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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