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Fertilization and Compost Effects on Nutrient Content and Growth in Cut Tulip Cultivation

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Abstract: This study has two different objectives. The first one is to compost the grape marc obtained from a food processing factory and different materials together to obtain a new organic material. The second was to use this organic material as an alternative growing medium to cultivate cut tulips and determine the effects of different fertilization rates on plant growth, development, and leaf nutrient uptake. Compost was added to the growing medium at 20% and 40%, and chemical fertilization was applied at different electrical conductivity (EC) levels (0.75, 1.10, and 1.45 dS m^{-1}). According to the results, the highest flower stem length (33.94 cm) and perianth length (42.71 mm) were obtained in the medium with 20% compost, while the longest vase life (8.94 days) was obtained with 40% compost and 1.45 dS m^{-1} EC level. The highest branch weight (28.29 g) was measured with 20% compost and 1.45 dS m^{-1} EC. In the cultivar 'Jan van Nes', 20% compost gave more favorable results than the other treatments. Increasing the EC level limited plant growth but increased the macro- and micronutrient content in the leaves. These results suggest that 20% compost can be used as an effective organic material in cut tulip production.

Keywords: Cut flower, Soilless agriculture, waste management, *Tulipa gesneriana*.

Gübreleme ve Kompostun Kesme Lale Yetiştiriciliğinde Besin İçeriği ve Büyüme Üzerine Etkileri

Öz: Bu çalışmanın iki farklı amacı vardır. Birincisi, bir gıda işleme fabrikasından elde edilen üzüm posası ve farklı materyallerin bir araya getirilerek kompostlaştırılması ve yeni bir organik materyal elde edilmesidir. İkincisi ise bu organik materyalin kesme lale yetiştiriciliğinde alternatif bir yetiştirme ortamı olarak kullanımını ve farklı gübreleme oranları ile bitkilerde büyüme, gelişim ve yapraktaki besin alımı üzerine etkilerin belirlenmesidir. Kompost yetiştirme ortamına %20 ve %40 oranlarında eklenmiş ve farklı elektriksel iletkenlik (EC) seviyelerinde (0.75, 1.10 ve 1.45 dS m^{-1}) kimyasal gübreleme uygulanmıştır. Sonuçlara göre, en yüksek çiçek sapı uzunluğu (33.94 cm) ve periant uzunluğu (42.71 mm) %20 kompost içeren ortamda elde edilirken, en uzun vazo ömrü (8.94 gün) %40 kompost ve 1.45 dS m^{-1} EC seviyesinde elde edilmiştir. En yüksek dal ağırlığı (28.29 g) %20 kompost ve 1.45 dS m^{-1} EC seviyesinde ölçülmüştür. 'Jan van Nes' çeşidinde, %20 kompost diğer uygulamalara göre daha olumlu sonuçlar vermiştir. Artan EC seviyeleri bitki büyümesini sınırlamış ancak yapraklardaki makro ve mikro besin içeriklerini artırmıştır. Bu bulgular, %20 kompostun kesme lale yetiştiriciliğinde etkili bir organik materyal olarak kullanılabileceğini göstermektedir.

Anahtar Kelimeler: Kesme çiçek, topraksız tarım, atık yönetimi, *Tulipa gesneriana*.

1. Introduction

Tulipa gesneriana, commonly known as the tulip, is a bulbous plant across the Mediterranean, Central and East Asia, Europe, and North Africa and is extensively cultivated globally (Hu et al., 2023). Tulipa is divided into two subgenera, Eriostemones and Leiostemones, and these subgenera are further subdivided into eight sections and contain approximately 55 species (Lim and Van, 2006). *Tulipa gesneriana* is the most widely cultivated species (Benschop et al., 2010). Today, tulips are commonly used in landscaping and as cut flowers (Su et al., 2022).

Tulips have recently been intensively produced in a soilless culture. In soil cultivation, soil-borne disease factors cause yield and quality loss. For this reason, substrate culture is preferred as the most usable method and has the highest applicability. In substrate culture, organic media such as peat, coconut peat, sawdust, tree bark, paddy husk, peanut shell, inorganic media such as sand, gravel, volcanic tuff, perlite, vermiculite, expanded clay, rock wool or synthetic media such as polyurethane foam are used (Eken & Şirin, 2018). The sustainability of organic and inorganic media has been decreasing, and new growing media are being sought to replace them. While determining these media, sustainability is at the forefront, and it is also aimed to have effects that can increase the quality and yield of the plant.

With rapid urbanization and global population growth, significant amounts of organic matter are wasted (Bong et al., 2017; Thomson et al., 2022). The primary organic wastes are food waste from residential, commercial, and manufacturing sectors and food processing factories (Melikoglu et al., 2013). These wastes are disposed of in ways incompatible with traditional organic waste management, such as landfilling, burial, or incineration. However, these organic wastes can be transformed by the biological decomposition of organic matter under aerobic conditions, and this process is known as 'composting' (Thomson et al., 2022). The compost obtained at the end of the composting process is used for soil improvement and as a growing medium. It also has commercial and agricultural value as an approach to dealing with organic waste (Hubbe et al., 2010; Meyer-Kohlstock et al., 2013; Walker et al., 2006). Compost is an increasingly popular product used as a substrate in soilless agriculture, offering numerous advantages through environmental and plant health approaches (Avilés et al., 2011).

The uncontrolled use of chemical fertilizers to stimulate plant growth, which started with the "Green Revolution," has led to severe environmental problems (Ning et al., 2017; Nikolaou et al., 2023; Tennakoon et al., 2019). These problems may lead to irreparable consequences if serious measures are not taken. In this context, the most critical solution to the problem is to use natural resources more rationally, reuse some waste, and incorporate it into plant production environments, thus ensuring sustainability. This study was planned, conducted, and finalized for this purpose. In this study, compost obtained from grape pomace as a substrate was tested at different ratios in the growing medium of ‘Jan van Nes’ cut tulip variety to determine its potential to be used as a new growing medium in addition to commercial growing media and its effectiveness in reducing the use of chemical fertilizers.

2. Materials and Methods

2.1. Plant and compost materials

The study used the 'Jan van Nes' variety of tulips (*Tulipa gesneriana*) as plant material. Tulip bulbs of the variety were provided from Asya Lale (Konya, Turkey). The species and variety, widespread in bulb and cut flower production abroad and becoming widespread in our country, were selected. The bulbs of the 'Jan van Nes' variety have a circumference of 11 cm, a flowering time of 35-40 days, a number of flowers per branch, a plant height of 50-55 cm, a flower color of yellow, and vase life of 6-8 days. The Triumph tulip group includes the 'Jan van Nes' tulip variety. The characteristics of Triumph tulip varieties are as follows: no catkins, medium-length stems, mid-season flowering, and Single Early and Single Late hybrids.

In the research, 8 tonnes of grape pomace, 1 tonne of barnyard manure, 8 straw bales of 12 kg, 40 kg of lime and 4 kg of urea obtained from Tokat Dimes Food Processing Factory were used for composting. For nutrient solution, 2 nutrient tanks with a capacity of 1000 L were preferred. The study was carried out in a 450 m² glass greenhouse with roof ventilation, without heating and cooling.

2.2. Methods

2.2.1. Preparation of the compost used in the study

The materials (barnyard manure, straw, lime, and urea) for compost to be used as a growth medium for tulip cultivation were mixed and produced under aerobic conditions according to the sequential heap composting method (Windrow Method) (Durmuş & Kızılkaya, 2018). The compost matured after 135 days, and 1 kg samples were taken after Ankara Soil, Fertilizer, and Water Resources Central Research Institute analyzed maturation. The physical, chemical and biological properties of the compost content were reported in the study conducted by Alkaç and Güneş (2022). At the end of the study, pH Richards (1954) and EC Maas (1986) analyses of tulip growing media were performed on samples taken from the crates after the bulbs were removed.

2.2.2. Pre-treatment of tulip bulbs and planting

The tulips were harvested from the soil in mid-June 2021 (when the leaves were dry). The cleaned bulbs were classified depending on the size of the calibration machine. The bulbs with completed female flower formation (G Stage) were taken to cold storage. The bulbs were stored at 20, 15, and 12 °C for 14 days at intervals of 20, 15, and 12 °C, respectively. The relevant company held the bulbs at 10 °C until November 18, when the bulbs were supplied. Bulbs delivered to us on November 18 were kept at seven °C for 14 days between November 18 and December 1 and at 5 °C for 70 days between December 1 and February 8. At the end of storage, the bulbs were planted in crates with a depth of 20 cm, a length of 60 cm and a width of 40 cm. 10x9=90 tulip bulbs were planted in each crate with 10 bulbs in size and 9 bulbs in the width of the crate, covered with fine sand with a thickness of 1.5-2 cm, and the crates were kept in cold storage at 10 °C and 75% moisture content. When the bulbs reached about 10 cm shoot length in the cold storage, they were moved to the greenhouse.

Fertilization: Fertilization was adapted according to solution formulations prepared according to Hoagland and Arnon (1950) and Alkaç and Güneş (2022). Tulips received only 1/3 of the specified amount of nutrient solution. The EC level of the first nutrient tank was adjusted to EC 1.1 ds m^{-1}, and the EC level of the second nutrient tank was adjusted to 1.45 ds m^{-1}. As a control, only water was given to the plants. Irrigation and fertilization were done with a drip irrigation system. The EC value of tap water applied as control was 0.75 ds m^{-1}. The tanks were checked every seven days, and the nutrient solutions' EC levels and pH values (5.6) were kept at the desired levels (Dole, 2005; Özzambak & Zeybekoğlu, 2004).

Greenhouse climatic conditions: The prepared crates were placed on the floor in the greenhouse. The climatic conditions inside the greenhouse were recorded with a data logger (Hobo, Datalogger). During the experiment, the average temperature in the greenhouse was 17 °C± 2 °C, the highest temperature was 33±2 °C and the lowest temperature was 5±1 °C, while the relative humidity in the greenhouse was 52±2%. In the greenhouse, 55% of the shading was made with a green net in the study area. Plants were irrigated with two rows of drip irrigation pipes (2 L h^{-1} flow rate) placed in the crates. The amount of irrigation was determined as 1 L of water per case, and the duration was calculated and given at regular intervals every two days. In the study, fertilization was started when tulip shoots reached 10 cm in length. Harvesting of tulips was carried out at the nodes where leaf formation started above the soil level before the petals turned color and the tips opened (Van Doorn, 1998).

Observations and measurements on tulips: In tulips, bud emergence time (days) and rate (%), full flowering time (days), flower stalk length (cm), flower stalk thickness (mm), branch weight (g), flower bud diameter (mm), flower bud length (mm) and vase life (days) characteristics were examined. Vase life was determined by cutting the stems of the flowers brought to the laboratory at a length of 30 cm and placing them in glass bottles containing 500 mL pure water in 3 replicates with three plants in each replicate. Vase life was determined when the flowers were placed in the vase until the leaves started turning yellow, the petals wilt and fall, and the flower stem bent (Karunaratne et al., 1997). The conditions of the vase life chamber were temperature 21±2 °C, humidity 52±5% (Hobo Data Logger U12-012, Onset, United States of America), light 482 lux, and day length 11 hours light and 13 hours dark.

2.2.3. Leaf analysis

Macro and microelement analysis: Leaf samples taken during the bud stage of tulip plants were dried in an oven at 80 °C and prepared for analysis. According to the method reported by Miller (1998), the readings of macro and micronutrients such as phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) dissolved in hydrochloric acid were determined by ICP-AES device. Nitrogen (N) was determined by the standard Kjeldahl fresh digestion method. According to the methods reported by Bowman et al. (1988) and Jones (2001), the ammonium (NH_4) formed from the breakdown of nitrogen in the plant sample by fresh combustion using Kjeldal flasks with sulfuric acid in the presence of catalysts was measured by distillation method.

2.2.4. Experimental design and statistical analysis

The study was established in a factorial arrangement in the randomized complete block design (RCBD) and each treatment in the study had 3 replicates and 90 bulbs per replicate were used in the study. The results obtained were evaluated by analysis of variance (ANOVA) in SPSS (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.) statistical programme. Duncan multiple comparison test was applied to determine the significance of the differences between treatments

3. Results

3.1. Effect of compost rates and fertilization with different EC levels on some quality characteristics of 'Jan van Nes' tulip cultivar

When we evaluated the effects of compost ratios (0%, 20%, 40%) and EC levels (0.75, 1.10, 1.45 dS m^1) on the quality traits of the tulip variety 'Jan van Nes', it was found that the differences in flower stem length, petal width and vase life were very significant, while flower stem thickness and branch weight were significant. No significant difference was observed for petal length. However, when the interaction of factors was considered, in some cases not only the effect of compost ratio or EC level was significant, but also the effect of these two factors together. For example, 20% compost and 1.10 EC resulted in the lowest stem length (27.84 cm), while 0% compost and the same EC resulted in a significant increase in stem length (33.81 cm). This shows that not only the compost ratio or the EC level, but also the interaction of these two factors played an important role. Similarly, the differences between 40% compost and 0.75 EC and 40% compost and 1.45 EC were too large to be explained by the independent effects of each factor alone. For example, 40% compost and 0.75 EC resulted in the widest petal width (17.73 mm), while 40% compost and 1.45 EC resulted in the narrowest petal width (14.91 mm). Similar interactions between branch weight and vase life were also observed. 20% compost and 1.45 EC produced the highest branch weight (28.29 g), while 0.75 EC produced a lower branch weight (23.69 g) at the same compost rate. In terms of vase life, 40% compost and 1.45 EC produced the longest vase life (8.94 days), while 20% compost and 1.10 EC produced the shortest vase life (7.36 days) (Table 1).

Table 1. Effect of fertilization treatments with different compost rates and EC levels on some quality characteristics of 'The Jan van Nes tulip cultivar.

Çizelge 1. *Farklı kompost oranları ve EC seviyeleri ile gübreleme uygulamalarının 'The Jan van Nes lale çeşidinin bazı kalite özellikleri üzerine etkisi.*

Compost (%) x Fertilization (EC)	FSL (cm)	FST (mm)	PW (mm)	PL (mm)	BW (g)	VL (day)
0 x 0.75	31.62±0.72 ab	8.70±0.10 a	17.19±0.28 a	41.64±0.51	28.03±0.91 a	7.74±0.14 b
0 x 1.10	27.84±0.70 c	8.31±0.11 ab	15.70±0.27 cd	39.13±0.57	25.28±0.54 ab	7.42±0.18 b
0 x 1.45	30.74±1.35 abc	8.70±0.11 a	17.03±0.35 ab	41.23±0.83	27.24±0.89 ab	7.08±0.14 b
20 x 0.75	33.47±0.47 a	8.11±0.11 b	15.66±0.32 cd	42.32±0.49	25.76±0.82 ab	8.71±0.20 a
20 x 1.10	33.81±1.36 a	8.75±0.27 a	15.78±0.38 cd	41.17±1.16	26.22±0.96 ab	7.36±0.25 b
20 x 1.45	31.18±1.00 ab	8.80±0.08 a	16.84±0.30 abc	42.25±0.72	28.29±0.94 a	7.46±0.22 b
40 x 0.75	29.00±0.00 bc	8.89±0.10 a	17.73±0.86 a	42.02±0.34	23.69±0.58 b	7.75±0.11 b
40 x 1.10	31.67±1.26 ab	8.37±0.35 ab	15.96±0.51 bcd	40.82±1.03	23.95±1.24 b	6.38±0.37 c
40 x 1.45	32.01±0.64 ab	8.34±0.10 ab	14.91±0.37 d	41.32±0.46	27.11±1.81 ab	8.94±0.26 a
Significance	0.001	0.038	0.001	0.122	0.040	0.001

FSL: Flower Stem Length, **FST:** Flower Stem Thickness, **PW:** Petal Width, **PL:** Petal Length, **BW:** Branch Weight, **VL**: Vase Life, **±:** Standart Error.

3.2. The effect of different compost rates and fertilization treatments with different EC levels on some phenological observations of 'Jan van Nes' tulip cultivar

It was observed that compost levels (0%, 20%, 40%) and EC levels (0.75, 1.10, 1.45 dS m^{-1}) had significant effects on the phenological characteristics of the tulip variety 'Jan van Nes'. Significant differences were found between bud emergence time and rate and full flowering time. However, it was observed that interactions also played an important role in these traits. For example, 0% compost and 0.75 EC resulted in the earliest bud emergence (47.17 days) and the highest emergence rate (63.70%), while 40% compost and 1.10 EC resulted in the latest bud emergence (57.83 days). This difference can be explained not only by the effect of EC level or compost ratio, but also by the effect of the combination of these factors. In addition, interactions are also important for flowering time. For example, 20% compost and 0.75 EC resulted in the longest flowering time (59.79 days), while 20% compost and 1.10 EC resulted in the shortest flowering time (57.04 days), indicating that not only the effects of both factors but also their interactions play a significant role (Table 2).

Table 2. Effect of fertilization treatments with different compost rates and EC levels on phenological observations in the 'Jan van Nes' tulip cultivar.

Çizelge 2. *Farklı kompost oranları ve EC seviyeleri ile gübreleme uygulamalarının 'Jan van Nes' lale çeşidinde fenolojik gözlemler üzerine etkisi.*

Compost (%) x Fertilization (EC)	BET (day)	BER (%)	FFT (day)
0 x 0.75	47.17±2.48 d	63.70±2.84 a	59.58±0.29 a
0 x 1.10	52.17±2.39 bcd	53.06±1.42 bc	59.33±0.38 a
0 x 1.45	51.29±1.79 cd	51.44±1.00 bcd	57.58±0.34 bc
20 x 0.75	57.83±0.39 a	50.33±1.64 bcd	59.79±0.46 a
20 x 1.10	56.04±0.67 abc	49.08±1.30 cd	57.04±0.41 c
20 x 1.45	51.17±1.68 cd	54.54±1.70 b	58.58±0.36 ab
40 x 0.75	56.00±0.00 bc	47.33±0.21 d	59.00±0.00 a
40 x 1.10	57.13±0.33 ab	46.53±0.34 d	57.50±0.33 bc
40 x 1.45	56.83±0.17 bcd	49.91±0.99 bcd	58.58±0.51 ab
Significance	0.001	0.001	0.001

BET: Bud Emergence Time, **BER:** Bud Emergence Rate, **FFT:** Full Flowering Time, **±:** Standart Error.

3.3. EC values of tulip growing media

At the end of the vegetation period of 'Jan van Nes' tulip cultivar, the EC levels of the samples taken from growing media with different compost rates (0%, 20%, and 40%), different EC levels (0.75, 1.10 and 1.45 dS m^{-1}) treatments were examined and the EC level was determined as 'No Salt' (0-4000=No Salt) in all treatments. The highest measured EC level (400 µS cm^{-1}) was obtained from the growing medium at a 20% compost rate, and the EC level was 1.10. The lowest EC level (160 µS cm^{-1}) was measured in the growing medium with no compost (0%) and an EC level of 0.75 dS m^{-1}.

3.4. pH values of tulip growing media

At the end of the vegetation period of 'Jan van Nes' tulip variety, when the pH levels of the samples taken from growing media with different compost ratios and different EC levels treatments were examined, pH levels were determined as 'neutral' (6.5<neutral 7.5) in all treatments in growing media without compost, with 20% and 40% compost. The highest pH level (7.60) was measured in the medium with 40% compost treatment and an EC level of 1.10. The lowest pH level (6.23) was measured in the growing medium without compost (0%) and with an EC level of 0.75.

3.5. Macro and micronutrient contents of tulip leaf samples

It was observed that the combination of different compost applications and EC levels significantly affected the macro and micro nutrient content in the leaves of 'Jan van Nes' tulip. It was found that the nutrient content was influenced not only by the independent effects of compost ratio and EC level but also by the interactions between these factors. The media provided the highest value in terms of nitrogen content (2.22%) with 0% compost and an EC value of 1.45 dS m^{-1}. On the other hand, the media with 40% compost and 0.75 dS m^{-1} EC had the lowest nitrogen content (1.52%). This difference can be explained by the effect of compost ratio or EC level and the interaction of these two factors. In particular, nitrogen content decreased as the compost ratio increased and EC level decreased, while media with higher EC levels provided higher nitrogen content. Phosphorus content was also affected by the interactions in a similar way. While the highest phosphorus content (0.52%) was obtained with 20% compost and 1.45 dS m^{-1} EC, 40% compost and 0.75 dS m^{-1} EC decreased the phosphorus content to the lowest level (0.32%). This result shows that phosphorus content remains low, especially for environments with high compost rates and low EC levels. In terms of potassium content, the highest value (1.78%) was obtained with 40% compost and 1.45 dS m^{-1} EC. On the other hand, the lowest potassium content (1.16%) was obtained with 0% compost and 0.75 dS m^{-1} EC. Here, it is clearly seen that interactions play an important role in potassium content. Iron content reached the highest value (148.17 ppm) in 20% compost and 1.45 dS m^{-1} EC level, while 40% compost and 0.75 dS m^{-1} EC level decreased the iron content to the lowest level (72.92 ppm). This interaction provides important information on how compost rate and EC level can affect iron uptake. In terms of copper content, 20% compost and 1.45 dS m^{-1} EC yielded the highest copper content (7.45 ppm), while 40% compost and 0.75 dS m^{-1} EC yielded the lowest copper content (3.53 ppm). This result shows that copper can change with the effect of compost rate and EC level. Zinc content reached the highest value (48.70 ppm) with 40% compost and 1.45 dS m^{-1} EC level, while 20% compost and 0.75 dS m^{-1} EC level decreased the zinc content to the lowest level (14.76 ppm). This difference also reflects the interactive effect of compost ratio and EC level. Manganese content reached the highest level (55.24 ppm) with 40% compost and 1.45 dS m^{-1} EC, while 0% compost and 0.75 dS m^{-1} EC showed the lowest manganese content (19.16 ppm). This shows that manganese uptake is particularly associated with high compost and high EC environments. Calcium content reached the highest value (1.61%) with 40% compost and 1.45 dS m-1 EC, while 0% compost and 0.75 dS m-1 EC provided the lowest calcium content (0.94%). This interaction shows that calcium uptake also changes with the effect of compost and EC level. Magnesium content reached the highest level with 20% compost and 1.45 dS m^{-1} EC, while 0% compost and 0.75 dS m^{-1} EC had the lowest magnesium content. This interaction also shows that magnesium uptake can be associated with high compost and EC levels (Table 3).

Table 4 presents the correlation matrix for the effects of different compost ratios and various EC levels on the quality parameters of tulips. The highest correlation was found between flower stem length and perianth length (r=0.698), while the lowest correlation was observed between the full bloom duration and perianth width (r=-0.00).

Table 3. The effect of different compost ratios and EC level fertilization applications on the macro and micro-nutrient contents in leaves of the 'Jan van Nes' tulip variety.
Çizelge 3. *Farklı kompost oranlarının ve EC düzeyinde gübreleme uygulamalarının 'Jan van Nes' lale çeşidinin yapraklarındaki makro ve mikro besin elementi içerikleri üzerine etkisi.*

Compost (%) x Fertilization (EC)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
0 x 0.75	1.57±0.02c	0.33±0.00d	1.16±0.01e	0.94±0.01e	0.24±0.01b	76.92±2.18d	4.12±0.15c	13.19±0.32f	19.16±0.64f
0 x 1.10	1.89±0.02b	0.43±0.00c	1.43±0.01c	1.43±0.01c	0.33±0.00b	125.92±2.31c	5.99±0.15b	28.48±0.69d	34.98±0.94d
0 x 1.45	2.22±0.03a	0.49±0.00b	1.67±0.03b	1.59±0.02a	0.45±0.01b	134.25±2.29ab	7.34±0.05a	40.98±0.47b	45.30±1.10b
20 x 0.75	1.54±0.02c	0.33±0.01d	1.21±0.02de	0.99±0.02e	0.24±0.01b	74.58±1.28d	3.83±0.13cd	14.76±0.27e	22.53±0.40e
20 x 1.10	1.86±0.02b	0.44±0.01c	1.45±0.01c	1.44±0.02bc	0.36±0.00b	126.58±2.27c	6.02±0.14b	32.12±0.50c	42.16±0.65c
20 x 1.45	2.17±0.01a	0.52±0.01a	1.74±0.02a	1.59±0.02a	0.83±0.36a	148.17±5.01a	7.45±0.05a	47.50±0.92a	54.91±0.52a
40 x 0.75	1.52±0.02c	0.32±0.00d	1.23±0.02d	1.04±0.01d	0.25±0.01b	72.92±1.17d	3.53±0.05d	15.59±0.21e	22.80±0.32e
40 x 1.10	1.87±0.02b	0.44±0.00c	1.40±0.02c	1.49±0.02b	0.36±0.01b	134.42±1.42ab	5.76±0.34b	32.68±0.23c	44.41±0.39b
40 x 1.45	2.19±0.02a	0.51±0.00ab	1.78±0.01a	1.61±0.02a	0.49±0.01ab	143.17±2.00a	7.42±0.03a	48.70±0.84a	55.24±0.43a
Significance	0.001	0.001	0.001	0.001	0.024	0.001	0.001	0.001	0.001

±: Standart Error.

Table 4. Correlation coefficients between the examined characteristics in the 'Jan van Nes' tulip variety.
Çizelge 4. *'Jan van Nes' lale çeşidinde incelenen özellikler arasındaki korelasyon katsayıları.*

Variables	FSL	FST	PW	PL	BW	VL	BET	BER	FFT
FSL		0.206*	0.095	0.698**	0.497**	0.115	0.113	0.154	-0.081
FST	0.206*		0.590**	0.513**	0.449**	-0.043	-0.124	0.212*	-0.080
PW	0.095	0.590**		0.451**	0.288**	-0.085	-0.202*	0.223*	-0.001
PL	0.698**	0.513**	0.451**		0.546**	0.066	0.015	0.166	-0.088
BW	0.497**	0.449**	0.288**	0.546**		0.148	-0.210*	0.397**	0.075
VL	0.115	-0.043	-0.085	0.066	0.148		0.133	0.150	0.429**
BET	0.113	-0.124	-0.202*	0.015	-0.210*	0.133		-0.490**	-0.108
BER	0.154	0.212*	0.223*	0.166	0.397**	0.150	-0.490**		0.437**
FFT	-0.081	-0.080	-0.001	-0.088	0.075	0.429**	-0.108	0.437**	

FSL: Flower Stem Length, **FST:** Flower Stem Thickness, **PW:** Petal Width, **PL:** Petal Length, **BW:** Branch Weight, **VL**: Vase Life, **BET:** Bud Emergence Time, **BER:** Bud Emergence Rate, **FFT:** Full Flowering Time, ****:** $p < 0.01$. ***:** $p < 0.05$.

4. Discussion

4.1. Effects of compost applications on the growth and flowering quality of tulip plants

It was observed that the addition of 20% compost to the growing medium positively affected tulip flower stem length but had a negative effect on bud emergence time. Statistically significant differences were found in bud emergence time and rates in the non-compost medium (0%). These findings are consistent with the study conducted by Khomami et al. (2019), who applied compost at 0%, 15%, 30%, 45%, 60%, and 100% v/v rates in *Dieffenbachia amoena* and reported that plant growth was increasingly limited as compost application rates increased. Similarly, Cristiano et al. (2018) investigated the effects of peat and sewage sludge-based compost (0%, 30%, and 60%) on *Lantana montevidensis* and found that higher compost concentrations (30 and 60%) negatively affected plant diameter, shoot development, leaf growth, and both fresh and dry mass.

In contrast, Baran et al. (2001) found that the optimum growth of *Hypostases phyllostagya* occurred when grape pomace compost was mixed with peat and perlite at a ratio of 50%. Zulfiqar et al. (2019) reported that 10% compost had a positive effect on the growth of *Dracaena deremensis*, while Papafotiou et al. (2017) showed that 25% compost application had beneficial effects on the growth of *Ficus benjamina*. Despite these positive findings in other plants, our results suggest that increased compost application in tulip cultivation has a negative effect on plant growth. This result may be due to the excessive nutrients provided by the compost, which may be detrimental to tulips, given the relatively low fertilizer requirements of tulips. These findings highlight the importance of optimizing compost application rates for specific plant species, as nutrient requirements and growth responses may vary significantly in different plant species.

4.2. The effects of fertilizer applications on the growth and flowering quality of tulip plants

Farmers commonly use chemical fertilizers to enhance soil fertility, but it is well-documented that excessive use of these fertilizers can degrade soil quality and harm the environment (Ali & Çığ, 2018). In this study, different fertilization applications were tested at various electrical conductivity (EC) levels (EC 0.75, EC 1.10, and EC 1.45) in an effort to reduce fertilizer usage while still maintaining soil fertility. Previous studies have shown that chemical fertilizers can positively affect plant growth. For instance, Boboc et al. (2021) reported that the application of 20-20-20 compound fertilizer enhanced plant growth in *Passiflora caerulea.* Similarly, Vâşcă-Zamfir et al. (2019) found that fertilization increased the number of leaves and branches in *Murraya exotica L.*, and Baltazar-Bernal and Jaen-Contreras (2020) indicated that fertilization promoted vegetative growth in *Heliconia cv. Tropics*.

In this study, the effect of fertilization treatments based on EC levels on tulip plants was examined. The results revealed significant differences between fertilization levels and EC values. Typically, plant growth and flower quality improve with higher fertilization doses. However, in this study, the highest growth was observed at EC 0.75 dS m^{-1}. This finding contrasts with general trends reported in the literature, where higher EC levels are usually associated with better growth. High EC and pH levels, however, were found to have negative effects, which is notable since high EC can lead to salt stress, and low pH levels can cause root rot. The ideal pH for tulip cultivation is between 6 and 7, suggesting that careful pH management is crucial for optimal growth. Additionally, the study found that EC levels increased in direct proportion to the fertilization doses applied, emphasizing the importance of closely monitoring EC levels when applying fertilizers. While artificial fertilizers are sometimes used to increase soil EC, careful balancing is essential to prevent adverse effects. In this study, the highest EC level (1.45 dS m^{-1}) resulted in negative outcomes, highlighting the potential risks of excessive fertilization.

In conclusion, this study provides important insights into the relationship between fertilization and EC levels in tulip cultivation. The findings challenge general assumptions found in the literature, particularly regarding the beneficial effects of higher EC levels, and underscore the need for further research to determine the most effective fertilization strategies for tulips.

5. Conclusion

In the study, grape waste, commonly cultivated in the region and composted over approximately 4.5 months, was utilized as a new organic material in tulip cultivation. Different ratios of this compost (20% and 40%) were applied. In the 'Jan van Nes' tulip variety, particularly favorable results in terms of critical quality criteria such as flower stem length (33.94 cm), perianth length (42.71 mm), and branch weight (28.29 g) were observed in plants with 20% compost application. Another quality criterion, vase life (8.94 days), yielded the best results in plants with 40% compost content and a fertilization level of 1.45 dS m^{-1}. Generally, the application of 20% compost showed better growth and flowering characteristics than the control and 40% compost ratio. Considering the significant input of imported peat in tulip cultivation in soilless agriculture, this study revealed that compost below 20% did not negatively affect plant development, allowing for the utilization of organic waste in the cultivation environment. Another application of the study was different levels of fertilization practices. The application with an EC level of 0.75 dS m^{-1} generally yielded the best results. Adverse effects on plant development were observed when the upper limit of fertilization with an EC level of 1.45 dS m^{-1} was reached. Considering the low fertilizer needs of tulips, it was observed that compost with a high EC, when combined, directly affected plant development.

When all treatments in the study were evaluated together, it was determined that different compost ratios and different EC levels positively affected the macro and micronutrient content in tulip leaves. When tulip cultivation is considered in general, the use of compost below 20% can be recommended. Due to the low fertilizer requirement in tulip cultivation, it is predicted that it will be beneficial to use compost and reduce fertilizer costs with low compost rates.

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