

## The Effects of Compound Fertilizers Application to Different Commercial Tulip Varieties in Natural Growing Area on Plant and Bulb Growth

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### ABSTRACT

The study was conducted in Ibradı district of Antalya, the natural growth area of the plant, between 2020 and 2021, to determine the effects of compound fertilizer application on the growth, flowering and bulb development of tulip (*Tulipa gesneriana* L.) varieties. For this purpose, 5 different commercially popular tulip varieties (Queen of night, Apeldorn, Pink impression, Jaap groot, Royal virgin) and 2 different compound fertilizers (10-52-10+TE, 20-20-20+TE) were used and no fertilizer application was made in the control. Compound fertilizer (NPK 15-15-15) was added to the soil before planting. The experiment was established according to a two-factor (variety, fertilizer) randomized block design with 3 replications and 10 plants in each replicate. At the end of the study, the first sprouting occurred between 49 (earliest)-84 (latest) days after planting date depending on the varieties, the beginning of flowering was between the third week of March and mid-April, and the end of flowering was occurred at the beginning of May. The flowering longevity was between 14 and 21 days, plant length was measured between 29.6-42.8 cm. It was determined that there were significant differences among the varieties in terms of the sprouting time, beginning of flowering time, flowering longevity, increased plant height and bulb yield, but had no effect on the other characters.

**Keywords:** Natural area, commercial variety, tulip, growth, development

### Doğal Yetiştirme Alanında Farklı Ticari Lale Çeşitlerine Bileşik Gübre Uygulamasının Bitki ve Soğan Büyümesi Üzerine Etkileri

### ÖZ

Çalışma, kompoze gübre uygulamasının lale (*Tulipa gesneriana* L.) çeşitlerinin büyüme, çiçeklenme ve soğan gelişimi üzerine olan etkilerini belirlemek amacıyla 2020-2021 yılları arasında bitkinin doğal yetiştirme alanı olan Antalya'nın İbradı ilçesinde yürütülmüştür. Bu amaçla ticari açıdan popüler olan 5 farklı lale çeşidi (Queen of night, Apeldorn, Pink impresion, Jaap groot, Royal virgin) kullanılmış ve 2 farklı kompoze gübre (10-52-10+TE ve 20-20-20+TE) uygulanmış, kontrol parsellerinde ise herhangi bir gübre uygulaması yapılmamıştır. Dikim öncesi toprağa (NPK 15-15-15) kompoze gübre ilave edilmiştir. Deneme iki faktörlü (çeşit, gübre) tesadüf blokları deneme desenine göre 3 tekerrürlü ve her tekerrürde 10 bitki olacak şekilde kurulmuştur. Çalışma sonunda; ilk sürgün çıkışlarının çeşitlere bağlı olarak soğan dikiminden 49 (en erken)-84 (en geç) gün sonra, ilk çiçeklenme başlangıcı mart ayının üçüncü haftası ile nisan ortası arasında, çiçeklenme bitişi ise Mayıs ayının başında gerçekleşmiştir. Çiçekte kalma süreleri 14-21 gün arası, bitki boyu değeri 29.6-42,8 cm arasında değişmiştir. Çeşitler arasında önemli farklılık olduğu, gübre uygulamalarının sürme zamanı, çiçeklenme başlangıcı ve çiçek süresi bakımından etkili olduğu, bitki boyu ve parsel başına soğan verimini arttırdığı, incelenen diğer karakterler üzerine etkili olmadığı belirlenmiştir.

**Anahtar Kelimeler:** Doğal alan, ticari çeşit, lale, büyüme, gelişme

### INTRODUCTION

Tulip (*Tulipa gesneriana* L.) is a bulbous plant belonging to Liliaceae family and has nearly 109 species worldwide [1, 2]. It is originally from Kazakhstan and has spread in Europe, North Africa and Asia [3]. Species are especially extended the Caucasus (65 species), Iran and adjoining regions (36 species) and Türkiye (18 species) [4]. As part of Kazakhstan was in the Ottoman Empire in the 16<sup>th</sup> century, some tulips were brought to present day

Turkey and planted in the gardens of the sultan of the Ottoman Empire. The tulip, which was introduced to West Europe and Holland from Türkiye in a short time, has become popular despite being expensive [5]. In 17<sup>th</sup> century Amsterdam, a tulip bulb was worth more than a diamond. After they were taken to Europe, breeding studies were started on tulips and gained great momentum. Over the years, there are more than 5000 varieties of tulips obtained by hybridization from natural species and it has become the most important ornamental bulb in the world due

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to attractiveness flowers and economic value [6, 3]. It is one of the most widely used both as cut flowers and as indoor and outdoor ornamental plants. It is also bulb production has become an important sector in the world [7].

The Netherlands has a leading position in the global flower trade. It is estimated to account for 81% of global flower bulb exports and 90% of world tulip production. Tulips are one of the most important exported products of the Netherlands, with the production of over 4 billion bulbs annually. In 2020, tulips were grown on 149,000 hectares in the Netherlands and tulip bulb exports were 250,000 million € in 2021. However, in the Netherlands, there were great losses in harvest in 2022-2023 due to the excessive rainfall after planting, hail events during the flowering period in April and extreme heat in June. It has been reported that the same problems were experienced in the 2023-2024 season and bulb sizes were low. In tulips growing on heavy clay soils, excessive rainfall caused the soil to become over-saturated, leading to a lack of oxygen and damaging the bulbs [8].

Türkiye imports almost all of its tulip bulbs (94%) from the Netherlands. In recent years, the production of tulip bulbs has started to increase gradually as tulips have started to be used in parks and gardens. It has increased by 1% in 2020 and has reached 40 million 690 thousand pieces [9]. Tulip bulbs are produced in Konya (400 da), Karaman, Balıkesir and Istanbul (Silivri) [7]. Ibradı district of Antalya, which is the study area, is the natural growing area of tulip and is close to Konya and Karaman borders.

Studies on tulips in recent years have mostly focused on increasing stem elongation, improving bulb quality and encouraging early flowering [10]. Khan et al. [6], stated that studies on bulb production, growth and flower quality in tulips are insufficient.

In ornamental geophytes such as tulips, plant growth and development depend on the nutrients stored in the bulbs [11]. Many researchers have reported that plant nutrients such as nitrogen, phosphorus and potassium play an important role in the growth and development of plants and improve the chemical and biological properties of the soil [12, 1]. Balanced fertilization is the nutrients necessary for quality flowers, high yield and plant development. Boeckmann [13] suggested feeding tulip bulbs with a balanced fertilizer. According to Wassink [14], the weight of the bulb before flowering decreases in tulips. The decrease in the reserves stored in the bulbs has important effects in the next growth period. The development of the new bulb, namely the bulblet formation, begins simultaneously with the development of the flower stalk. Therefore, it is

important to supplement adequate nutrients for the formation of new bulbs. The importance of nitrogen fertilization for tulip bulb production not only on growth and bulb yield it is also important for the nitrogen content of the daughter bulbs used for planting the following year. Fertilization of tulips with nitrogen (N) is generally done in two periods, autumn and spring. Starting from planting, a small amount of nitrogen is taken up by the roots in winter and trace amounts of NO<sub>3</sub> accumulate in the roots. N uptake reaches its maximum level starting from shoot emergence in spring. It has also been found that N accumulation in the roots initially during the winter enlarged the main bulb during the flowering period. Additional N application can be applied following flowering to stimulate growth [15]. 20:20:20+TE is water soluble grade compose fertilizer containing 5.6% NO<sub>3</sub>-N, 4.4% NH<sub>4</sub>-N and 10% NH<sub>2</sub>-N including 20% each of water-soluble P and K [16]. 10:52:10 is water soluble form compound fertilizer containing 10% total N, 8.1% NH<sub>4</sub>-N and 1.9% NH<sub>2</sub>-N including 52% each of water-soluble P<sub>2</sub>O<sub>5</sub>, 10% K<sub>2</sub>O [17]. Bankar and Mukhopadhyay [18] were studied the effects of NPK on the growth of *Polianthes tuberosa*. In the study where N (0, 5, 10, 15 or 20 g/m<sup>2</sup>), P<sub>2</sub>O<sub>5</sub> (0, 20 or 40 g/m<sup>2</sup>) and K<sub>2</sub>O (0, 20 or 40 g/m<sup>2</sup>) were treatments they reported that 20:20:20 g/m<sup>2</sup> NPK application promoted flowering and improved growth of tuberose. According to Khan et al. [6], phosphorus promotes root development, facilitates growth and the uptake of other nutrients.

Consequently, the present study was conducted to determine the effects of balanced and phosphorus-based fertilization on plant growth, flower quality and bulb yield of tulip cultivars grown in Ibradı Ormana, their natural area.

## MATERIALS AND METHODS

### *Experimental site*

The research was carried out in area of 1000 m<sup>2</sup> located in Antalya Ibradı Ormana district (37°41'29"N-31°34'48"E, at an altitude of 923 meters), the homeland of tulips between December 2020 and May 2021. The average meteorological measurements of Ibradı location according to long-term averages are given in Table 1 [19]. The climate of the area in general is temperate-Mediterranean. Some climatic data (relative humidity, maximum, minimum and average temperature values and total rainfall) from obtained during the growing period between December 2020 and May 2021 are included in Table 2. In the study required climate data Republic of Türkiye Ministry of Environment, Urbanization and Climate Change were obtained

from the meteorological directorate stations. Soil samples were taken from 3 different points of the area in November 2020 and analyzed and pH, electrical conductivity (EC), composition (sand, clay, silt content), organic matter, available phosphorus (P), exchangeable potassium (K), calcium (Ca) and magnesium (Mg) values were determined (Table 3).

Table 1. Average meteorological measurements of Ibradı location according to the long-term averages (1960-2014)

| Annual Averages                        | Months |      |      |      |      |      |      |      |      |      |      |      |
|--|--------|------|------|------|------|------|------|------|------|------|------|------|
|  | 1      | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   |
| Maximum temperature (°C)               | 8.7    | 10.0 | 13.4 | 17.7 | 22.5 | 28.0 | 32.0 | 32.3 | 27.2 | 21.2 | 15.4 | 11.1 |
| Minimum temperature (°C)               | 1.1    | 1.7  | 4.3  | 8.0  | 12.2 | 16.7 | 20.4 | 20.8 | 16.2 | 11.3 | 6.9  | 3.4  |
| Humidity (%)                           | 72.0   | 69.0 | 60.7 | 60.1 | 58.1 | 46.7 | 39.7 | 37.3 | 47.4 | 56.7 | 62.3 | 68.7 |
| Wind speed (m sec <sup>-1</sup> )      | 1.4    | 1.4  | 1.4  | 1.4  | 1.2  | 1.3  | 1.3  | 1.3  | 1.2  | 1.3  | 1.4  | 1.4  |
| Sunbathing time (h day <sup>-1</sup> ) | 4.6    | 4.3  | 6.2  | 7.0  | 8.0  | 9.1  | 9.5  | 10.2 | 9.1  | 6.2  | 5.2  | 4.2  |

Table 2. Some meteorological data during the growing period (2020-2021)

| Months   | Max. temp. (°C) | Min. temp. (°C) | Average temp. (°C) | Relative humidity (%) | Total precipitation (mm) | Wind speed (m sec <sup>-1</sup> ) |
|----------|-----------------|-----------------|--------------------|-----------------------|--------------------------|-----------------------------------|
| December | 15.7            | -0.3            | 7.3                | 79.4                  | 327.4                    | 1.5                               |
| January  | 14.7            | -5.7            | 5.3                | 75.4                  | 288.0                    | 1.9                               |
| February | 17.4            | -6.5            | 6.5                | 60.5                  | 67.8                     | 1.9                               |
| March    | 17.3            | -4.5            | 6.3                | 65.7                  | 213.6                    | 2.0                               |
| April    | 28.2            | -0.6            | 12.4               | 53.6                  | 27.6                     | 2.0                               |
| May      | 32.5            | 9.8             | 19.4               | 42.1                  | 0.0                      | 1.9                               |

Table 3. Results of the physical and chemical analyses of the soil samples from habitat of Ibradı Ormana growing area



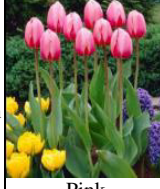

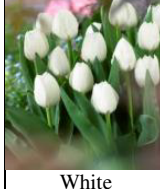
| Physical and Chemical Properties | Natural Medium (Ibradı/Ormana) |
|----------------------------------|--------------------------------|
| Sand (%)                         | 44                             |
| Clay (%)                         | 37.8                           |
| Silt (%)                         | 46.0                           |
| Texture                          | Siltly Clay Loam               |
| pH (1: 2.5)                      | 6.87 (slightly acidic)         |
| EC (%)                           | 0.017 (unsalted)               |
| CaCO <sub>3</sub> (% Lime)       | 11.3 (medium lime)             |
| Organic Substance (%)            | 3.2 (high)                     |
| P (ppm)                          | 23                             |
| K (ppm)                          | 255                            |
| Ca (ppm)                         | 2500                           |
| Mg (ppm)                         | 205                            |

*Plant material, planting preparation and planting*

Bulbs with a circumference of 10/12 cm belonging to five different tulip varieties (Apeldoorn, Jaap Groot, Pink Impression, Queen of Night and Royal Virgin) which were obtained from the Asya tulip company and have been met cooling requirements were used as plant material (Table 4). Apeldoorn, Jaap Groot, Pink Impression varieties are classified as

early mid, Royal Virgin as middle late and Queen of Night as late in terms of flowering period.

Table 4. The characteristics of the varieties used as plant material

| Varieties       | Picture/Color   | Calibre | Flowering period (month) | Plant height (cm) |
|-----------------|---|---------|--------------------------|-------------------|
|                 |   |         |                          |                   |
| Apeldoorn       | <br>Red     | 10/12   | 2/3<br>early mid         | 40-60             |
| Jaap Groot      | <br>Yellow  | 10/12   | 2/3<br>early mid         | 40-60             |
| Pink Impression | <br>Pink   | 10/12   | 2/3<br>early mid         | 40-60             |
| Queen of Night  | <br>Black | 10/12   | 5/6<br>late              | 40-60             |
| Royal Virgin    | <br>White | 10/12   | 4/5<br>Late mid          | 30-40             |

At the middle of November, the soil for growing tulips was made ploughed to not less than 40-50 cm depth. Before the preparation of the beds, NPK (15-15-15) base fertilizer was thoroughly mixed with the soil at a dose of 120 grams per m<sup>2</sup> and spread. The bed width and height were 100 cm and 30 cm respectively. The width of the path between the beds was 50 cm. The shape and appearance of the trial area is shown in Figure 1-2. Before planting, the research plots were cleared of weeds manually and beds was performed. The bulbs were left in a solution containing 50% Benomyl as a protectant against fungal diseases for 30 minutes prior to planting. The bulbs were planted in 45 plots containing 200 bulbs per 8 m<sup>2</sup> parcel area with a total of 9000 pieces at a depth of 10 cm with 20.0×20.0 cm spacing on 04 December 2020. Planting was completed by hand on

one day and the bulbs were irrigated. Other irrigations were done during fertilization treatments. There was further irrigation during fertilization treatments. After planting, fungicide containing 25 g/L Fludioxonil 10 g/L Metalaxyl-M active substance was applied with 4 liters of water as 10 ml per m<sup>2</sup>.

The diameters of the bulbs were measured before planting and the average diameter of the bulbs of Queen of Night variety was 2,47 cm and the weight was 8,2 g. These values were 3.31 cm, 3.11 cm, 3.26 cm, 3,05 cm and 17.5 g, 13.5 g, 13.1 g, 12.5 g for Apeldoorn, Pink Impression, Jaap Groot and Royal Virgin varieties respectively.

Table 5. Fertilization treatments according to varieties

| Parcel No | Varieties                     | Parcel No | Varieties                     | Parcel No | Varieties                     |
|-----------|-------------------------------|-----------|-------------------------------|-----------|-------------------------------|
| A1        | Queen of Night- (10:52:10+TE) | D1        | Royal Virgin (20:20:20+TE)    | G1        | Apeldoorn (20:20:20+TE)       |
| A2        | Apeldoorn (10:52:10+TE)       | D2        | Jaap Groot (20:20:20+TE)      | G2        | Royal Virgin (20:20:20+TE)    |
| A3        | Pink Impression (10:52:10+TE) | D3        | Queen of Night (20:20:20+TE)  | G3        | Jaap Groot (20:20:20+TE)      |
| A4        | Royal Virgin (10:52:10+TE)    | D4        | Pink Impression (20:20:20+TE) | G4        | Pink Impression (20:20:20+TE) |
| A5        | Jaap Groot (10:52:10+TE)      | D5        | Apeldoorn (20:20:20+TE)       | G5        | Queen of Night (20:20:20+TE)  |
| B1        | Jaap Groot (20:20:20+TE)      | E1        | Apeldoorn (Control)           | H1        | Queen of Night (10:52:10+TE)  |
| B2        | Apeldoorn (20:20:20+TE)       | E2        | Queen of Night (Control)      | H2        | Pink Impression (10:52:10+TE) |
| B3        | Pink Impression (20:20:20+TE) | E3        | Royal Virgin (Control)        | H3        | Apeldoorn (10:52:10+TE)       |
| B4        | Queen of Night (20:20:20+TE)  | E4        | Pink Impression (Control)     | H4        | Jaap Groot (10:52:10+TE)      |
| B5        | Royal Virgin (20:20:20+TE)    | E5        | Jaap Groot (Control)          | H5        | Royal Virgin (10:52:10+TE)    |
| C1        | Pink Impression (Control)     | F1        | Pink Impression (10:52:10+TE) | I1        | Queen of Night (10:52:10+TE)  |
| C2        | Royal Virgin (Control)        | F2        | Apeldoorn (10:52:10+TE)       | I2        | Pink Impression (10:52:10+TE) |
| C3        | Jaap Groot (Control)          | F3        | Royal Virgin (10:52:10+TE)    | I3        | Apeldoorn (10:52:10+TE)       |
| C4        | Queen of Night (Control)      | F4        | Jaap Groot (10:52:10+TE)      | I4        | Royal Virgin (10:52:10+TE)    |
| C5        | Apeldoorn (Control)           | F5        | Queen of Night (10:52:10+TE)  | I5        | Jaap Groot (10:52:10+TE)      |

**Treatments**

The trial was conducted in factorial randomized block design, the total number of treatments combinations were fifth teen which include five tulip cultivars (Apeldoorn, Jaap Groot, Pink Impression, Royal Virgin and Queen of Night) and three fertilizer applications (water soluble composed phosphorous 10:52:10+TE, composed balanced 20:20:20+TE and control) applied in 45 plots with three replicates (Table 5). Tap water (EC 0.75) was used as a control. EC levels of compound fertilizers were prepared as 1.10 ds/m<sup>-1</sup> and pH 5.8. Soil application of compound phosphorus and balanced fertilizers diluted in water with concentrations of 3.5 grams per square meter

was applied at three different times from 25 December to 4 May (one time in winter, two time in spring), in all varieties. After fertilizer application, irrigation was carried out. The harvesting of the bulbs was done after cutting the flowers and when the leaves started to get yellow in first week of June.

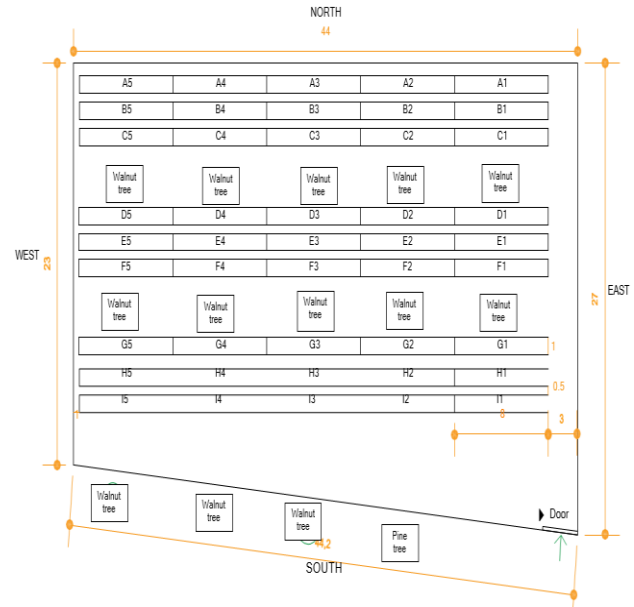


Figure 1. Trial plan shape



Figure 2. Trial area image

The observations and measurements were started to be taken when the first flower stalk appeared. First sprouting time (day), beginning of flowering time (day), end of flowering time (day), flowering

longevity (day), plant height (cm), were determined according to Salman et al. [2], bulb size (cm), bulb weight (g) according to Fayaz et al. [20] in the study.

The datas were subjected to variance analysis by using JMP statistical program and the differences between the means were indicated according to the "Tukey Test" at a 0.05 level of significance.

## RESULTS

### Growth Characteristics

•*First Sprouting Time (day)*: The data obtained between to first sprouting times from the planting of the bulbs was recorded (Table 6). According to the findings on the first sprouting time of tulips of the research, the effects of variety, fertilizer and variety-fertilizer interaction was found to be quite significant ( $p < 0.01$ ). Although the Royal Virgin variety is mid-late, it was the variety that showed the earliest emergence. This was followed by Pink Impression, Apeldoorn and Jaap Groot from the early mid varieties. Queen of Night, a late variety, was the latest variety to sprouting. The earliest sprouting was obtained from the 20:20:20+TE application.

•*Plant Height (cm)*: As a result of the evaluation of the data about plant height; the varieties, the fertilization applications and interactions were found to have statistically significant effects ( $p < 0.01$ )

(Table 6). Among the varieties, the longest plant height was recorded in late variety of Queen of Night (42.83 cm); followed by Apeldoorn (42.00 cm) and Jaap Groot (41.11 cm). In terms of fertilization treatments, the best results were obtained from 20:20:20+TE treatments and the lowest results were obtained from control. The application of 10:52:10+TE, which is a phosphorus dense fertilizer, showed lower values than the balanced fertilizer in terms of plant height.

### Flowering Characteristics

•*Beginning of Flowering Time (day)*: Data were obtained when tepal colors became visible in the flowers of 30 randomly selected plants per plot. According to data presented in Table 7 that fertilizer application was shown significant effect ( $p < 0.01$ ) at the beginning of flowering stage. Varieties had been reached this stage in between the last week of March and mid of April. Among the cultivars, Royal Virgin (115.11 days) reached the beginning of flowering the earliest, while Queen of night cultivar flowered the last (130.60 day). The application of 20:20:20+TE were extended days to from planting to flowering (121.06 day) while 10:52:10+TE application shortened the time until the beginning of flowering (120.33 days) compared to the control.

Table 6. The values of first sprouting time and plant height

| Cultivars                 | First Sprouting Time (day) |             |             |                   | Plant Height (cm)     |             |             |                   |
|---------------------------|----------------------------|-------------|-------------|-------------------|-----------------------|-------------|-------------|-------------------|
|                           | Fertilizer Treatments      |             |             | Mean of Cultivars | Fertilizer Treatments |             |             | Mean of Cultivars |
|                           | Control                    | 20:20:20+TE | 10:52:10+TE |                   | Control               | 20:20:20+TE | 10:52:10+TE |                   |
| Queen of Night            | 84.66 a                    | 84.10 a     | 84.66 a     | 84.48 a           | 41.50 g               | 43.63 b     | 43.36 c     | 42.83 a           |
| Apeldoorn                 | 67.33 c                    | 64.00 d     | 67.00 cd    | 66.11 c           | 41.10 i               | 43.66 a     | 41.23 h     | 41.99 b           |
| Pink Impression           | 53.33 e                    | 48.00 f     | 53.33 e     | 51.55 d           | 39.73 j               | 38.60 l     | 42.36 e     | 40.23 d           |
| Jaap Groot                | 73.00 b                    | 73.00 b     | 73.00 b     | 73.00 b           | 42.40 d               | 39.16 k     | 41.76 f     | 41.10 c           |
| Royal Virgin              | 48.00 g                    | 48.00 g     | 53.33 e     | 49.77 e           | 27.86 o               | 30.46 n     | 30.66 m     | 29.66 e           |
| Mean of Treatments        | 65.26 a                    | 63.42 b     | 66.26 a     |                   | 38.51 c               | 39.87 a     | 39.10 b     |                   |
| LSD (0.05)                | A:1.42                     | B:0.94      | A×B: 3.07   |                   | A:2.27                | B:1.81      | A×B: 25.84  |                   |
| Significance:             |                            |             |             |                   |                       |             |             |                   |
| Cultivars (C)             | ***                        |             |             |                   | ***                   |             |             |                   |
| Fertilizer Treatment (FT) | ***                        |             |             |                   | ***                   |             |             |                   |
| C×T                       | ***                        |             |             |                   | ***                   |             |             |                   |

A: cultivars B: fertilizer A×B: cultivars × fertilizer interaction

Table 7. The values of beginning of flowering time and end of flowering time

| Cultivars                 | Beginning of Flowering Time (day) |             |             |                   | End of Flowering Time (day) |             |             |                   |
|---------------------------|-----------------------------------|-------------|-------------|-------------------|-----------------------------|-------------|-------------|-------------------|
|                           | Fertilizer Treatments             |             |             | Mean of Cultivars | Fertilizer Treatments       |             |             | Mean of Cultivars |
|                           | Control                           | 20:20:20+TE | 10:52:10+TE |                   | Control                     | 20:20:20+TE | 10:52:10+TE |                   |
| Queen of Night            | 129.44 a                          | 131.72 a    | 130.63 a    | 130.53 a          | 150.43 a                    | 150.00 a    | 150.00 a    | 150.14 a          |
| Apeldoorn                 | 117.66 d                          | 121.00 bc   | 116.66 d    | 118.44 c          | 132.00 d                    | 135.00 c    | 133.33 cd   | 133.44 c          |
| Pink Impression           | 117.00 d                          | 121.00 bc   | 116.66 d    | 118.22 c          | 129.00 f                    | 135.33 c    | 134.33 cd   | 132.88 c          |
| Jaap Groot                | 122.33 b                          | 122.33 b    | 120.00 c    | 121.55 b          | 139.66 b                    | 132.66 cd   | 135.00 c    | 135.77 b          |
| Royal Virgin              | 116.66 d                          | 111.00 e    | 117.66 d    | 115.11 d          | 139.33 b                    | 134.66 cd   | 135.00 c    | 136.33 b          |
| Mean of Treatments        | 120.92 ab                         | 121.06 a    | 120.33 b    |                   | 138.08 a                    | 137.53 a    | 137.53 a    |                   |
| LSD (0.05)                | A:1.09                            | B:0.72      | A×B: 2.35   |                   | A:1.25                      | B:0.83      | A×B:2.70    |                   |
| Significance              |                                   |             |             |                   |                             |             |             |                   |
| Cultivars (C)             | ***                               |             |             |                   | ***                         |             |             |                   |
| Fertilizer Treatment (FT) | ***                               |             |             |                   | n.s.                        |             |             |                   |
| C×T                       | ***                               |             |             |                   | ***                         |             |             |                   |

A: cultivars B: fertilizer A×B: cultivars × fertilizer interaction

•*End of Flowering Time (day)*: The data obtained from the end of the flowering of tulip varieties are given in Table 7. Data shows that fertilizer does not effect on the end date of flowering time. However, at the end of flowering the varieties showed differences. According to the varieties from the middle of April to the beginning of May was flowering ended.

( $p < 0.001$ ) affected flowering longevity. The shortest flowering period was found in Jaap Groot variety (14.22 days), while the longest flowering period was found in Royal Virgin variety (21.22 days). Varieties subjected to 10:52:10+TE treatment had the longest flowering period (17.20 days).

Table 8. The values of flowering longevity

| Cultivars                 | Fertilizer Treatments |             |             | Mean of Cultivars |
|---------------------------|-----------------------|-------------|-------------|-------------------|
|                           | Control               | 20:20:20+TE | 10:52:10+TE |                   |
| Queen of Night            | 20.49 ab              | 19.00 b     | 19.33 b     | 19.60 b           |
| Apeldoorn                 | 15.33 c               | 14.00 cde   | 15.66 c     | 15.00 c           |
| Pink Impression           | 13.33 de              | 15.33 c     | 15.33 c     | 14.66 c           |
| Jaap Groot                | 15.00 cd              | 12.66 e     | 15.00 cd    | 14.22 c           |
| Royal Virgin              | 21.66 a               | 21.33 a     | 20.66 ab    | 21.22 a           |
| Mean of Treatments        | 17.16 a               | 16.46 b     | 17.20 a     |                   |
| LSD (0.05)                | A:0.87                | B:0.57      | A×B: 1.87   |                   |
| Significance              |                       |             |             |                   |
| Cultivars (C)             | ***                   |             |             |                   |
| Fertilizer Treatment (FT) | ***                   |             |             |                   |
| C×T                       | ***                   |             |             |                   |

A: cultivars B: fertilizer A×B: cultivars × fertilizer interaction

•*Flowering Longevity (day)*: The effects of fertilizer applications on the flowering longevity are represented in Table 8. Cultivars, fertilizer and the cultivars × fertilizer interaction significantly

**Bulb Characteristics**

•*Bulb Diameter (cm)*: The effects of the fertilization and variety × fertilization on bulb diameter were statistically insignificant (Table 9). The maximum diameter of bulbs was in the 20:20:20+TE treatment (3.21) while the minimum diameter of bulbs was obtained from control treatment (3.17 cm).

•*Bulb Dry Weight (g)*: The effects of the fertilizer application and variety × fertilizer interaction on bulb weight were statistically insignificant, while the effect of varieties was statistically significant ( $p < 0.01$ ) (Table 9). The greatest bulb weight was obtained from the 20:20:20+TE fertilization application (14.03 g), whereas the lowest bulb weight was recorded in 10:52:10+TE (13.84 g) When the bulb weights of the varieties were examined, Apeldoorn was found to heaviest have a bulb weight (18.30 g).

Table 9. The values of bulb diameter and bulb weight

| Cultivars                 | Bulb Diameter (cm)    |             |             | Mean of Cultivars | Bulb Weight (g)       |             |             | Mean of Cultivars |
|---------------------------|-----------------------|-------------|-------------|-------------------|-----------------------|-------------|-------------|-------------------|
|                           | Fertilizer Treatments |             |             |                   | Fertilizer Treatments |             |             |                   |
|                           | Control               | 20:20:20+TE | 10:52:10+TE |                   | Control               | 20:20:20+TE | 10:52:10+TE |                   |
| Queen of Night            | 2.58 e                | 2.54 e      | 2.58 e      | 2.57 d            | 8.94 f                | 8.11 f      | 8.44 f      | 8.49 d            |
| Apeldoorn                 | 3.58 a                | 3.48 abcd   | 3.65 a      | 3.57 a            | 17.93 ab              | 17.73 abc   | 19.23 a     | 18.30 a           |
| Pink Impression           | 3.26 bcd              | 3.41 abcd   | 3.32 abcd   | 3.31 b            | 15.85 abcde           | 16.87 abcd  | 15.53 bcde  | 16.08 b           |
| Jaap Groot                | 3.31                  | 3.54 ab     | 3.41 abcd   | 3.42 ab           | 14.07 cde             | 14.07 cde   | 12.91 e     | 13.68 c           |
| Royal Virgin              | 3.12 cd               | 3.10 d      | 3.06 d      | 3.09 c            | 13.22 de              | 13.40 de    | 13.12 e     | 13.24 c           |
| Mean of Treatments        | 3.17 a                | 3.21 a      | 3.19 a      |                   | 14.00 a               | 14.03 a     | 13.84 a     |                   |
| LSD (0.05)                | A:0.16                | B:0.11      | A×B: 0.35   |                   | A:1.79                | B:1.20      | A×B: 3.87   |                   |
| Significance:             |                       |             |             |                   |                       |             |             |                   |
| Cultivars (C)             | **                    |             |             |                   | **                    |             |             |                   |
| Fertilizer Treatment (FT) | n.s                   |             |             |                   | n.s                   |             |             |                   |
| C×T                       | n.s                   |             |             |                   | n.s                   |             |             |                   |

A: cultivars B: fertilizer A×B: cultivars × fertilizer interaction

Table 10. The values of number of bulblets per plant

| Cultivars                 | Fertilizer Treatments |             |             | Mean of Cultivars |
|---------------------------|-----------------------|-------------|-------------|-------------------|
|                           | Control               | 20:20:20+TE | 10:52:10+TE |                   |
| Queen of Night            | 6.13                  | 6.16        | 5.83        | 5.73 b            |
| Apeldoorn                 | 7.00                  | 6.50        | 6.60        | 6.70 a            |
| Pink Impression           | 4.53                  | 4.90        | 4.83        | 4.75 c            |
| Jaap Groot                | 3.23                  | 3.76        | 3.53        | 3.51 d            |
| Royal Virgin              | 7.1                   | 5.40        | 6.90        | 6.46 b            |
| Mean of Treatments        | 5.37 a                | 5.58 a      | 5.53 a      |                   |
| LSD (0.05)                | A:0.71                | B:0.47      | A×B: 1.54   |                   |
| Significance              |                       |             |             |                   |
| Cultivars (C)             | **                    |             |             |                   |
| Fertilizer Treatment (FT) | n.s                   |             |             |                   |
| C×T                       | n.s                   |             |             |                   |

A: cultivars B: fertilizer A×B: cultivars × fertilizer interaction

•*Bulb Yield (number/plot<sup>-1</sup>)*: According to the results of statistical analysis, varieties, fertilizer application and effects between the varieties × fertilizer application were shown a significant difference ( $p < 0.01$ ) (Table 11). The highest bulb yield value was found to be 1117.66 number/plot<sup>-1</sup> in Royal Virgin and Jaap Groot variety had the lowest bulb yield (359.66 number/plot<sup>-1</sup>). The highest bulb yield was obtained with 770.00 number/plot<sup>-1</sup> from 20:20:20+TE treatment. The minimum bulb yield per plot was found in the control treatment (563.40 number/plot<sup>-1</sup>).

•*Number of Bulblets/Plant<sup>-1</sup>*: The highest bulblets number were obtained with 5.58 number /plant<sup>-1</sup>

from 20:20:20 treatment. The minimum bulblets per plant was found in the control treatment (5.37 number/plant<sup>-1</sup>). According to varieties average the highest bulblets number were 6.70 number/plant<sup>-1</sup> of Apeldoorn. This was followed up with the 6.46 and 5.73 number/plants<sup>-1</sup> by Royal Virgin and Queen of Night varieties, respectively.

Table 11. The values of bulb yield number per plots

| Cultivars                 | Fertilizer Treatments |              |              | Mean of Cultivars |
|---------------------------|-----------------------|--------------|--------------|-------------------|
|                           | Control               | 20:20:20+ TE | 10:52:10+ TE |                   |
| Queen of Night            | 560.00 g              | 360.00 i     | 550.00 g     | 490.00 d          |
| Apeldoorn                 | 715.00 e              | 810.00 c     | 760.00 d     | 761.66 b          |
| Pink Impression           | 536.00 g              | 656.00 f     | 475.00 h     | 555.66 c          |
| Jaap Groot                | 200.00 j              | 491.00 h     | 388.00 i     | 359.66 e          |
| Royal Virgin              | 806.00 c              | 1533.00 a    | 1014.00 b    | 1117.66 a         |
| Mean of Treatments        | 563.40 c              | 770.00 a     | 637.40 b     |                   |
| Significance:             |                       |              |              |                   |
| Cultivars (C)             | **                    |              |              |                   |
| Fertilizer Treatment (FT) | **                    |              |              |                   |
| C×T                       | **                    |              |              |                   |

## DISCUSSION

Salman et al. [21] were conducted a study to determine the effects of compound fertilizers on the flower and bulb quality of tulip plants. For this purpose, they were used to eight different *Tulipa gesneriana* commercial varieties ('Negrita', 'Sogetsu', 'Menton', 'Oxford Elit', 'Claudia', 'Inzell', 'Leen David Mark' and 'Queen of the Night') and were planted in an open field. NPK 15-15-15 was applied before planting. Ammonium nitrate (NH<sub>4</sub>NO<sub>3</sub> 33-0-0) applications were applied in two different periods; before flowering and during flowering. No fertilizer was used in the control plots. According to the results obtained by the researchers, the average values of the sprouting time were between 23.7 and 36.3 days. In another study, Salman et al. [2] were investigated the bulb and floristic properties of biofertilizer applications in different tulips varieties. According to the data obtained from the research; The first sprouting was occurred 49-72 days after the planting date, flowering longevity was between 13 and 20 days, plant height was between 33.8-44.6 cm. While they were found the average values of the duration from planting to flowering varied between 94.3 to 123.3 day. In our study were found the average values of the sprouting time between 48.88 and 83.28 days, days to flowering was 120.33-121.06 days. flowering longevity varied between 14-21 days. In our study and between the two different studies of Salman et al., although there are similarities between the lower and upper values it is thought that this difference may be because of some different varieties used, growing area, planting time

and climatic differences. Different fertilizer and rates can also have a significant impact on results.

Altaee and Alsawaf [22] were found that their study the addition of nitrogen fertilizer by resulted in a significant increase in plant height, whereas potassium fertilizer the effect in increasing plant height had no significant in tulips. Similarly, in our study, balanced fertilizer with higher nitrogen content gave higher values in terms of plant height than fertilizer with higher potassium content.

Khan et al. [6] were carried out to the effect of nutrients on growth, flower quality and bulb production of tulip cv. 'Apeldoorn'. Treatments were comprised as three levels of nitrogen (0, 75 and 150 kg.ha<sup>-1</sup>), two levels each of phosphorus (0 and 50 kg.ha<sup>-1</sup>), potassium (0 and 50 kg.ha<sup>-1</sup>) and zinc (0 and 5 kg.ha<sup>-1</sup>). Nitrogen application was caused a significant increase in the number of days to flowering, while phosphorus, potassium and zinc were caused a significant decrease in the number of days to flowering compared to the control. The results obtained from our study are in agreement with the findings by Khan et al. [6].

Effects of different nitrogen levels (0, 15, 20, 25 and 30 g) alone and in combination with fixed doses of phosphorus and potassium on the growth of another bulbous plant, *Dahlia pinnata*, has been examined. Fertilizer applications significantly affected the days until flowering, number of flowers/plants, plant height and number of flowers. While maximum days to flower (123 day) with 30 g N, minimum days to flower (91 day) was recorded with 15 g P. Maximum number of flowers with per plant (13 number) and maximum plant height (106.3 cm) was observed in plants fertilization with 25 g N+ 15 g P+15 g K [26]. Similarly in our study, increasing nitrogen doses also extended the time from planting to flowering and plant height.

Bhattacharjee [23] stated that increasing level of nitrogen increased corm weight, size and number of cormels per plot in gladiolus. On the other hand, the control plants had the minimum corm weight, corm diameter and number of corms per plant. Likewise, Basnet et al. [24] were studied the effects of individually application different doses of nitrogen (0, 50, 100, 150 kg) and phosphorus (0, 50, 100 kg) fertilizers on the growth and development of gladiolus. They found that increasing nitrogen and phosphorus doses were more effective on onion diameter, weight and yield. In terms of bulb quality characteristics, the highest nitrogen dose gave better results than the highest phosphorus dose. Likewise in our study, high nitrogen dose was more effective than high phosphorus dose on the bulblets and bulbs yield. Pant [25] was conducted a study to evaluate the effect

of different doses of nitrogen and phosphorus on gladiolus corm and cormel development in gladiolus (*Gladiolus* sp.) cv. American Beauty. While low nitrogen dose (50 kg/ha) gave the highest cormel yield (17.71 g/plant), higher nitrogen dose (100 and 150 kg/ha) fertilizer provided the lowest cormel yield. Variable doses of phosphorus did not have a significant effect on corm diameter, but had a significant effect on corm yield per plant. Higher doses of phosphorus fertilizer (50 and 100 kg/ha) provided the highest yield compared to the control. Phosphorus at 100 kg/ha and nitrogen at 0 kg/ha provided the highest cormel weight (25 g/plant), while nitrogen at 150 kg/ha and phosphorus at 0 kg/ha produced the lowest cormel weight (1.95 g/plant) produced. The interaction effect shows that cormel yield responds better to higher levels of phosphorus combined with lower nitrogen levels. Ismael et al. [27] were investigated the effects of organic farmyard manure (O0=0, O1=200, O2=400 g/m<sup>2</sup>) N:P:K: 15:15:15 fertilizer (F0=0, F1=80, F2=120 g/m<sup>2</sup>) application on floristic properties and bulb yields in commercial tulip cultivar in the Tikrit district. The flowering and bulb quality traits were significantly affected by the addition of farmyard manure and NPK to the soil. Farmyard fertilizer applications increased spike and flower diameters and decreased flowering days compared to NPK fertilizer applications. NPK applications increased the weight and diameter of the bulbs. In our study, although fertilizer applications were increased bulb weight and bulb diameter, it was not found to be statistically significant.

### CONCLUSION

As a result of this research that fertilizer applications containing NPK has been observed that the effects of tulips (*Tulipa gesneriana* Linn.) on growth, flowering and bulb yield parameters are significant. Although the importance of organic fertilization is increasing as an alternative to chemical fertilization in ornamental plants, studies have reported that it is more appropriate to use them together rather than using them individually. In this study, it was tried to determine the most appropriate chemical fertilizer dose for the cultivation of tulip in its natural environment. 10:52:10+TE can be recommended for flowering properties, 20:20:20+TE fertilizer can be recommended for onion quality properties. In line with these results, their use together with organic fertilizers can be tried in future studies.

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### REFERENCES

- Gani, G., Lone, R.A., Rather, Z.A., Nazki, I.T., Wani, M.A. 2019. Effect of nutrient sprays and planting depths on growth and bulb production of tulips. *Journal of Experimental Agriculture International*, 30(2):1-8, Article no. JEAI.46261 ISSN:2457-0591 (Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606.
- Salman, A., Budak, B., Wallace, M.Y. 2020. The effect of bio fertilizer application on bulb yield and floristic properties of different commercial tulip varieties. *Bursa Uludağ Üniversitesi Ziraat Fakültesi Dergisi* 34(Özel Sayı):249-258.
- Li, J., Price, M., Mei Su, D., Zhang, Z., Yu, Y., Fen Xie, D., Dong Zhou, S., Fen Gao, X. 2021. Phylogeny and comparative analysis for the plastid genomes of five tulipa (Liliaceae). *Hindawi BioMed Research International*, Vol.2021 ID.6648429, <https://doi.org/10.1155/2021/6648429>.
- Khaleghi, Alireza, Ali Khadivi, Zonneveld, B JM. 2018. Morphological variations among and within species of wild tulip (*Tulipa* L.) from Iran. *Genetic Resources and Crop Evolution* 65(2018):2241-2266.
- Raven, S. 2020. The history of tulip. *The History of the Tulip* | Sarah Raven (Online August 5, 2024).
- Khan, F.U., Jhon, A.Q., Khan, F.A., Mir, M.M. 2006. Effect of NPK and Zn on growth, flowering and bulb production in tulip under polyhouse conditions in Kashmir. *J. Hort. Sci.* 1(2):129-134.
- İzgi Saraç, Y., Balkaya, A., Deligöz, İ. 2021. Lale. *Süs bitkileri ıslahı (Türler)*, Gece Kitaplığı, s:373-414.
- Karlsson, M. 2024. The Dutch tulip bulb industry in times of change. Will the Netherlands be able to continue supplying the world with bulbs? Bachelor's thesis, Swedish University of Agricultural Sciences, SLU Department of people and society department of biosystems and technology, Degree of Bachelor of Science in Horticultural Management Alnarp, SLU 2024.
- Anonymous, 2021. *Plant. Peyzaj ve süs bitkisi dergisi*. <https://www.plantdergisi.com/sus->



- bitkileri-uretimi-2020-yilinda-azaldi.html (Online August 5, 2024).
10. Navor, T.G., Gonzalez, G.A., Tellez, L.T. 2021. Cerium (Ce) affects the phenological cycle and the quality of tulip (*Tulipa gesneriana* L.). *Agro Productividad*, April, 2021. 14(4):59-63.
  11. Theron, K.I., Jacobs, G. 1996. Changes in carbon hydrate composition of the different bulb components of *Nerine bowdenii* W.Watson (Amaryllidaceae). *J. Am. Soc. Hort. Sci.* 121:343-346.
  12. Scott, P. 2008. Mineral nutrition of plants. In: *Physiology and Behavior of Plants*, John Wiley and Sons, Ltd. pp:75-87.
  13. Boeckmann, C. 2021. Growing tulips. How to plant, grow and care for tulips. <https://www.almanac.com/plant/tulips#:~:text=soil%20must%20be%20well%2ddraining,a%20large%20enough%20planting%20site>.
  14. Wassink, E.C. 1965. Light intensity effects in growth and development of tulips in comparison with those in gladiolus. *Mede. Landb Hoogeschool, Wageningen*, 65(15):1-21.
  15. Niedziela Jr, C.E., Nelson, P.V., Dickey, D.A. 2015. Growth, development, and mineral nutrient accumulation and distribution in tulip from planting through post anthesis shoot senescence. *International Journal of Agronomy*, 2015(1), 341287.
  16. Anonymous, 2024-a. ASIST 20-20-20+TE Ec Fertilizer <https://growway.com.tr/urunler/asist-20-20-20-te> (Online August 10, 2024).
  17. Anonymous, 2024-b. LIBRO 10-52-10+TE. Astranova <https://www.astranova.com.tr/urun/libro-10-52-10te> (Online August 12, 2024).
  18. Bankar, G.J., Mukhopadhyay, A. 1990. Effect of NPK on growth and flowering in tuberose cv. Double. *Indian Journal of Horticulture* 47(1):120-126
  19. Karaca, C., Büyüktaş, D., Baştuğ, R., Aydınşakir, K., Tekelioğlu, B. 2017. Antalya koşullarında kıyas bitki su tüketiminin alansal ve zamansal dağılımının belirlenmesi. *Derim*, 34(2), 158-171. <https://doi.org/10.16882/derim.2017.292134>.
  20. Fayaz, K., Khan, F.U., Nazki, I. T., Nisa, M. U., Verty, P., Singh, V.K. 2018. Effect of Integrated Nutrient Application on Yield and Bulb Production Characters in Tulip (*Tulipa gesneriana* L.) cv. “Red Beauty”. *International Journal of Current Microbiology and Applied Sciences*, ISSN:2319-7692.
  21. Salman, A., Wallace, M.Y., Zeybekoğlu, E., Alp, Ş., Özzambak, E. 2018. The effect of fertilizer application on the bulb yields and floristic traits on some tulips cultivars. *International Conference on Multidisciplinary, Science, Engineering and Technology (IMESET'18 Dubai)*, Oct 25-27, 2018, Dubai.
  22. Altae, A.Y., Alsawaf, M.D. 2020. Effect of levels of chemical fertilizer and gibberellic acid in the growth and flowering of tulip. *Eco. Env. & Cons*, 26(1):67-72, Copyright@ EM International ISSN 0971-765X.
  23. Bhattacharjee, S.K. 1981. Influence of nitrogen, phosphorus and potassium fertilization on flowering and corm production in gladiolus. *Singapore J. Primary Industries*, 9(1):23-27.
  24. Basnet, M., Shakya, S.M., Pant, S.S. 2018. Effect of different nitrogen and phosphorous doses on gladiolus yield in Ilam, Nepal. *Nepalese Journal of Agricultural Sciences*, Vol.17, ISSN:2091-042X; e ISSN:2091-0428.
  25. Pant, S.S. 2005. Effect of different doses of nitrogen and phosphorus on the corm and cormel development of gladiolus (*Gladiolus* sp.) cv. American beauty. *Journal of the Institute of Agriculture and Animal Science*, 26, 153-157.
  26. Khan, G.A., Muhammad Sajid, M.S., Zubair, M., Noor-ul-Amin, N.U.A. 2007. Response of Dahlia pinnata to different levels of nitrogen alone and in combination with constant doses of phosphorus and potassium. *Sarhad Journal of Agriculture*, 23(3):571-576, ref.8
  27. Ismael, B.S., Kamil, A.N., Hashim, N.N., Dudkiewicz, M. 2023. Influence of organic manure and chemical fertilization on flowering and yield bulbs of tulip frenged, *Tulipa gesneriana* L. In *IOP Conference Series: Earth and Environmental Science* 1213(1):12-27, IOP Publishing.