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Determination of Promising Tulip Genotypes Belonging to Different *Tulipa* Species with Pedigree Selection Method

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ABSTRACT

Tulip (*Tulipa* spp.), belonging to the Liliaceae family, is a bulbous ornamental plant with approximately 280 natural species and 4000 varieties. The aim of this study was to select the most promising genotypes of different tulip (*Tulipa* spp.) species grown in Turkey with the objective of selection breeding and developing homogenous pure lines of these tulip genotypes (suitable for use as park and landscape plants, possessing traits like large flower, thick stem, long flower life, etc.). The study consisted of 74 tulip genotypes belonging to different *Tulipa* species. The weighted ranking method was used to select superior tulip genotypes with pedigree selection breeding. Local genotypes scored between 380 and 865 points according to the weighted ranking methods. In addition, tulip genotypes were grouped into classes based on the selection criteria, and the classes and distribution frequencies of tulip genotypes were identified. The top 10 most promising tulip genotypes were selected for evaluation in the variety breeding program. The first three highest-scoring genotypes were G2 (865 point), G3 (790 point), and G1 (785 point) of *T. agenensis* species, respectively.

Keywords**:** Tulip, genetic resources, selection, frequency distribution, diversity, weighted ranking methods

Introduction

The breeding of high-quality new varieties in the ornamental plant sector is accomplished through the use of modern breeding techniques. The breeding studies in ornamental plants were first initiated by the private sector in the middle of the 19th century. The breeding programs were later carried out by institutions, universities, and research stations in ornamental plants for different purposes (Balkaya et al., 2021; Lal et al., 2022). The objectives of variety breeding studies can be summarized as resistance to biotic and abiotic stress conditions, gaining qualified fragrance characteristics, introducing new colors, morphological changes in plant and flower structure, differences in flowering time, longevity, and post-harvest performance (Horn and Peterson 2002; Gülbağ 2015; Balkaya et al., 2021).

Wild species of the natural flora, or plant species that are genetic resources used by growers, are disappearing over time due to genetic erosion. The extensive use of hybrid varieties, which have high productivity potential, has recently led to the extinction of many wild forms and local varieties in recent years. Sustainability in crop production can only be achieved through the conservation of wild species and local varieties (Akgün et al., 1998). Many of the traits that are directly affected by natural and artificial selection usually have quantitative variation. The studies on quantitative traits are of great importance for the economic use of germplasm resources. Therefore, agronomic traits and their genetic characteristics should be investigated concurrently while evaluating the genetic resources in breeding programs (Escribano et al., 1998).

The pre-breeding stage in plant breeding studies is to maintain heterogeneous and rich genetic diversity in the gene pools. Thus, qualified genetic materials are constructed with genetic resources of heterogeneous structure having different characteristics from one another (Balkaya et al., 2021). The structure and genetic diversity of natural populations are affected by many factors, such as the diversity of habitat where the genotypes are located, plant fertilization biology, distribution of propagating materials (seeds and other vegetative plants), plant life cycle, population size, gene flow, and mutation rate (Ballesteros-Mejia et al., 2016). The wild forms and local cultivars are important genitors in transferring new traits to the cultivated crops. Identification of the variation present in populations is very important for the utilization of genetic resources in accordance with the targeted objectives in breeding studies (Tan, 2005). Understanding the structure and genetic diversity of the population is crucial for plant breeders to develop new varieties with agriculturally prominent and desirable traits by using valuable wild germplasm. The highest genetic diversities, especially in the traits related to flowering potential, flowering times, and flower structures have been obtained in the tulip breeding programs (İzgi Saraç et al., 2021).

Türkiye is a rich country with tulip genetic resources. This genetic diversity is very important, especially for the breeding of new commercial tulip varieties. Selection is one of the most important factors that may change the population structure in tulip breeding. The original gene frequency of a population is altered through selection methods and therefore, some genotypes are decreased or increased over time (Balkaya et al., 2011). The shortening of the breeding process with pre-selection is important in tulip breeding. The selection made in the early period when the bulbs do not have the ability to flower is the pre-selection. The aim of pre-selection is to make early selection in terms of bulb production, cut flower and disease resistance (İzgi Saraç et al., 2021). The breeders save labor, time, and space with a good pre-selection. Plant height, leaf and flower stalk strength, position and number of leaves, ratio between flower and leaf number, earliness, flower appearance, flower life and flower size are highly important in the selection of tulip genotypes. In addition, plant growth habit, stem thickness, and leaf appearance are other important traits (İzgi Saraç et al., 2010). The variety breeding studies in tulip species in Türkiye are insufficient compared to those in other plant species. The tulip varieties, namely Arda, Muş1071 and Kumru, were developed by population breeding within the scope of the project titled "Variety development in tulip (*Tulipa* spp.) and hyacinth (*Hyacinthus* spp.) species in Türkiye and introduction of new varieties to the ornamental sector" and these were registered as the first domestic tulip varieties in Türkiye (İzgi Saraç et al., 2021). However, these varieties with their existing characteristics cannot compete with the foreign F_1 varieties.

The purpose of this study was to select promising genotypes that are suitable for use in parks and landscapes, covering the area, having large flowers, thick stems, and long flower life, earliness and developing pure lines belonging to these tulip genotypes. Therefore, the selection breeding was carried out by the "Pedigree selection breeding" method in the available tulip gene pool.

Materials and Methods

The bulbs of 71 tulip genotypes, which were determined by Izgi Saraç et al., (2010) according to their adaptability and flower characteristics among the genetic sources of 114 tulip genotypes previously collected from the flora of Turkey, were used in the study (Table 1). The first local tulip varieties (Arda, Muş1071 and Kumru) developed by the Black Sea Agricultural Research Institute were also included as control (Table 1). The tulip bulbs were planted on January 15, 2018. Before planting, 30 bulbs of each tulip genotype were soaked in a 1% Captan + 0.1% Antracol® solution for 30 minutes to prevent fungal diseases. Then soil, peat, and perlite were mixed in a ratio of 1:1:1 and placed in plastic containers. Fifteen bulbs were planted in each plastic container (width, 37 cm; length, 56 cm, and height 24 cm dimensions) in the open field condition for each genotype. Standard fertilization and irrigation practices were applied for all genotypes.

In this study, pedigree selection method was used in tulip breeding. The flower and the other plant traits data were evaluated by the modified weighted ranked (WR) method ((İzgi Saraç et al., 2021). The WR method is a tool commonly used in statistical analyses. This method is known as "Tartılı derecelendirme" in Turkish and almost exclusively used in the studies with multivariate data generated in horticultural research (Balkaya and Yanmaz 2005; Balkaya and Ergün 2008; Çakır et al., 2019). Ten plants from each tulip genotype were examined for the selection criteria. The evaluations of the selection criteria are given below.

a. Plant stance: Classified as upright, semi-upright, and lateral.

b. Plant height (cm): The distance from the soil level to the tip of the tepals was measured using a tape measure during the full flowering period of the plant.

c. Stem thickness (mm): The thickness of the middle part of the stem was measured using a digital caliper.

d. Flower longevity (days): The flowering period of the plant was determined in the field as the time difference (days) between the first flowering of the plant and the wilting of the flower petals.

e. Flower size (mm): Flower size was measured at the widest point of the flower with the help of a digital caliper when the plant was in the flowering stage.

f. Diameter of the main bulb (cm): The circumference of the bulb was measured using a tape measure.

g. Number of bulblet formed from the mother bulb (number): The number of bulblet formed from the mother bulb was counted.

Class values of selection criteria, Class Scores (CS) and Relative Scores (RS) were assigned to each tulip genotypes (Table 2). The total points of tulip genotypes were calculated by summing Class Scores (CS) and multiplied by Relative Scores (RS). At the end of this study, genotypes that were above the average score were selected as the superior tulip genotypes. In addition, the tulip genotypes were classified with respect to the detailed traits for the distribution frequencies (%).

Results and Discussion

The weighted ranking scores obtained by the selection of tulip genotypes are given in Table 3. The total scores calculated by multiplying the class and relative scores of tulip genotypes for each trait emphasized in the selection are also shown in Table 3. Accordingly, the scores of all the tulip genotypes ranged from 380 (G52) to 865 (G2) points. The three highest scoring genotypes were G2 (865 point), G3 (790 point) and G1 (785 point) which belong to *T. agenensis* species (Figure1), followed by G72 (750 point), G14 (745 point) and G18 (740 point), respectively (Table 3). The majority of the high-scoring tulip genotypes had the highest scores for all traits emphasized in the selection. The weighted ranking scores of 49 tulip genotypes were higher than the average score of all genotypes (513 points). Since the number of genotypes selected in the selection process was high, the top 10 most promising tulip genotypes with the highest scores were selected as a parental for the hybrid breeding program.

Selection technique is an important mechanism that modifies the structure of the original population in breeding studies. The gene frequency of the current population changes in accordance with the selection breeding aim, thus affecting the distribution of all genetic materials (Balkaya et al., 2011). Tulip genotypes were grouped into classes according to the weighted ranking method and the classes and distribution frequencies of tulip genotypes were determined in detail. The results of grouping demonstrated that 29 of the tulip genotypes were upright, 41 of them were medium, and 4 of them (G23, G27, G28, G43) had lateral plant habitus (Table 4). The tulip genotypes should be medium and erect in parks and landscaping and as potted plants, and the tulip genotypes should be erect in cut flowers according to consumer demands. The majority of the studied tulip genotypes had these characteristics.

The tulip (*Tulipa* spp.) genotypes displayed high variation and phenotypic diversity for plant height trait in this study. The plant height of 40.5% of the genotypes were grouped as moderately short, 25.7% as short, 25.7% as medium, 5.4% as tall, and 2.7% as very tall (Table 5). The plant height of more than 50% of the tulip genotypes evaluated in the study was between 10 cm and 25 cm. The plant height of *Tulipa mongolica* species in China was determined to range from 10 cm to 25 cm (Zhao, 2003). İzgi Saraç (2015) also reported that the plant height of 61 tulip genotypes varied between 10 cm and 25 cm. The results present study were similar with these findings.

The stem thickness in tulip genotypes is an important selection criterion that is directly correlated with the upright stance of the plant and its resistance to breakage ((İzgi Saraç et al., 2021). This trait is desired trait for the development of new varieties by the tulip breeders. More than half of the genotypes (52.5%) had a medium stem thickness and 39.2% had a thin stem thickness (Table 6). Moreover, the flowering life span of tulip (*Tulipa* spp.) genotypes indicated that 6.8% of the tulips were in the long, 47.3% in the medium, and 44.6% in the short flower longevity group (Table 7). Half of the tulip genotypes evaluated in the study had a medium flower longevity characteristic, which was considered significant. The flower longevity of tulip varieties varied between 6 and 22 days (İzgi Saraç et al., 2021). Breeders evaluate tulip plants with a long flowering period with respect to their vase longevity and select the genotypes with long vase longevity (Van der Meulen et al., 1997). In terms of flower size, 39.1% of the tulip genotypes had small flowers, 33.9% had medium flowers, 18.9% had very large flowers and 8.1% had large flowers (Table 8). The flower size is a considerably important trait of tulip plants because it enables them to visually stand out. The tulip genotypes in present study showed considerable phenotypic variation and the selected genotypes showed stand out with respect to their flower size.

The majority of the tulip genotypes (56.8 %) were in the medium bulb diameter group as targeted in the selection study (Table 9). Four tulip genotypes with the desired very large bulb diameter were identified. Two of the very large genotypes were local tulip varieties. The size of 33.8% of the tulip genotypes was between 8 cm and 12 cm. Moreover, three tulip genotypes with small bulb diameters were also recorded (Table 9). According to the number of bulbs formed from the mother bulb of tulip genotypes, 55.4% of the genotypes were in the "low" group (between 3 and 4 pieces) and 18.9% were in the "very low" group (less than 2 pieces) (Table 10). Straathof et al., (1997) determined the annual increase in the diameter of the mother bulb and the number of bulbs in a pedigree selection test for the production of tulip bulbs. The researchers reported that a preliminary selection based on bulb production can be carried out by measuring the annual increase in the diameter of the mother bulb and the number of bulbs. This indicates that the number of bulbs is a very important criterion for selection breeding. The results revealed that the G1 and G2 genotypes of *T. agenensis*, which are in the 'very good' group, are the most promising tulip genotypes from the selection perspective.

Conclusions

The variety breeding studies in Türkiye, especially in tulip species among ornamental plants, are quite limited compared to other plant species. All the hybrid tulip varieties used in cultivation are imported from other countries. Therefore, the dependence on foreign countries for tulip bulbs is continuously increasing. Despite the favorable ecological conditions of Türkiye for bulbous plants, importing tulip bulbs is not an acceptable situation. However, private sector and/or public institutions, organizations, and universities do not have short- or long-term comprehensively breeding programs for the development of domestic hybrid tulip varieties. This study was carried out on tulip variety breeding. The pedigree selection method was used in selection breeding.

In this study, the tulip genotypes collected from different locations in Türkiye were distributed into frequency groups based on the selection criteria. Thus, tulip breeders will be able to easily select genotypes suitable for different breeding programs. The results of the study will contribute to the development of new hybrid tulip varieties, and evaluation of local tulip genotypes with different qualities in accordance with the objectives of the targeted variety breeding programs in the future.

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G1 G3 G2

Figure 1. The flower appearance of selected promising tulip genotypes in this study. (Original)

Table 1. Code, accession numbers and, scientific name, origins of the tulip (*Tulipa* spp.) genotypes.

Genotype Code	Accession No	Scientific Name	Origin
G1	248 05-04	*Tulipa agenensis* DC. (4 genotypes)	Amasya
G2	104 05-03		Amasya
G3	252 27-01		Gaziantep
G4	305 35-05		İzmir
G5	118 42-09	*Tulipa armena* Boiss. (30 genotypes)	Konya
G6	129 38-03		Kayseri
G7	124 66-02		Yozgat
G8	237 42-02		Konya
G9	125 38-01		Kayseri
G10	116 42-07		Konya
G11	121 01-02		Adana
G12	223 44-05		Malatya
G13	123 66-01		Yozgat
G14	401 09-01		Aydın
G15	239 44-02		Malatya
G16	245 26-03		Eskişehir
G17	402 60-01		Tokat
G18	316 04-02		Ağrı
G19	217 35-02		İzmir
G20	109 42-04		Konya
G21	250 21-02		Diyarbakır
G22	315 04-01		Ağrı
G23	243 26-04		Eskişehir
G24	119 70-01		Karaman
G25	236 69-01		Bayburt
G26	203 24-02		Erzincan
G27	127 38-04		Kayseri
G28	128 38-05		Kayseri
G29	202 46-01		Kahramanmaraş
G30	103 05-05		Amasya
G31	211 46-01		Kahramanmaraş
G32	107 42-07		Konya
G33	225 58-01		Sivas
G34	103 05-02		Amasya
G35	218 48-04	*Tulipa saxatilis* Sieber (1 genotype)	Muğla

Continuing table 1

Genotype Code	Accession No	Scientific Name	Origin
G36	115 42-06	*Tulipa pulchella* (Regel) Baker (4 genotypes)	Konya
G37	110 68-01		Aksaray
G38	117 42-08		Konya
G39	310 10-04		Balıkesir
G40	220 65-10	*Tulipa humilis* Herb. (1 genotype)	Van
G41	230 10-02	*Tulipa sylvestris* L. (2 genotypes)	Balıkesir
G42	235 11-01		Bilecik
G43	228 06-03	*Tulipa sintenisii* Baker (3 genotypes)	Ankara
G44	304 27-01		Gaziantep
G45	313 49-01		Muş
G46	311 65-01	*Tulipa julia* C. Koch (8 genotypes)	Van
G47	301 63-01		Şanlıurfa
G48	212 65-03		Van
G49	129 38-06		Kayseri
G50	319 08-02		Artvin
G51	209 62-01		Tunceli
G52	221 65-04		Van
G53	301 63-01		Şanlıurfa
G54	240 59-01	*Tulipa undilatifolia* B. (1 genotype)	Tekirdağ
G55	101 07-05	*Tulipa orphanidea* Boiss.ex Heldr (12 genotypes)	Antalya
G56	224 34-01		İstanbul
G57	306 35-06		İzmir
G58	216 45-01		Manisa
G59	242 45-02		Manisa
G60	232 22-01		Edirne
G61	102 48-01		Muğla
G62	229 59-02		Tekirdağ
G63	233 43-01		Kütahya
G64	241 35-04		İzmir
G65	309 10-03		Balıkesir
G66	204 17-01		Çanakkale
G67	303 63-03	*Tulipa aleppensis* Boiss.ex Regel (3 genotypes)	Şanlıurfa
G68	251 21-03		Diyarbakır
G69	222 23-01		Elazığ
G70	317 05-07	*Tulipa praecox* Ten (1 genotype)	Amasya
G71	401 09-01	*Tulipa clusiana* DC. (1 genotype)	Aydın

Table 2. Weighted ranking criteria used in the pedigree selection of local tulip genotypes.

Selection Criteria	Classes	Class Score (CS)	Relative Scores (RS)
	Upright	10	
Plant Stance	Medium	7	15
	Lateral	3	
	Short (2.9-9.0)	1	
	Medium short (9.0-15.1)	2	
Plant Height (cm)	Medium (15.1-21.2)	3	15
	Medium tall (21.2-27.3)	4	
	Tall (27.3-33.4)	5	
	Thick (3.84-5.10)	10	
Stem Thickness (mm)	Medium (2.57-3.84)	7	15
	Thin (1.3-2.57)	3	
	Long (20 >)	10	
	Medium (14-20)	8	
Flower Lifespan (day)	Short (8-14)	5	15
	Very short (8 <)	2	
	Very big (39.4-47.6)	10	
	Big (31.2-39.4)	8	
Size of Flower (mm)	Medium (23.0-31.2)	5	15
	Small (14.8-23.0)	3	
	Very large (12 >)	10	
	Large (8-12)	7	
Main Bulb Diameter (cm)	Medium (4-7)	5	10
	Small (3 <)	3	
	High 5>	10	
	Medium 4-5	8	
Number of Bulbs Formed From The Main Bulb (pcs.)	Low 3-4	5	15
	Very low 2<	3	

Table 3. Relative score x class scores and total scores of tulip genotypes in terms of each trait.

Genotype	A	B	C	D	E	F	G	Total
G1	150	60	150	75	150	50	150	785
G2	150	75	150	120	150	70	150	865
G3	150	45	150	150	150	70	75	790
G4	105	30	105	75	75	50	45	485
G5	105	30	105	150	120	70	75	655
G6	105	15	105	75	75	70	75	520
G7	105	15	105	75	75	70	75	520
G8	105	15	45	150	75	70	75	535
G9	105	30	105	120	75	70	75	580
G10	105	15	105	120	150	70	75	640
G11	105	15	105	120	75	70	75	565
G12	105	30	105	75	45	50	120	530
G13	105	30	105	120	150	70	75	655
G14	150	60	105	120	120	70	120	745
G15	105	30	45	150	75	50	75	530
G16	105	15	105	120	45	50	45	485
G17	150	30	45	75	45	50	75	470
G18	150	45	105	120	150	50	120	740
G19	105	30	150	120	150	90	75	720
G20	105	15	45	150	75	30	120	540
G21	150	45	105	120	45	50	75	590
G22	150	15	45	30	45	30	120	435
G23	45	15	105	120	45	50	45	425
G24	105	30	105	120	45	50	75	530
G25	105	30	45	120	45	50	45	440
G26	105	30	105	120	150	70	75	655
G27	45	60	45	150	120	50	75	545
G28	45	30	105	150	150	50	45	575
G29	105	30	105	75	45	50	75	485
G30	150	45	105	120	45	50	75	590
G31	150	30	105	75	45	50	120	575
G32	105	45	105	120	150	70	75	670
G33	105	15	45	75	45	50	75	410
G34	150	30	105	75	150	50	45	605

Continuing table 3

Genotype	A	B	C	D	E	F	G	Total
G35	150	15	105	75	75	50	120	590
G36	105	15	45	30	45	90	75	405
G37	150	30	45	150	150	50	120	695
G38	105	15	45	75	75	50	75	440
G39	105	30	45	75	45	50	75	425
G40	105	30	45	75	45	50	75	425
G41	105	45	105	75	45	50	75	500
G42	105	15	45	75	45	50	75	410
G43	45	30	105	75	75	30	45	405
G44	105	45	105	150	150	70	75	700
G45	105	45	105	75	45	70	120	565
G46	105	30	45	120	45	50	75	470
G47	105	45	45	120	45	50	75	485
G48	105	15	45	75	45	50	75	410
G49	105	15	45	120	75	70	75	505
G50	150	15	45	75	75	50	120	530
G51	105	30	45	75	75	50	75	455
G52	105	15	45	75	45	50	45	380
G53	150	30	105	75	120	50	75	605
G54	105	45	105	120	75	70	75	595
G55	150	30	105	150	120	70	75	700
G56	150	45	45	120	45	70	120	595
G57	150	45	105	120	75	50	75	620
G58	150	45	105	120	75	70	75	640
G59	150	30	45	150	45	50	75	545
G60	150	45	105	75	75	50	75	575
G61	150	45	150	120	75	70	75	685
G62	150	45	105	120	75	50	75	620
G63	105	30	45	75	45	50	75	425
G64	150	30	45	120	75	50	120	590
G65	105	15	45	75	45	50	75	410
G66	105	30	45	120	75	30	75	480
G67	105	30	105	120	45	50	45	500
G68	150	30	105	75	75	70	75	580

Continuing table 3

Genotype	A	B	C	D	E	F	G	Total
G69	105	30	105	75	75	50	75	515
G70	150	45	45	75	75	50	75	515
G71	150	45	45	120	75	70	75	580
G72	150	45	150	120	75	90	120	750
G73	150	60	105	120	75	90	120	720
G74	150	75	45	120	75	50	12	527

*A: Plant habitus, B: Plant height (cm), C: Stem thickness (mm), D: Lifespan of flower (day), E: Diameter of flower (mm), F: Diameter of bulb (mm), G: Number of bulblet (pcs.)

Table 4. Distribution frequencies of local tulip genotypes according to the plant habitus.

Plant Habitus	Genotype No	Distribution Frequencies (%)
Upright	G1, G2, G3, G14, G18, G21, G22, G35, G30, G31, G34, G37, G48, G50, G55, G56, G57, G58, G59, G60, G61, G62, G64, G68, G70, G71, Kumru, Muş1071, Arda	39.2
Moderate	G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G15, G16, G17, G19, G20, G24, G25, G26, G29, G32, G33, G36, G38, G39, G40, G41, G42, G44, G45, G46, G47, G49, G51, G52, G53, G54, G63, G65, G66, G67, G69	55.4
Lateral	G23, G27, G28, G43	5.4

Table 5. Distribution frequencies of local tulip genotypes in terms of plant height.

Plant Height (cm)	Genotype No	Distribution Frequencies (%)
Short (2.9-9.0 cm)	G6, G7, G8, G10, G11, G16, G20, G22, G23 G33, G35, G36, G38, G42, G48, G49, G50 G52, G65	25.7
Medium Short (9.1-15.1 cm)	G4, G5, G9, G12, G13, G15, G17 G19, G24, G25, G26, G28, G29, G31, G34, G37, G39, G40, G43, G46, G51, G53, G55, G59, G63, G64, G66, G67, G68, G69	40.5
Medium (15.2-21.2 cm)	G3, G18, G21, G30, G32, G41, G44, G45, G47 G54, G56, G57, G58, G60, G61, G62, G70, G71, G72	25.7
Tall (21.3-27.3 cm)	G1, G14, G27, G73	5.4
Very Tall (27.4-33.4 cm)	G2, G74	2.7

Table 6. Distribution frequencies of the local tulip genotypes in terms of stem thickness.

Stem Thickness (mm)	Genotype No	Distribution Frequencies (%)
Thick (3.85-5.10 mm)	G1, G2, G19, G22, G61, Kumru	8,1
Medium (2.58-3.84 mm)	G3, G5, G7, G8, G9, G10, G11, G12, G13, G16, G18, G20, G21, G23, G24, G26, G35, G28, G29, G30, G31, G32, G34, G41, G43, G44, G45, G47, G49, G54, G55, G57, G58, G60, G62, G67, G68, G69, Muş1071	52.5
Thin (1.3-2.57 mm)	G4, G6, G14, G15, G17, G25, G27, G33, G36, G37, G38, G39, G40, G42, G46, G48, G50, G51, G52, G53, G56, G59, G63, G64, G65, G66, G70, G14, Arda	39,2

Table 7. Distribution and frequencies of local tulip genotypes in terms of flower longevity.

Flower Longevity	Genotype No	Distribution Frequencies (%)
Long (20 > days)	G27, G28, G44, G55, G59	6.8
Medium (14-20 days)	G2, G3, G5, G7, G8, G9, G10, G13, G14, G15, G18, G19, G20, G21, G24, G26, G32, G34, G37, G46, G53, G54, G56, G57, G58, G61, G62, G64, G66, G67, G68, G71, Kumru, Muş1071, Arda	47.3
Short (8-14 days)	G1, G4, G6, G11, G12, G16, G17, G23, G25, G35, G29, G30, G31, G33, G36, G38, G39, G40, G41, G42, G43, G45, G47, G48, G49, G50, G51, G52, G60, G63, G65, G69, G70	44.6
Very Short (8 <days)	G22	1.3

Table 8. Distribution and frequencies of tulip genotypes in terms of flower size.

Flower Size	Genotype No	Distribution Frequencies (%)
Very Large (39.5-47.6 mm)	G1, G2, G3, G8, G10, G18, G20, G26, G28, G30, G32, G37, G40, G44	18.9
Large (31.3-39.4 mm)	G5, G11, G14, G27, G47, G55	8.1
Medium (23.1-31.2 mm)	G6, G9, G15, G35, G36, G38, G43, G49, G50, G51, G54, G57, G58, G60, G61, G62, G64, G66, G68, G69, G70, G71, Kumru, MuŞ1071, Arda	33.9
Small (14.8-23.0 mm)	G4, G7, G12, G13, G16, G17, G19, G21, G22, G23, G24, G25, G29, G31, G33, G34, G39, G41, G42, G45, G46, G48, G52, G53, G56, G59, G63, G65, G67	39.1

Table 9. Distribution frequencies of tulip genotypes according to main bulb diameter values.

Bulb Diameter (cm)	Genotype No	Distribution Frequencies (%)
Very Big (12 > cm)	G19, G36, Kumru, Muş1071	5.4
Big (8-12 cm)	G2, G5, G6, G7, G8, G9, G10, G11, G13, G14, G17, G26, G35, G27, G28, G32, G44, G45, G49, G54, G56, G58, G61, G68, G71	33.8
Medium (4-7 cm)	G1, G3, G4, G12, G15, G16, G18, G21, G23, G24, G25, G29, G30, G31, G33, G34, G37, G38, G39, G40, G41, G42, G43, G46, G47, G48, G50, G51, G52, G53, G55, G57, G59, G60, G62, G63, G64, G65, G67, G69, G70, Arda	56.8
Small (3 < cm)	G20, G22, G66	4.0

Table 10. Distribution frequencies of local tulip genotypes according to the number of bulblets from the main bulb.

The Number of Bulbs from The Main Bulb	Genotype No	Distribution Frequencies (%)
Very Good (5> number)	G1, G2	2.7
Good (4-5 number)	G12, G14, G18, G20, G22, G35, G29, G31, G37, G45, G50, G56, G64, G71, Kumru, Muş1071, Arda	23.0
Low (3-4 number)	G3, G5, G6, G8, G9, G10, G11, G13, G15, G17, G19, G21, G24, G26, G27, G32, G33, G34, G36, G39, G40, G41, G42, G44, G46, G47, G48, G49, G51, G53, G55, G57, G58, G59, G60, G61, G62, G63, G65, G66, G70	55.4
Very Low (2< number)	G4, G7, G16, G23, G25, G28, G30, G38, G43, G52, G54, G67, G68, G69	18.9

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