Research Article

Growth and Flowering Responses of Elite Varieties of Tulip (*Tulipa gesneriana* L.) in Rawalpindi Climate Zone

Monis Hussain Shah[1]*, Riaz Ur Rehman[2], Riaz Ali Shah[1], Farwa Batool[3], Rizwan Rafique[4], Muhammad Usman[5], Sajida Bibi[6], Sadia Yasin[7] and Samida Qamar[8]

[1]Horticultural Research Institute for Floriculture and landscaping, Rawalpindi, 44000, Pakistan; [2]Directorate of Floriculture (T & R), Punjab, Lahore, 54000, Pakistan; [3]Floriculture Training Center, Bagh-e-Jinnah Lahore, 54000, Pakistan; [4]Extension and adaptive Research, Chakwal, 48800, Pakistan; [5]Institute of Horticultural Sciences, Faculty of Agriculture, University of Agricultural, Faisalabad, 38000, Pakistan; [6]Nuclear Institute for Agriculture and Biology, 38000, Pakistan; [7]Food science and technology department, Minhaj University, Lahore, 54000, Pakistan; [8]Parks and Horticultural Authority, Lahore, 54000, Pakistan.

Abstract | The tulip is an important cut flower around the globe. The Tulip is not famous in Pakistan for sale and cultivation for commercial purposes as well. The evaluation of exotic varieties are very important for recommendation to local farmers for better yield. Four tulip varieties cv. Antarctica, Oxford, Ballerina and Apeldoorn were purchased for evaluation. The 100 bulbs of each variety were planted in the bed. The performance of the plants during 2017-18 were judged by observing the bulb germination percentage, leaf width (cm), leaf length (cm), scape length (cm), flower size (mm), primary color of the flower, secondary color of flower, no. of large, medium and small size of bulbs and number of bulbs harvested. The bulbs were harvested and stored at 5±2°C (In Refrigerator). The morphological attributes of plants were observed better in cv. Antarctica and Oxford. The research was repeated during the subsequent years. The variable response was observed in various varieties of tulip in Rawalpindi climate. The cv. Antarctica and Oxford were observed as best performer wise all the attributes. The same varieties are recommended to local farmers for cultivation as well.

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***Correspondence** | Monis Hussain Shah, Horticultural Research Institute for Floriculture and landscaping, Rawalpindi, 44000, Pakistan; **Email:** monishussain50@gmail.com
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Introduction

Tulip (*Tulipa gesneriana* L.) is leading cut flower around the globe. It is a bulbous plant that contain bulbs as a source of food (Jhon and Neelofar, 2006). The Tulip have more than 100 species and countless varieties of commercial importance (Coskuncelebi *et al*., 2008), wild types of tulip are abundantly found throughout the hilly areas of Pakistan especially in Murree and Islamabad. The production of tulip is not carried out abundantly in Pakistan for both commercial and home gardening due to that import

is very limited each year. The import of tulip from abroad is increasing each year. The trends of growing tulips in Northern areas is gaining popularity as well. Netherland is the world leader in tulip production which shares 88% (14400 ha) (Statista, 2019). Netherlands produces billions of tulips (4.32 billion) of worth 2.3 billion tulips used as source material for cultivation in subsequent season. Almost 1.3 billion (57%) tulips cultivated in the Netherlands for the production of cut-flowers. The remaining tulips (European Union: 0.63 billion and outside the European Union: 0.37 billion) are exported to South, South East Asia and other countries (Statista, 2019). In France tulips production is managed by the Dutch production companies. The French grown tulips are used in Netherlands in early planting (November-December). The Tulips are cultivated on Southern Hemisphere in France for autumn flowering (October-December) (Buschman, 2005). In Pakistan 100% Tulips are imported from Netherlands. The production and acreage under Tulip have not been recorded in Pakistan because it's a comparatively newly introduced floral crops in Pakistan (Bashir *et al*., 2018). The import of tulip is increasing every year in Pakistan and tulip mass impacts are showed every year in Azad Kashmir and Gilgit. The tulip has great commercial value in market of Islamabad and other big cities however tulip is not commercially available in other small or medium populated cities of Pakistan.

The main hurdles in tulip production in Pakistan are lack of awareness regarding production, propagation material availability, market sale value and consumer preferences at wider level (Anonymous, 2006). Amongst all the challenges of tulip production and commercialization, the key aspects is that the lack of availability of propagation material and high cost of production that is due to sole import of propagation material from Netherland (Danish and Rose, 2018). Pakistan agriculture industry is lacking floriculture bulbs production. The wild bulbs of tulip can be found in hilly areas of Pakistan such as Murree and Islamabad that is called Gwarikh (*Tulipa lehmanniana*). The lacking of breeding and production of local plant material in Tulip is far cry in Pakistan. The lack of production of local planting material for commercial purposes is due to lack of attention of research staff related to agriculture. Production of these bulbs can not only promote the crop diversity in local agriculture system and promote the export of fresh flowers and planting material to abroad. Pakistan can capture nearby markets of Middle East and South East Asia (Sajjad *et al*., 2014). Generally, it is reported that tulip is multiplied vegetative through bulbs sustained for long durations in well-drained soil (Jaap and Marjan, 2007). The Rawalpindi and Islamabad generally have rough and calcareous soil that can be modified by adding organic matter as well. Such kind of modified soils can be used for long term utilization for bulb multiplication, more over the temperature of Rawalpindi and Islamabad remain mild during all summers and high temperature did not prevail for long duration (Sheikh *et al*., 1987). Present study is based on the evaluation of various varieties of tulip that are planted for further recommendation to the local farmers for cut-flower production and provision to the local market.

Materials and Methods

The research was conducted in Horticultural Research Institute for Floriculture and Landscaping, Islamabad during the year of 2017-19. The land is prepared by adding the significant amount of leaf manure (20kg/m^2), sand and FYM as well, because bulb growth required soft and light textured soil, pH of soil was 6.5. The land was prepared before 3 month and level fellow for organic matter decomposition added during preparation. The bulbs of tulip cv. Antarctica, cv. Ballerina, cv. Apeldoorn and cv. Oxford were purchased from retail market. The plantation was done on flat bed in early December. The 100 bulbs of each variety were planted in the bed. The performance of the plants during 2017-18 were judged through observing the attributes, bulb germination %age, leaf width (cm), leaf length (cm), scape length (cm), flower size (mm), primary color of the flower, secondary color of flower, no. of large, medium and small size of bulbs and number of bulbs harvested. The bulbs were harvested and stored at 5±2 (In refrigerator). The bulbs in storage environment were observed as color of the bulb, fungal spores, odor, mean fresh weight (g), sprouting (present/absent) and storage temperature (°C). The bulbs were replanted on the flat beds following the same process of land preparation as well during the year of 2018-19. To observe the bulbs response in second year the attributes were as bulb germination %age, leaf width (cm), leaf length (cm), scape length (cm), flower size (mm), primary color of the flower, secondary color of flower, large, medium and small size of bulbs (nos.) and number of bulbs harvested. The data was analyzed by calculating

the means followed by ANOVA and tables were made for illustration as well (Steel *et al.*, 1997).

Results and Discussion

Response of fresh bulbs of commercial tulip cultivars during 2017-18 and their storage

The results (P > 0.05) showed good germination (cv. Antarctica, Oxford:100%, Ballerina: 96, and Apeldoorn: 98) from the fresh (Table 1) bulbs of cv. Antarctica, cv. Oxford during the year of 2017-18 where cv. Antarctica showed highest leaf length (14.35cm), while the highest leaf width was observed in cv. Oxford. The longest scape length was observed in Cv. Antarctica (29.92cm) however the largest flower size was found in cv. Oxford (71.5mm) that was red colored variety of tulip. The highest number of large size bulbs were also observed in cv. Antarctica (132) and Oxford (121). The bulbs were harvested when their leaves were dry and yellow in colors. The small size of the bulbs was significantly more in numbers during the harvesting. The bulbs were stored in refrigerator for for 12-15 weeks. The bulbs were then be removed from refrigerator and placed in cool and dry temperature (18-22°C) for a week before sowing. There was no sign of fungus or any other disease on surface of bulbs (Table 2). The significant number of bulbs were also sprouted in the storage conditions as well. The loss of color was also not observed in storage conditions as well.

Response of commercial tulip cultivars after storage during 2018-19

The germination (Antarctica: 20, Apeldoorn: 46 and Oxford: 43) percentage was observed significantly lower compared with fresh bulbs plantation during the year of 2018-19. The earliest bulbs germination/sprouting was observed in cv. Antarctica. The highest leave length (12.2cm) and leaf width was observed in cv. Antarctica. The highest scape length (23.2cm) and flower size (75.4mm) was observed in cv. Oxford. The highest number of bulbs that can be sown in next season was observed in cv. Oxford (70%) and Antarctica 40%). However, the cut-flower of unusual behavior were observed when the stored bulbs were re-sown in the beds as well. The variety cv. Ballerina did not sprouted in second year of 2018-19 and bulbs germinated was not observed and rotten in the soil. While the cv. Apeldoorn did not performed up to the standard of commercial cut-flower production in second season (Table 3).

Table 1: *Response of commercial tulip cultivars in HRI-Islamabad in 2017-18.*

Varieties	Bulb germination %age	Mean time of bulbs sprouting	Leaf length (cm)	Leaf width (cm)	Scape length (cm)	Flower size (mm)	Primary Color of the flower	Secondary color of flower	Large size bulbs (Nos.)	Medium size bulbs (Nos.)	Small size of bulbs (Nos.)	Total number of bulbs harvested
Antarctica	100	40.33± 3.23	14.35± 0.160	7.56± 0.08	29.92± 0.354	31.5± 0.171	Creamy	Yellow	20	32	80	132
Ballerina	96	38.56± 2.98	12.07± 0.211	4.47± 0.213	16.64± 0.406	45.28± 0.387	Orange	Yellow	15	20	45	80
Apeldoorn	98	41.43± 4.13	13.57± 0.191	7.75± 0.073	21.5± 0.515	53.14± 0.459	Red	Black	30	12	60	102
Oxford	100	39.67± 3.43	12.35± 0.214	9.07± 0.146	23.28± 0.669	74.5± 0.831	Red	Yellow	23	18	80	121

Table 2: *Response of commercial tulip cultivars in storage conditions at 10 °C in 2018.*

Storage attributes	cv. Antarctica	cv. Ballerina	cv. Apeldoorn	cv. Oxford
Color of the bulbs	Normal (White/ Creamy)	Normal (White/ Creamy)	Normal (White/ Creamy)	Normal (White/ Creamy)
Fungal Spores	-ive	-ive	-ive	-ive
Odor	Odor less	Odor less	Odor less	Odor less
Mean Fresh weight (g)	12.3	14.4	13.4	10.4
Sprouting (Present/Absent)	+ive	+ive	+ive	+ive
Storage temperature °C	5±2	5±2	5±2	5±2

Table 3: *Response of commercial tulip cultivars in HRI-Islamabad after storage in 2018-19.*

Varieties	Bulb germination %age	Mean time of bulbs sprouting	leaf length (cm)	Leaf width (cm)	Scape length (cm)	Flower size (mm)	Primary color of the flower	Secondary color of flower	Large size (%)	Medium size (Nos.)	Small size of bulbs (Nos.)	Total number of bulbs harvested
Antarctica	20	70.56±3.44	12.2±2.3	8.6±3.2	18.2±3.4	32.3±3.5	Creamy	Yellow	10	10	30	40
Apeldoorn	46	68.98±3.54	10.5±4.3	6.3±2.6	15.5±2.4	50.4±2.4	Red	Black	8	10	20	30
Oxford	43	71.45±5.34	9.2±5.2	7.7±3.4	23.2±3.2	75.4±4.3	Red	Yellow	-	20	50	70

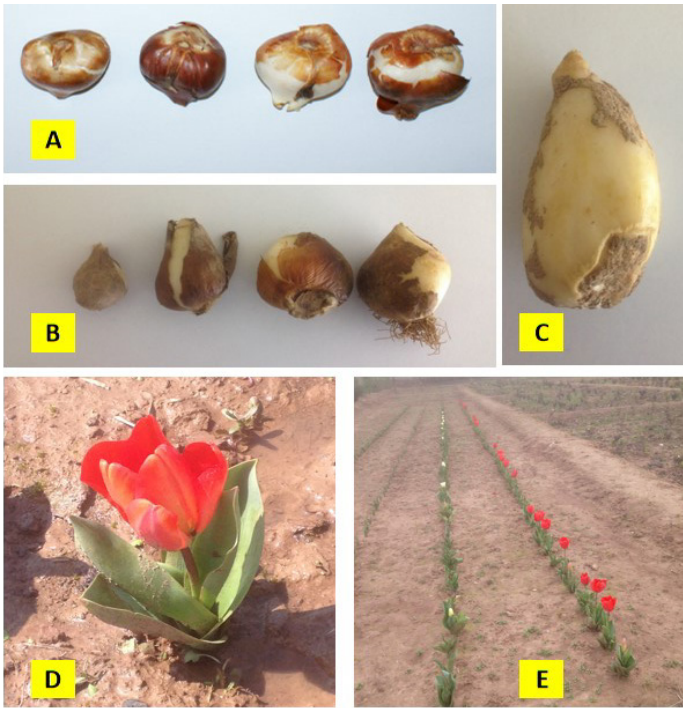

Figure 1: *A: the fresh bulbs of 2017-18 that were purchased from international importers, B: bulbs after preservation almost for 5 months prior to sowing in 2018-19. C: bulbs loss of regular shape observed during the year of 2019 after spring flowering. D: Extremely short flower stem size and E: is irregular and sparse bearing of flowers as well.*

Response of fresh bulbs of commercial tulip cultivars during 2017-18 and their storage

The elite varieties of cv. Antarctica, Ballerina, Apeldoorn and Oxford are planted for commercial flowering and sale in Pakistan (Ali *et al.*, 2015). The high germination and sprouting of the bulbs were observed during the present study when fresh bulbs were sown. The early germination and high percentage of bulbs sprouting with ultimate flowering in yellow colored verities that is might be due to the better correlation with environmental temperature. The present results are correlated with study of Moore *et al.* (1979) that depicted early flowering due to resistance in the varieties against physiological disorders in variety of temperature change in short time span. Resistance against physiological disorders may also be due to endogenous growth promoters that promote early flowering pattern development and trigger early flowering (Pharis and King, 1985). The variation in leaf width and length was observed in various varieties in the indigenous climatic conditions as well during the study. The variation in the leaf size, flower color, and flower size or flower diameter depends on the genotype environment interaction. The large leaf width and length also showed the greater number of large size of bulbs compared with other varieties such as cv. Apeldoorn and Oxford have large leave hence large number of large size of bulbs compared with other varieties (Sestras *et al.*, 2007). The size of flower directly depends on the health of plant while healthy leaves and good size of bulbs also the integral part of plant health (Sestras *et al.*, 2007). Sestras *et al.* (2007) evaluated different tulip varieties and observed that flower diameter, leaf size and color are controlled by the climatic factors and genomic latent of cultivars. The variation in more number of good bulb sizes might be due to the presence of increase number of leaves. Increased number of leaves promote the process of photosynthesis that increases the size of bulbs underground. Components of environment such as humidity, light, temperature and edaphic factors might have played a role in the expansion and contraction of bulb sizes (Moore *et al.*, 1979). The combination of environmental and genetic factors might have too resulted in the larger size of bulb (Ahmad and Gul, 2002). The phenomenon of correlation of large size of sister bulbs with more leaves and large size of mother bulbs with suitable environmental components is also supported by Nard *et al.* (1997).

Response of commercial tulip cultivars in HRI-Islamabad after storage in 2018-19

The flowering tulip bulbs produces scape bearing terminal flowering in winters in Pakistan. Some cultivars are multi-floral in which the flowers are emerged on terminal edge of scape (Nard *et al.*, 1993). However, some varieties and species have the potential to produce more than one flower in single scape while majority produces only one flower per scape. The annual life cycle of tulip bulb

can be divided into three steps. (1) Rapid root growth starts when the bulbs are planted in autumn season. Already differentiated apical bud into aerial organs, slowly elongates during in low temperature and form flower stems. (2) During spring season when temperatures rises; the plant growth become faster. In high temperature the scape and flower bud formation rapidly elongate and form flower. During the process of flower formation, the transformation flower buds to vegetative buds (daughter-bulbs) for next generation of mother-bulbs starts and accelerate after flowering. Concomitantly scales of original mother-bulb are desiccated (Carl *et al*., 2015). (3) In the end of spring season, aerial organs of bulbous plants become pale while roots senesce is occurred and daughter-bulb growth become stopped. During the summer, bud differentiation (vegetative and floral) occurs within previous daughter-bulbs, which are now mother bulbs. It is advent that Bulbs must reach up to a critical size (weight) for producing the flowers. While the size of bulbs for flowering is varies by genotype, the minimum size is usually six to eight grams. This range corresponds to approximately six to nine centimeters in circumference (Carl *et al*., 2015). In present study the bulbs were dig up and replanted during the years of 2017-18. The harvested bulbs of reasonable size were replanted in autumn. The bulbs showed late sprouting and short flower stem length. That is might be due to dig up of bulbs for storage for next season plantation, however the chances of rotting of bulbs were greater due to that the bulbs were harvested. After second plantation the bulbs were fully consumed and did not produced the daughter bulbs for obtaining the reasonable size of bulbs for continuing the process in subsequent years. The bulbs regeneration for subsequent season plantation involves a huge metabolic and epigenetic changes. The genotype dependent factors control epigenetic changes for flowering and further multiplication of bulbs as well. The low temperature and full filling the chilling requirements promote the bulb enlargement followed by flower bud differentiation. The process related to the bulbs consumption in subsequent generations is not fully understand and illustrated (Leeggangers *et al*., 2017).

Conclusions and Recommendations

Tulip (*Tulipa gesneriana* L.) is the most important cut-flower around the globe. The cut-flower of tulip is a unique cut flower that impress the population of the world by bed planting. Response of four tulip cultivars was observed for better floral size and survival as well. Cv. Oxford and cv. Antarctica were better flower size and stem length respectively. The same varieties produces large daughter bulbs. The response of the varieties was not satisfactory in second year plantation as well. That shows that each year new bulbs should be planted as well. The less production of daughter bulbs were also observed in other varieties as well. The present study will be helpful for the farmers for selection of suitable commercial variety for better yield and earning as well. The present study will be opening the further research avenue on tulip and could be a very good line to follow for introducing some promising tulip varieties in future.

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Novelty Statement

This is a first study conducted in Pakistan on production technology of tulip bulbs in various climates and growing conditions.

Author's Contribution

Monis Hussain Shah: Conducted the study and wrote the manuscript.
Riaz Ur Rehman and Riaz Ali Shah: Supervised the study.
Farwa Batool: Helped in cunducting the research.
Rizwan Rafique: Performed statistical analysis and technical review.
Muhammad Usman: Did final review and corrections.
Sajida Bibi: Helped in discussio and statistical analysis.
Sadia Yasin: Helped in writing and review.
Samida Qamar: Reviewed the manuscript and helped in photography.

Conflict of interest
The authors have declared no conflict of interest.

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