INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
17–0190/2018/20–1–25–32
DOI: 10.17957/IJAB/15.0323
http://www.fspublishers.org

Full Length Article

Evaluation of Commercial Tulip Accessions for Flowering Potential in Climatic Conditions of Faisalabad

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Abstract

Tulips are amongst the choicest cutflower that possess eminent status in global floriculture. However, they are not as productive in subtropical regions as they are in temperate zones. This crop has recently been introduced in Pakistan but the exotic cultivars responded with partial success in the new environment. A study was conducted to compare the potential of some elite cultivars (Apeldorn, Barcelona, Clear water, Golden Apeldorn, Ile de France, Leen Van der Mark, Parade, Purple flag, Queen of night, Spring green) for cut tulip production in the climatic condition of Faisalabad. Results indicated that cultivars like Parade, Leen Vander Mark and Ile de France responded best amongst the tested cultivars regarding their fresh mass, leaf area, tepal diameter, flower quality, stem diameter, earlier days to flower bud emergence, vase life and bulbils attributes. Overall, cultivar response was significantly inconsistent in context to their growth, morphology, flowering potential and post-harvest quality. Hence these cultivars (Leen Vander Mark, Ile de France and Parade) are recommended for commercial cultivation keeping in view their vigorous growth potential and adaptability.

Keywords: *Tulipa*; Environmental conditions; Flowering potential; Post-harvest quality

Introduction

Tulip, a perennial geophyte from *Liliaceae* family belongs to genus *Tulipa* having 150–160 species originated in central Asia (Coskuncelebi *et al.,* 2008). It is amongst the most favorite cutflowers that occupy 4th position in the international flower trade (Jhon and Neelofar, 2006). Thousands of tulip genotypes were introduced about 400 years ago as a garden flower in The Netherlands where it gained remarkable popularity in its production and cultivation. The importance of flower can be valued by its massive use in landscaping in veiled gardens (Pompodakis *et al*., 2004). This crop possesses wide diversity in flower morphology and growth patterns (de Hertogh and le Nard, 1993) that responds differently in varying climatic zones (Pathania and Sehgal, 1997). They are not only cultivated as cutflower but also for potting, bedding and as border plant in different climatic zones (Ohyama *et al.,* 2006).

In this regard, temperature is the most influencing factor affecting growth, development and flowering process in tulips that require 12 to 16 weeks of above ground cold temperature exposure for a lengthened flower stalk (Kamenetsky and Okubo, 2013). For initiation of flowering, a relatively higher temperature (17–23ºC) is needed while low temperature (2–9ºC) is beneficial to induce many physiological changes required for floral stalk development and elongation (Asghari, 2014). Similarly, tulips have shorter display life induced by leaf yellowing (Ferrante *et al.,* 2003) and early senescence of flower heads that cause fading of petals due to improper plant water relationship and early tepal senescence followed by abscission (Iwaya-Inoue and Takata, 2001) in many cultivars.

Pakistan, being an emerging market for floral products particularly for cutflowers (Manzoor *et al.,* 2001) is offering a slew of opportunities to different businesses particularly in central Punjab that possess potential for tulip cultivation. Flower cultivation in Pakistan is becoming a lucrative enterprise for the farmers of small land holdings and their production is estimated about 10 to 12 thousand tons per annum (Khan, 2011) with inclined increase in their demand (Rehman, 2004). There exists dire need to introduce new flower crops in the country based upon modern production practices compatible to our environmental and climatic conditions (Sajjad *et al.,* 2014). However, tulips are not as productive in plains as they are in hilly areas because of their high chilling requirements (Ahmed *et al*., 2013) as majority of the cultivars are developed in cooler regions across the globe thus a prolonged cold temperature is essential for their adequate growth and successive development of flower stems (Asghari, 2014). In winter season, parts of flower develop slowly and quick elongation of stalk takes place in spring season (de Hertogh and le Nard, 1993).

To cite this paper: Bashir, M., M.A. Khan, M. Qasim and S.M.A. Basra, 2018. Evaluation of commercial tulip cultivars for flowering potential in climatic conditions of Faisalabad. *Int. J. Agric. Biol.,* 20: 25–32

Currently, no appreciable research has been done in Pakistan on tulips to facilitate its cultivation especially screening of different varieties when grown at low altitude. By considering the potential of tulip as an innovative cutflower in the local market and being an unaccustomed crop by the growers in the country, this study was conducted with an insight for exploring the best suited varieties under the climatic condition of Faisalabad by considering their vegetative growth and flowering attributes under open field conditions.

Materials and Methods

Plant Material and Growth Conditions

The experiment was conducted in Floriculture area of Institute of Horticultural Sciences, University of Agriculture, Faisalabad (latitude=31°-26´N, longitude=73°-06´ E, altitude=184.4 m). Forced bulbs of uniform size 11-12 cm in circumference of 10 promising cultivars of Dutch origin for cutflower production were purchased from Greenworks Pvt. Ltd. a stoop flower bulb company of Holland in Pakistan (Table 3). All field practices were well maintained to support optimal conditions for plant growth and development. Bulbs were sown on raised beds in sweet sand as a soil medium having properties mentioned in Table 1.

Plant Husbandry and Treatments

Each cultivar was considered as treatment to assess their adaptability and growth response in climatic conditions of Faisalabad (Pakistan) with the meteorological conditions as explained in Table 2. Bulbs were planted at raised beds at a distance of 15 cm bulb to bulb and at depth of twice the size of bulbs with 3 replicates. 50 bulbs of uniform size of each cultivar were planted per replication in the month of November, 2014. Prior to planting in the soil, bulbs were treated with fungicide Topsin-M ^{70WP} @ 1 mgL^{-1} of water (Granneman, 2016). Bulbs were kept dipped in the solution for 5 min for adherence of fungicide on bulbs surface. Cultivars were evaluated on the basis of their morphological, floral and postharvest attributes. Basal dose of NPK (17:17:17) 10 gm^{-2} (Ali *et al.*, 2014) was applied prior to planting because of inadequate nutritional status of the soil as revealed in Table 1. Irrigation was applied after planting with canal water and further irrigations were maintained according to requirement while 3 irrigations in total, were applied during the course of experiment. The field was kept free from weeds, bird attack and other unfavorable biotic factors.

Observations

Data was collected from twenty plants randomly selected from each replication. Plant fresh mass was measured on digital balance and their average was calculated.

Table 1: Physical and chemical properties of soil

Soil characteristics	Soil depth	
	0–6 (inch)	6–12 (inch)
Texture	Loamy	Loamy
pH	8.30	8.10
EC (dS m^{-1})	0.42	0.37
Exchangeable Sodium (mmol/100g)	0.90	0.70
Organic matter (%)	0.51	0.54
Macronutritional status of soil		
Nitrogen (mgL^{-1})	0.049	Weak
Phosphorus (mgL^{-1})	4.3	Too weak
Exchangeable potassium (mgL^{-1})	105	Medium

Table 2: Environmental factors during the life cycle of tulip cultivars (2014-2015)

Months	Environmental factors			
	Temperature (°C)	RH (%)	Rainfall (mm)	Sunshine (h)
November-14	18.9	61.7	10.0	07.6
December-14	12.2	75.0	0.0	04.7
January-15	11.7	75.3	12.2	05.0
February-15	16.5	66.0	20.5	05.6

Table 3: Various tulip cultivars tested for their adaptability

Cultivar Name	Flower color	Category
Apeldorn	Yellow	Single late
Barcelona	Pink	Regular cut
Ile de France	Maroon	Regular cut
Clear water	White	Regular cut
Golden Apeldorn	Mustard	Darwin hybrid
Leen Vander Mark	Red with yellow edge	Regular cut
Parade	Orange	Darwin hybrid
Purple flag	Purplish black	Regular cut
Queen of night	Deep maroon	Single late
Spring Green	White with light green edge	Viridiflora

Plant dry mass (g) was measured after chopping the plant into pieces and were packed in paper bags. They were then placed in drying oven (Memmert-110, Schawabach) at 72°C for 72 h. Leaf area was calculated from fully mature basal leaves with the help of formula devised by Kemp (1960) for monocots: Leaf area = Maximum length × maximum width × 0.68.

Portable chlorophyll meter (SPAD-502; Konica Minolta Sensing, Inc., Japan) was used to measure leaf greenness (SPAD value). SPAD-502 chlorophyll meter estimates total chlorophyll contents in the leaves with high degree of accuracy. Measurements were taken from the abaxial surface of fully expanded second to third leaf from base of the plant (Khan *et al*., 2003). Stem diameter, tepal and flower diameter was measured with digital calipers. Length and width of petal from fully mature flowers was measured by measuring tape. Days to floral bud emergence were recorded from the time of planting till emergence of flower bud on the plant. Flower quality was rated by 3 different judges (postgraduate floriculture students) adapting the method described by Cooper and Spokas (1991). It was rated in numbers using scale ranging from 1 to 9. 1= poor quality, 5= medium quality and 9= good quality. The flowers were harvested when perianth started showing color and were immersed in buckets containing distilled water and then shifted to the Postharvest and Floriculture laboratory. The lower most leaf and base of the stem was trimmed to avoid air embolism and were placed individually in the glass vases containing 250 mL of distilled water. Vase water was changed with fresh distilled water after the interval of 2 days and lower half inch of stems was cut with sharp scateurs to remove any bacterial clogging. Vaselife (days) was estimated by the method of Gul and Tahir (2013) counted from the day of transfer of cut stems to the holding solution and terminated when 50% flowers had senesced. Flowers were harvested at tight bud stage early in the morning when the perianth had partially attained the color. Flowers were considered dead when more than 50% of the flower got misshapen or faded. For vaselife evaluation, indoor temperature was maintained at 20° ± 2°C, 80 ± 20% relative humidity, 0.2–0.4 m s^{-1} air speed, light from white florescent tubes was provided set to a daily 12 h photoperiod under a photosynthetic photon flux density (PPFD) of 8–12 μmol $m^{-2}s^{-1}$ at stem level in the laboratory. Senescence (days) was calculated by the method of Desai *et al.* (2012). Cut stems while in glass vases containing distilled water were visually observed and were recorded when flowers started to show the symptoms of color change, tepal desiccation, blemishes or formation of any transparent area. Tepal abscission was recorded by the method of van doorn and Stead (1997) when first petal got abscised or shed naturally while assessing the shelf life display. Bulb attributes were estimated after their conditioning in the field for a month and then uprooted. Bulblets produced per plant were weighed on an electric balance. Diameter of bulblets was recorded with the help of digital calipers and number of bulbils produced per plant was recorded from each treatment.

Experimental Design and Statistical Analysis

Experimental unit having 3 replications and ten treatments was designed in a simple Randomized Complete Block Design (RCBD). The obtained featured values, as the average, were statistically verified by means of variance analysis method (ANOVA). The difference among the means was compared by Tukey HSD test at the significance level of $\alpha = 0.05$ by using Statistix 8.1 computer package. Differences among treatments were considered significant only when $P \leq 0.05$.

Results

Vegetative Attributes

Results indicated significant ($P \leq 0.05$) differences regarding plant fresh mass, dry mass, scape length and leaf area for all the tested cultivars (Fig. 1a, b, c and d). Beside this realization, climatic conditions of Faisalabad incredibly supported the growth and development of some cultivars (Ile de France, Leen vander Mark and Parade). Response of all the tested cultivars grown in open field was found to be inconsistent in context to their vegetative attributes. Highest leaf expansion was observed in plants of Leen Vander Mark cultivar followed by Parade, while least expansion of leaf area and plant fresh and dry mass were noted in Purple flag and Queen of night respectively. Similarly, maximum scape length was observed in plants of Barcelona cultivar, followed by Parade and Ile de France while the shortest scape length was noted in Purple flag (Fig. 1c).

Leaf Chlorophyll Contents

Chlorophyll is a vital biomolecule, needed for photosynthesis. A satisfactory amount of chlorophyll contents is needed by the plants to acclimate in new environments. There was a significant difference ($P \leq 0.05$) among cultivars regarding chlorophyll contents (SPAD Value) (Fig. 1e). The maximum SPAD value was found in Leen Vander Mark cultivar, followed by Barcelona, Ile de France, Parade and Golden Apeldorn. But, the cultivar Queen of night cultivar failed to perform under climatic conditions of Faisalabad by exhibiting the least SPAD value. Cultivars with better morphological features and higher chlorophyll contents exhibited the improved flowering potential over other cultivars tested.

Floral Attributes

There was a significant difference ($P \leq 0.05$) among cultivars regarding days to flower bud emergence, tepal and flower diameters, length and width of petals and flower quality (Fig. 2a, b, c, d and e). Days to emerge flower bud after sowing and maximal tepal and flower diameters, petal length and width and highest flower quality score were found in Parade cultivar. Nevertheless, cultivar Spring Green took the highest number of days to flower bud emergence. Least tepal diameter, petals width and flower quality score were exhibited by the cultivar Purple flag (Fig. 2b, e and f). The Apeldorn cultivar possessed the smallest flower diameter and petal length (Fig. 2c, d) while Spring green exhibited the smallest scape diameter among all tested cultivars (Fig. 2g).

Display Life Attributes

Like many other cut flowers, shorter vaselife, bent neck and early senescence abridge market value and post-harvest significance of tulips. Environmental conditions of Faisalabad substantially influenced post-harvest attributes of exotic cultivars of tulip. Vaselife is the period during which a cutflower retains its usable and appreciable appearance in a vase. Post-harvest response of tested cultivars was significantly different ($P \leq 0.05$) (Fig. 3a).

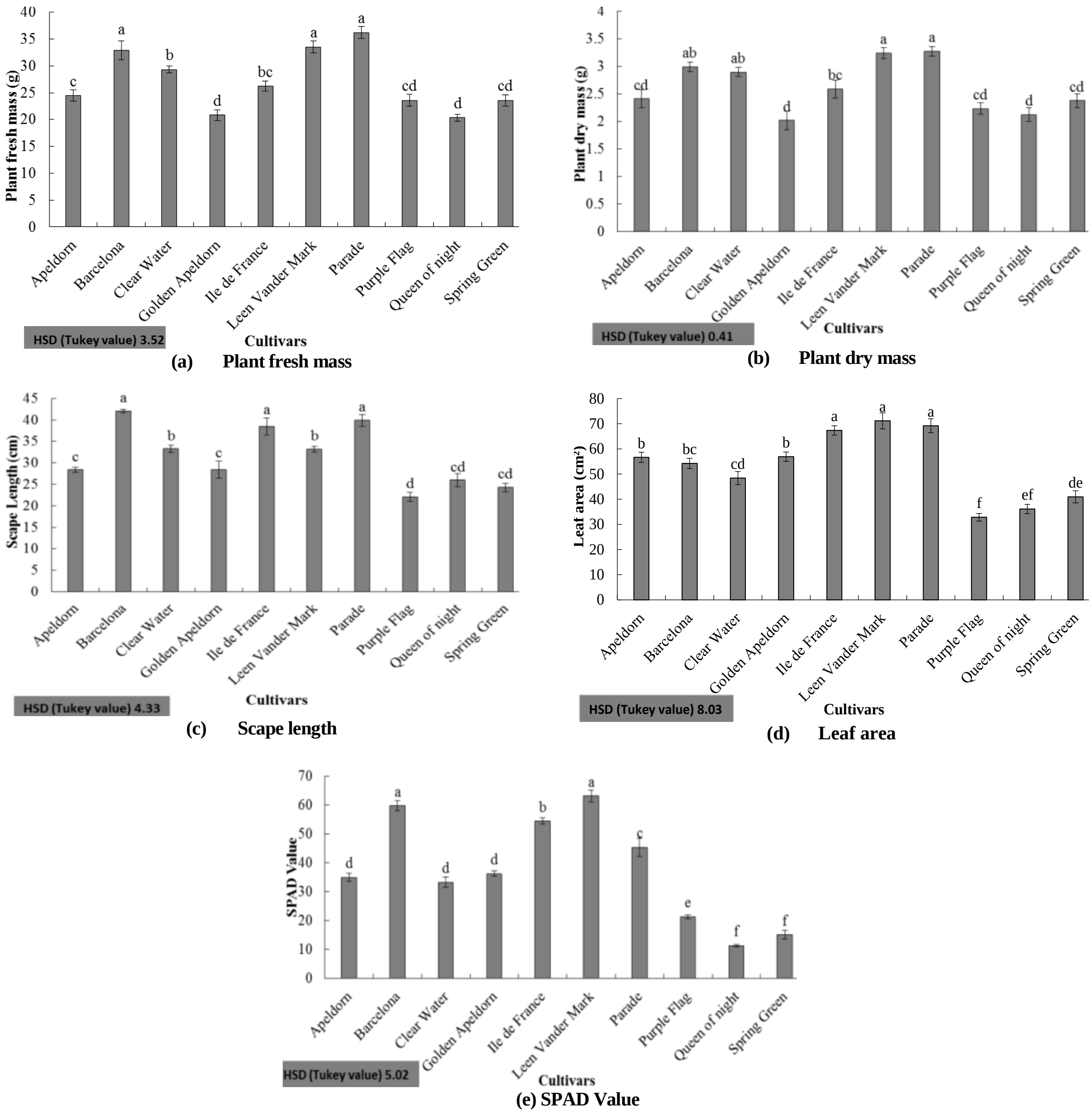


Fig. 1: Graphical presentation of vegetative attributes of different cultivars of tulip grown under Faisalabad conditions (a) Plant fresh mass (g), (b) Plant dry mass (g), (c) Scape length (cm) (d) Leaf area (cm^2), (e) SPAD Value

Longest vaselife, maximum number of days to start senescence and tepal abscission were noted in cultivar Leen Vander Mark whereas, the cultivar Purple flag exhibited the shortest display life, earliest senescence and tepal abscission (Fig. 3a, b and c).

Bulb Attributes

Bulb attributes are important in assessing the potential of perennating organs that are indicator of ultimate value in geophytes. These traits are also vital to check the acclimation of exotic cultivars to new environment. Tested exotic cultivars differed significantly ($P \leq 0.05$) from each other in their response of bulbils traits (Fig. 3d, e and f). Highest mass of bulbils per clump was found in Clear water cultivar though the maximum number of bulbils and their diameter were found in Leen Vander Mark and Apeldorn cultivar respectively. Least bulb mass was noted in plants of Queen of night followed by Purple flag. Similarly, the cultivar Purple flag exhibited the least number of bulbils and bulbil diameter.

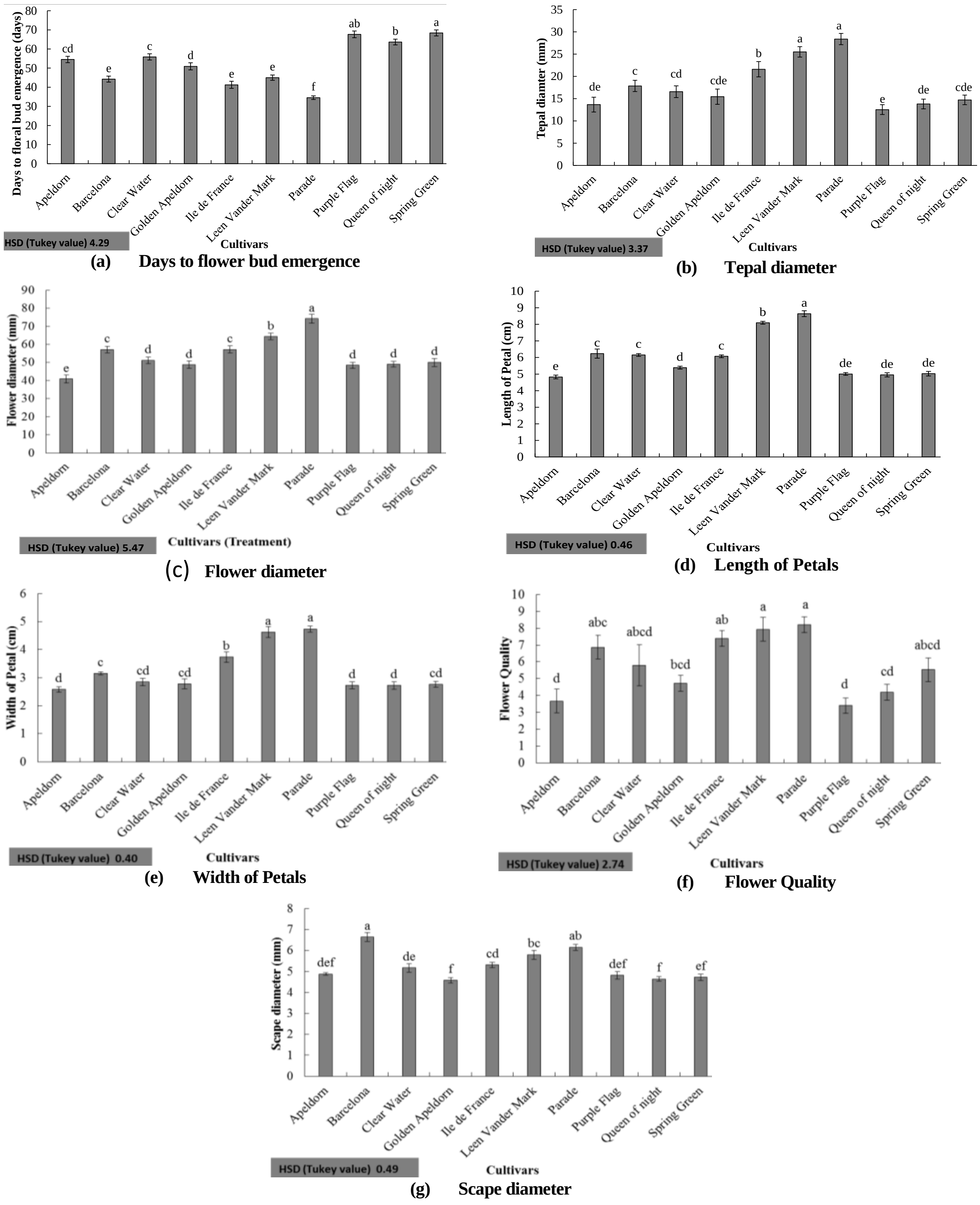


Fig. 2: Graphical presentation of floral attributes of different cultivars of tulips grown under Faisalabad conditions (a) Days to flower bud emergence (days), (b) Tepal diameter (mm) (c) Flower diameter (mm), (d) Length of petals (cm), (e) Width of petals (cm), (f) Flower quality, (g) Scape diameter (mm)

Discussion

Tulip cultivars responded differently under Faisalabad conditions which explain the fact that they are environment specific in their growth performance and potential under different environmental conditions which exists in other flower crops like gladiolus (Ahmad *et al*., 2013). Majority of the phases involved in growth and development in bulbous plants is coined with seasonal thermoperiodicity that regulates growth cycle in them (Khodorova and Boitel-

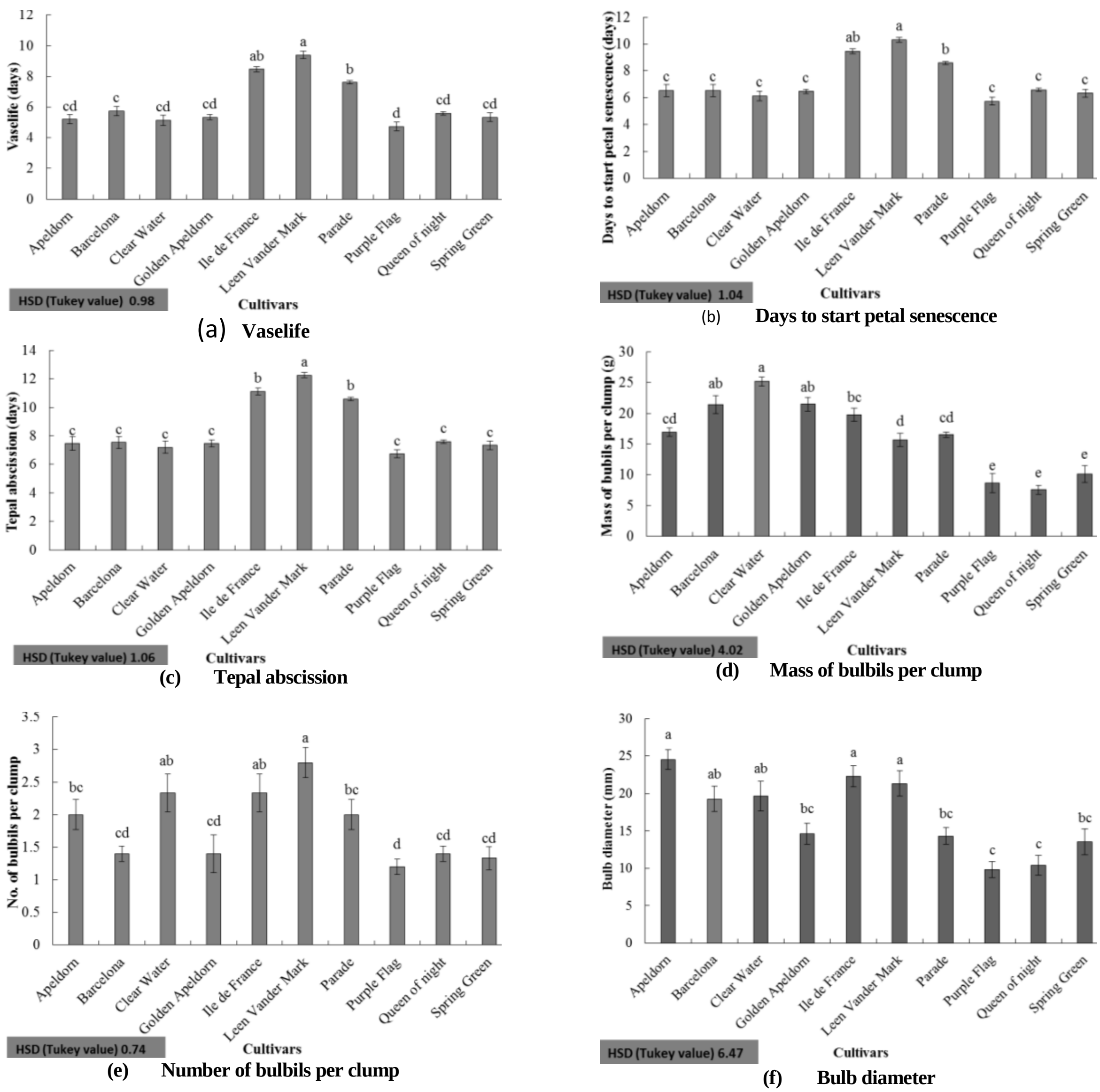
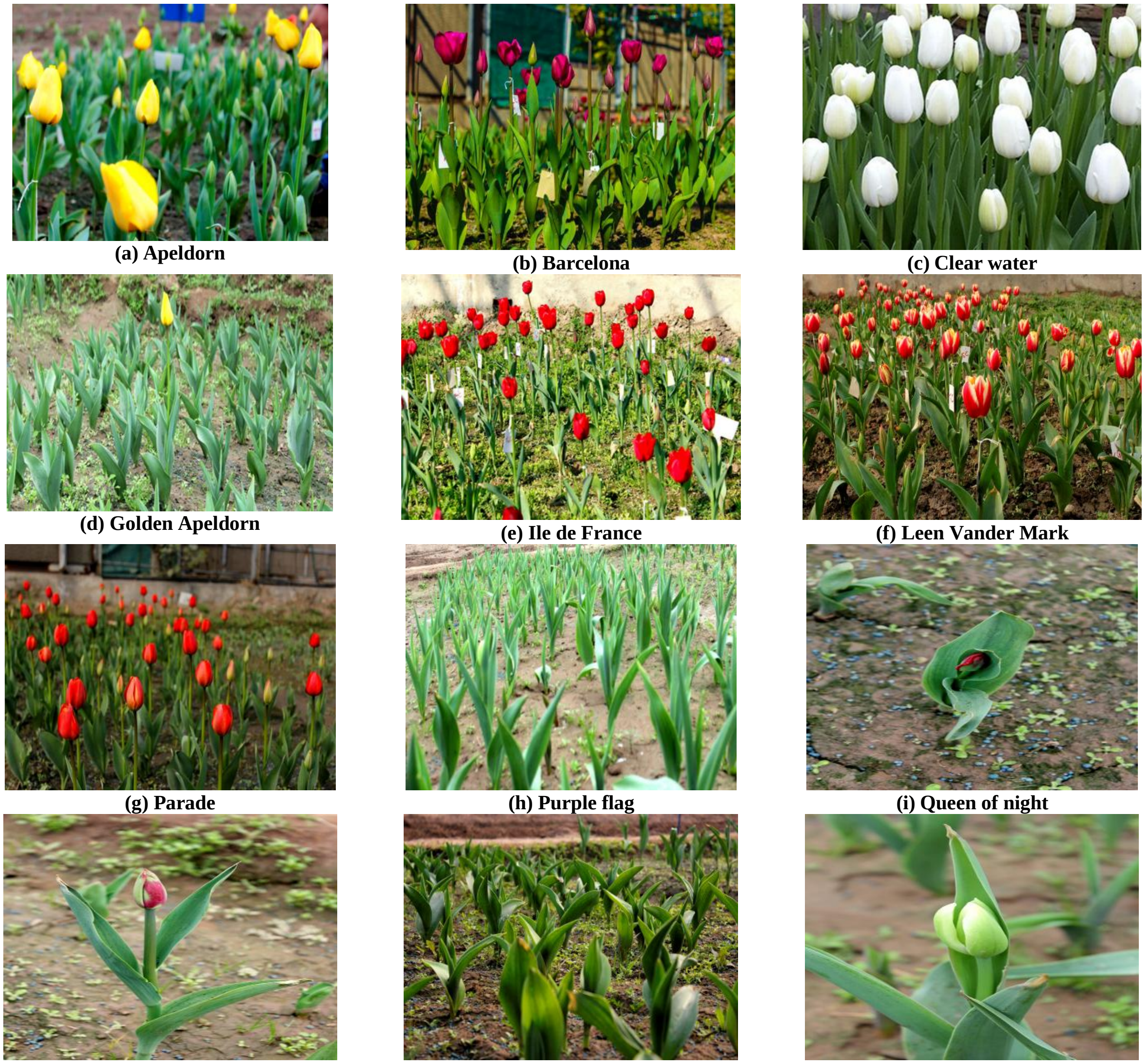


Fig. 3: Graphical presentation of display life and bulb attributes of different cultivars of tulips grown under Faisalabad conditions (a) Vase life (days) (b) Days to start senescence (days), (c) Tepal abscission (days), (d) Mass of bulb per clump (g), (e) Number of bulbils per clump, (f) Bulb diameter (mm)

Conti, 2013). Various environmental stimuli like light, humidity and temperature influenced the development of perennating organs as well as aerial parts of the plants that play predominant role in scheming growth and flowering pattern (de Hertogh and le Nard, 1993). In the present study, different morphological, floral and bulbous attributes varied significantly among the tested cultivars. Parameters like leaf morphology, leaf area and stem diameter are the ultimate indicator of adequate temperature condition during various stages of growth (Samach, 2012). However, these parameters do not sufficiently depict the environmental factors involved in completing the short duration of plant life cycle in the spring season (de Hertogh and le Nard, 1993). As, earlier studies have proven that leaf expansion is regulated differentially in different genotypes of Arabidopsis (Massonnet *et al*., 2015). Therefore, more chlorophyll contents in Leen Vander Mark and Barcelona cultivar may be produced by better leaf development (Houborg *et al*., 2015).

During growth phase rapid cell division occurred at relatively higher temperature (18/14°C day/night) in majority of the bulbous flower crops that hastens flowering but the flower size remains smaller at this range (Gandin *et al.,* 2011). Highest leaf area, fresh and dry mass were observed in plants of (Parade cultivar, followed by Leen Vander Mark) that revealed their better adaptability regarding growth and quality indices based on biomass production, caused by favorable environment (Ens *et al*.,



(a) Apeldorn **(b) Barcelona** **(c) Clear water**
(d) Golden Apeldorn **(e) Ile de France** **(f) Leen Vander Mark**
(g) Parade **(h) Purple flag** **(i) Queen of night**
(j) Queen of night at harvesting stage **(k) Spring green** **(l) Spring green**

Fig. 4: Growth response of different cultivars of tulip in open field under Faisalabad condition

2013). Hence, warmer spring yielded lower quantity of bulbs than for the plants in relatively low temperature (12/8°C), which sustained the growth with prolonged freshness (Badri *et al.*, 2007; Lundmark *et al.*, 2009). Earlier flower bud emergence resulted in early completion of life cycle in tulips and ascertained the harvesting stage in exposure to low temperature conditions (Noy-Porat *et al.*, 2009) with better floral attributes. Moreover, flower initiation and development required particular duration of low temperature exposure for florogenesis. This condition might have activated various sucrose-cleaving enzymes in the bulbs because of warmer temperature that resulted in rapid shift from cell elongation to cell maturation that impeded starch accumulation (Lundmark *et al.*, 2009; Gandin *et al.*, 2011). Carbon assimilation beyond the optimum temperature at higher temperature regimes aggravated the incorporation capacity of carbon in the bulbs that might lead to feedback inhibition in the rate of photosynthesis. As the duration of photosynthetically active period increased, it delayed the flower senescence (Shahri and Tahir, 2011) with improved display life of Leen Vander Mark cultivar.

Tepal and flower diameter were totally dependent upon the bulbs vigor while Sestras *et al.* (2007) reported that various tulip cultivars have their specific set of climatic compatibility and peculiar genetic potential. Likewise, highest bulb mass observed in Clear water followed by Golden Apeldorn, Apeldorn, Barcelona, Leen Vander Mark and Parade depicted that they had sufficient energy reserves to develop a healthier crop in the succeeding year. Memon *et al.* (2009) reported that cormel mass varied from variety to variety in gladiolus crop. Highest number of bulbils and their diameter were found in Leen Vander Mark and Apeldorn cultivar respectively. Highest number of bulbils in these cultivar might be due to its better acclimation and interaction with environment (Jhon *et al.,* 2007). From this trend, it can be inferred that better growth, leaf development and improved biomass of Parade cultivar attributed to its highest quality score than other cultivars. This stands true with the findings of Asghari (2014) where low temperature conditions improved the cut flower quality in tulips.

Conclusion

Leen Vander Mark, Barcelona, Parade and Ile de France cultivar of tulip were found better performing and acclimatized to climatic conditions of Faisalabad. As their growth, morphology, flower quality and post-harvest response was superior to other tested cultivars. Due to better interaction of these cultivars with environmental conditions of Faisalabad these are suggested for their commercial cultivation for cut flower production and ornamental use.

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(Received 20 February 2017; Accepted 16 March 2017)