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Original paper

Flowering Phenology, Stalk Anatomy and Vase Life of Four Cultivars of Gerbera hybrida

(Flowering Phenology, Stalk Anatomy of Gerbera)

SORINA A. PETRA[1], MIHAELA I. GEORGESCU[1*], CRISTINA R. MANESCU[1], FLORIN TOMA[1], IOANA M. PADURE[3], ELENA SĂVULESCU[2], ELISABETA DOBRESCU[1]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Horticulture, Department of Landscape architecture, Biodiversity and Ornamental plants, 59 Marasti Boulevard, District 1, 011464, Bucharest, Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Horticulture, Department of Bioengineering of Horti-Viticultural Systems, 59 Marasti Boulevard, District 1, 011464, Bucharest, Romania
[3]Universalmuseum Joanneum, Natural History Museum, Weinzöttlstraße 16 8045 Graz, Österreich, Austria;

Abstract Flowering phenology is an important feature for producers to establish planting time and time of harvest. Because each cultivar reacts different in similar growth conditions, due to their complex genetic inheritance, studies may initiate to evaluate their performance. Cultivars 'Aladin','Anita', 'Creme Eye' and 'Navelino' were investigated during autumn-winter regarding flowering phenology, stalk anatomy and vase life of cut flowers. Results showed some differences among cultivars. Cultivars needed 55-58 days from planting to flowers harvesting, but the intermediate phases were dissimilar. Transverse sections of stalk in the apical and median zone showed that cultivars developed structures to sustain the inflorescence, thus the neck bending and stalk bending had an insignificant occurrence. Except 'Creme Eye', all the cut flowers performed best in tap water, with a vase life of 15.2-19.1 days. Cultivars proved suitable for greenhouse cultures in Romania.

Keywords *Gerbera hybrida*, bud initiation, inflorescence, sclerenchyma, vase solutions.

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✉ *Corresponding author: MIHAELA IOANA GEORGESCU, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Horticulture, Department of Landscape architecture, Biodiversity and Ornamental plants, 59 Marasti Boulevard, District 1, 011464, Bucharest, Romania; Tel. +40728023011; postal address: 59 Marasti Boulevard, District 1, Bucharest, Romania; zip code: 011464
E-mail: mihaelaigeorgescu@yahoo.com;

Introduction

Cultivars of *Gerbera hybrida* are extremely appreciated worldwide for the flowers coming in a different range of colour, shape and size. Due to their complex genetic inheritance – *Gerbera jamesonii* x *Gerbera viridifolia*, and probable some other species (TOURJEE et al, 1994; HANSEN, 1999), cultivars proved different reaction to growth conditions (MENG et al, 2004; HATAMZADEH et al, 2012; LI et al, 2019; CANTOR and BUTA, 2011) and postharvest longevity (WERNETT et al, 1996).

In order to acquire the maximum yield of quality flowers, producers have to consider not only *Gerbera* cultivars' requirements, but also to take knowledge about flowering phenology at each cultivar they grow. In Europe, flowering of *Gerbera* is problematic during winter months, mainly because of the impossibility to establish a good relationship among day length, temperature and light level (DE VISSER et al, 2010; DE GELDER et al, 2014; DUECK et al, 2017). Although *Gerbera* is a short day plant, it produces fewer flowers as the nights become shorter and supplying light during winter have positive effect on yield (AUTIO, 2000; PETTERSEN and GISLEROD, 2003; CRISTIANO et al, 2008).

Although, the postharvest life span of the cut flowers varies with the cultivars (MAHMOOD et al, 2013; BISWAL et al, 2017; ZAHARIA et al, 2018), growing season had also an influence on the vase-life longevity. In some cultivars, the longest vase-life (18.37 days) was found in flowers harvested in winter (ACHARYA et al, 2010).

The purpose of this work was to investigate the flowering phenology, stalk anatomy and vase life of cut flowers of four cultivars of *Gerbera hybrida*, in greenhouse conditions, during autumn-winter, in order to establish their performance and provide helpful information to growers and consumers.

Material and Methods

Investigations were carried out during September – December 2019 on plants of four cultivars of *Gerbera hybrida* ('Aladin', 'Anita', 'Creme Eye' and 'Navelino'), at the University of Agronomical Sciences in Bucharest (latitude 44°24'49"N and longitude 26°05'48"E), Romania. In September, plugs were planted in individual plastic pots (diameter = 18 cm, height = 16 cm) containing a mixture of garden soil, sawdust compost, peat and perlite in a volume ratio of 1:1:1:0.25. Pots were placed in a greenhouse with hanging growing gutter system, under natural illumination, at 20-24°C. Nutritive solutions containing N:P:K in a volume ratio of 3:1:5, were distributed with the water through drip irrigation system. For flowering phenology, 20 plants from each cultivar were observed once at three days, from the flower budsinitiation to wilting flower.

For anatomical investigations, hand cross-sections of flower stems were carried outin two zones, beneath inflorescence (apical zone) and at 15 cm below it (median zone). The sections were clarified with chloral hydrate in saturated solution, for 24 hours and washed with tap water. Observations and measurements were performed with the Leica DM 1000LED microscope, with the eye piece lens of 10 x and objective lenses 25 x, provided with LAS-CORE software. Photos were taken with the DFC 295 camcorder.

Vase life was tested in December 2019, whenten flowers from each cultivarwere harvested in the morning at the commercial maturity (when the two outer whorls of flowers in the floral head showed mature stamens). The experience was designed to reproduce the conditions that consumers can provide at home. Therefore, stalks end were cut in water at 35 cm length and then placed individually in 100 ml glass cylinders, filled with : S_0 – tap water (control); S_1 – lemon juice 2% + sucrose 1% + 0.2% bleach; S_2 – colourless soft drink 50% + ½ tablet aspirin; S_3 – a commercial universal preservative for cut flowers; S_4 – a commercial cut flower food. The flowers were kept in a room with indirect light, at an average air temperature of 22-24ºC.

Data were analyzed statistically using one-way ANOVA test and significance of the difference among means was estimated with LSD (Least Significant Difference) Post Hoc Test at 5% level of significance.

Results

Flowering phenology varied with the cultivar (Table 1). Flowers were ready to be harvested after 55.05-58.05 days after planting.

Table 1. Phenological response of *Gerbera hybrida* cultivars

Cultivars	Days from planting to harvest	Days from planting to bud initiation	Days from bud initiation to harvest	Days from harvest to wilting flower	Inflorescence diameter (cm)	Stalk length (cm)
Aladin	58.05 a	27.10 a	31.90 a	15.20 a	7.46 c	44.72 b
Anita	55.10 b	23.80 c	32.00 a	10.35 d	8.51 a	47.54 a
Creme Eye	55.20 b	27.15 a	29.25 c	11.45 c	7.71 b	41.50 c
Navelino	55.05 b	24.90 b	31.05 b	13.05 b	7.02 d	39.63 d
LSD ($P \leq 0.05$)	*0.26*	*0.30*	*0.23*	*0.36*	*0.11*	*0.85*

(LSD – Least Significant Difference)
All data within columns with the same letter are not statistically different at $P \leq 0.05$.

Although three of the cultivars – 'Anita', 'Creme Eye' and 'Navelino', needed 55 days to grow and develop until harvest, the intermediate phases were quite different. First cultivar that initiated flower buds was 'Anita' (23.80 days after planting). At the rest of cultivars bud initiation was observed soon after (in 1-3 days). The time required for flowers to reach the commercial stage for harvest varied between 29.25 days ('Creme Eye') and 32.00 days ('Anita').The largest inflorescence (8.51 cm) was measured at 'Anita' cultivar and the smallest (7.02 cm) at 'Navelino'. Inflorescences development differed with the cultivars (Fig. 1).

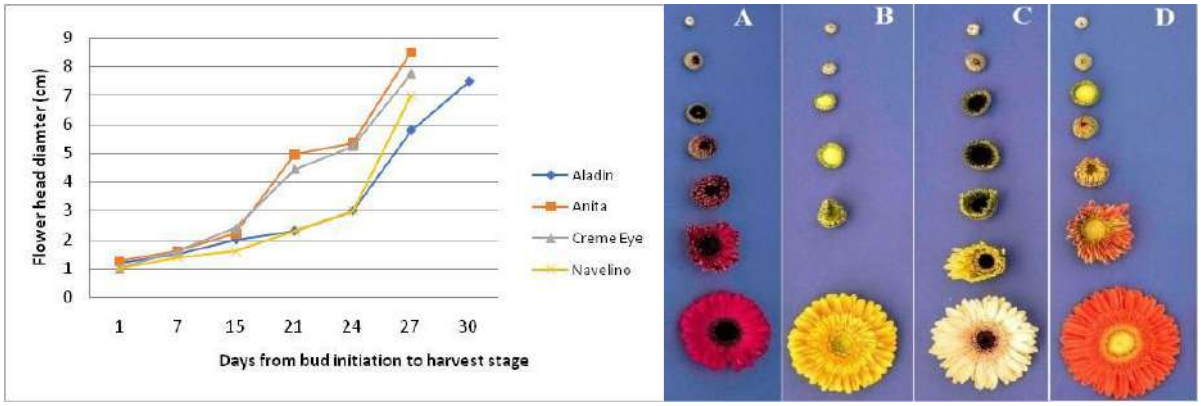

Figure 1. Dynamic of inflorescences development from bud initiation to harvest.
(A – Aladin; B – Anita; C – Creme Eye; D – Navelino)

After 15 days from bud initiation, cultivars 'Anita' and 'Creme Eye' had an intense development, flowers doubling their size in five days. For the other two cultivars, flowers increased more in size after 21 days. Stalk length varied also with the cultivar, with a minimum value of 39.63 cm at 'Navelino' and a maximum value of 47.54 cm at 'Anita', at the time of harvest. Inflorescence life span on plant, after commercial stage of harvest, varied from 15.02 days ('Aladin') to 10.35 days ('Anita').

Stalk transverse sections showed slightly differences among cultivars. The epidermal cells areisodiametic, single-layered and covered with cuticle (Fig. 2). Excepting the 'Creme Eye', all cultivars may havetector trichomes on epidermis. The parenchyma cells were almost isodiametric at all cultivars. At 'Creme Eye' cultivar first layers of parenchyma were slightly collenchymatic. The parenchyma layer appeared much larger in apical than in median zone at all cultivars (Table 2). Central cylinder was delimited by a sclerified pericycle and the vascular bundles of various sizedwere placed alternately. In apical zone, pericycle appeared as an interrupted sclerenchymatic ring, evident only next to vascular bundles. In median zone, pericycle formed a continuous ring, much more developed next to the vascular bundles.

All cultivars presented a decrease of sclerenchyma next to the vascular bundles from the median to the apical zone, as well as the thickness of the cell walls.

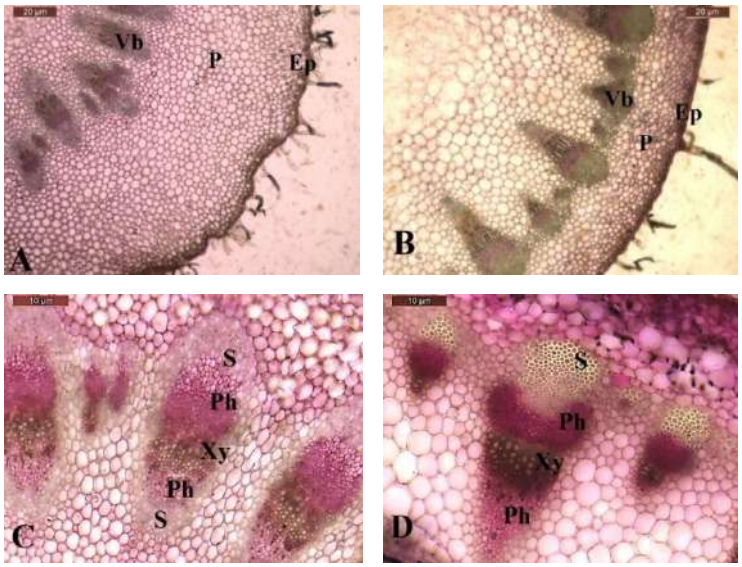

Figure 2. Microscopic images of stalk section: **A**) apical zone; **B**) median zone; **C**) details of central cylinder in apical zone; **D**) details of central cylinder in median zone. (Abbreviations: Ep – Epidermis, P – Parenchyma, Ph – Phloem, S – Sclerenchyma, Vb – Vascular bundle, Xy – Xylem).

Table 2. Stalk anatomy characteristics of four cultivars of *Gerbera hybrida*

Characteristics (µm)	Aladin		Anita		Creme Eye		Navelino	
	Apical zone	Median zone	Apical zone	Median zone	Apical zone	Median zone	Apical zone	Median zone
Parenchyma	494.2	224.1	450.7	224.7	482.9	220.3	525.4	260.1
Vascular bundle length	361.4	512.9	399.3	470.6	359.5	458.3	348.6	446.7
Sclerenchyma	77.3	148.8	85.8	152.1	70.9	134.9	83.4	121.8
Upper phloem	108.1	72.9	103.6	53.5	100.2	56.7	86.5	60.7
Xylem	90.6	95.0	95.8	88.4	70.3	91.1	85.3	86.7
Lower phloem	82.9	127.0	56.9	48.2	63.1	106.9	78.3	79.8

In the apical area, cultivar 'Anita' formed an extended sclerenchyma, but the cell walls were very slightly thickened. Vascular bundles were bicollateral type, with the xylem delimited by an extensive upper phloem and a smaller lower phloem. The length of vascular bundles decreases from the median to the apical zone at all cultivars.Flowerstalks kept in water had increased vase life relative to other solutions, for all cultivars except 'Creme Eye' (Table 3).

Table 3. Reaction of cultivars to different vase solutions

Parameters	Solution	Cultivars				LSD*
		Aladin	Anita	Creme Eye	Navelino	
Vase life (days)	S_0	19.1 a	15.2 c	14.2 d	16.0 b	*0.31*
	S_1	16.3 b	15.1 c	16.9 a	8.2 d	*0.35*
	S_2	12.1 b	9.3 d	14.1 a	11.4 c	*0.37*
	S_3	13.7 c	14.4 b	17.2 a	11.9 d	*0.50*
	S_4	17.5 a	9.1 d	15.4 b	11.4 c	*0.57*
Solution uptake (ml)	S_0	30.4 b	30.3 b	32.0 a	31.4 a	*0.84*
	S_1	39.0 b	34.5 c	33.6 c	40.9 a	*1.70*
	S_2	34.7 b	37.0 a	33.2 c	31.4 d	*0.71*
	S_3	33.3 b	30.1 c	37.6 a	33.8 b	*0.96*
	S_4	29.8 c	37.3 b	39.4 a	36.5 b	*1.19*
Stalk elongation (mm)	S_0	70.3 a	0.1 d	20.4 c	35.2 b	*0.57*
	S_1	35.5 a	5.1 d	30.9 b	20.8 c	*0.93*
	S_2	80.2 a	0.2 d	30.6 c	35.0 b	*0.65*
	S_3	75.7 a	50.4 b	35.3 d	40.4 c	*0.69*
	S_4	70.5 a	40.7 b	30.4 c	30.8 c	*1.09*

*(LSD – Least Significant Difference)
All data within rows with the same letter are not statistically different at $P \leq 0.05$.

However, all the vase solutions preserved the flowers at least 8 days. The longest vase-life was remarked at 'Aladin' cultivar (19.1 days in S_0). Neck bending problem was observed only in case of cultivar 'Anita', held 9.3 days in solutions S_2 and 15.1 days in S_1 (Fig. 3). Stalk bending, another frequent problem of *Gerbera* flowers shortened vase life at all cultivars kept in solution S_2. Stalk bending was observed more in case of cultivar 'Navelino'.

Fig. 3. Aspects from the vase life experiment: (1) after 10 days; (2) after 16 days.
(A – 'Aladin'; B - 'Navelino'; C – 'Creme Eye'; D – 'Anita'. Solutions: S_0 – tap water; S_1 – lemon juice 2% + sucrose 1% + 0.2% bleach; S_2 – colourless soft drink 50% + ½ tablet aspirin; S_3 – a commercial universal preservative for cut flowers; S_4 – a commercial cut flower food).

Solution uptake was different with cultivar. The minimum uptake was of 29.8 ml at 'Aladin' on solution S_4 and the maximum of 40.9 ml at 'Navelino' on solution S_1. Two of the cultivars, 'Aladin' and 'Navelino' absorbed more solution S_1 and the other two, 'Anita' and 'Creme Eye', solution S_4.

Stalk elongation was presentedwith different intensitiesat all cultivars. The greatest tendency of elongationshowed 'Aladin', with values between 35.5-80.2 mm in different solution, including tap water. In some solutions, 'Anita' cultivar remained at the same stalk length as at the beginning of the experiment (S_0 and S_2) and in other solutions the stalks grew up till 50.4 mm (S_3).

Discussion

Variations between cultivars regarding flowering phenology were confirmed by other authors (SARKAR and GHIMIRAY, 2004; CHOBE et al, 2010; LONGCHAR and KEDITSU, 2013; PATIL and KULKARNI, 2015). However, the time from planting to harvest was similar for three of the four cultivars in this study ('Anita', 'Creme Eye' and 'Navelino') even if the buds initiation and their development were at a different rate. Autumn planting proved to be favourable for evolution of *Gerbera* plants, which initiated flowers in less than a month and opened first flowers after 55-58 days from planting. The time needed by *Gerbera* plants to induce and open flowers depends greatly by cultivar, temperature and light (DENG and HARBAUGH, 2010; PETTERSEN and GISLEROD, 2003; CRISTIANO et al, 2008). Except for 'Navelino' cultivar, inflorescences had have diameters at the upper limit of the producers' indications. Instead the stalk length, which in the case of *Gerbera* cut-flowers is desirable to be at least 50 cm, it did not exceed this value at any cultivar. Variations in inflorescence diameters and stalk length were reported also by other authors (JEEVAJOTHI et al, 2003; SHAMMY et al, 2012; HOSSAIN et al, 2015), who suggested that they are genetically and environmentally controlled.

Observations at anatomical level revealed the existence of structures to sustain the inflorescence at all cultivars. Although mechanical tissues were absent in apical zone, the thickness of cortical parenchyma can support the inflorescence only by hydration of its cells. Therefore, except 'Creme Eye', all the cut flowers performed best in tap water. Also, neck bending had an insignificant occurrence. For all cultivars, in the median zone parenchyma layers were collenchymaticand consequently the incidence of stalk bending at cut flowers was reduced. Some authors presumed that the stalk strength of cut flowers is closely related with the lignifications of xylem and intervascular sclerenchyma cells (MAROUSKY, 1986; DONALDSON, 2001; PERIK et al, 2012; HAMEDAN et al, 2019).

Independent of vase solutions and cultivar, flowers lived more with 3-6 days in tap water or other solutions than those that remained on the plant, at the same stage (commercial maturity). Despite of fact that water preserved longer time the cut flowers, solutions that were uptaked more were S_1 at 'Aladin' and 'Navelino' and S_4 at 'Anita' and 'Creme Eye'. The presence of sucrose and other food components of these solutions could explain the result, similar with other studies (NAIR et al, 2003; MEMAN and DABHI, 2006; KHAN et al, 2015).

Conclusions

Studies on flowering phenology revealed differences among cultivars. The quality of the inflorescences obtained during autumn-winter period, expressed by their diameter and stalk length was satisfactory for all four cultivars. Also, the postharvest quality of the cut flowers was reasonable. The anatomy of the stalks revealed that all cultivars presents structures, which can prevent neck bending and stalk bending, even if the vase solution is simply water. However, more researches are needed to test the different planting time, because is generally known the influence of light and temperature on the performance of *Gerbera* cultivars. Due to the stalk elongation problem, cultivar 'Aladin' is not recommended for combination with other flower in mixed bouquets or flower arrangements.

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