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Effect of Cultivar on Water Relations and Postharvest Quality of Gerbera (*Gerbera jamesonii* Bolus ex. Hook f.) Cut Flower

[1]Nazari Deljou Mohammad Javad, [2]Pour Youssef Mahmood,
[3]Karamian Roya and [4]Jaberian Hamedani Hamideh

[1]Department of Horticulture, Mahabad Branch, Islamic Azad University, Mahabad, Iran
[2]Department of Agronomy, Mahabad Branch, Islamic Azad University, Mahabad, Iran
[3]Department of Biology, Bu-Ali Sina University, Hamedan, Iran
[4]Department of Biotechnology, Tehran Branch, Payame Nor University, Tehran, Iran

Abstract: Vase life, stem bending percentage and water uptake were evaluated in 15 different gerbera (*Gerbera jamesonii* Bolus ex. Hook f.) cultivars. There were significant differences for vase life (10-18 days), stem bending percentage (0-100%) and average of water uptake during 10 days. Results showed that there were close relationship between vase life and water uptake and also stem bending and water uptake; so the cultivars with high water uptake had a longer vase life and lower stem bending percentage. Also, the cultivars with longer vase life and lower stem bending showed steady water uptake rate than cultivars with shorter vase life and higher stem bending. The results led to the conclusion that cultivar and water relation had a significant effect on gerbera postharvest quality, particularly, vase life and stem bending.

Key words: Stem bending · Vase life · Water uptake · Cultivar screening · *Gerbera jamesoni*

INTRODUCTION

Gerbera (*Gerbera jamesonii* Bolus ex. Hook f.) is one of ten popular cut flowers in the world and according to the global trends in floriculture; it occupies the fourth place in cut flowers [1]. The main postharvest disorders of cut gerbera flowers are flower wilting and stem break [2]. The main reasons of these disorders are genetic [3, 4], water relation [5], postharvest storage temperature [6] and some phytohormones [7, 8]. Genetic has a critical role in vase life and stem bending of gerbera [9]. Ferrante *et al.,* (2007) [3] in a cultivars screening experiment on gerbera cultivars showed that vase life varied among cultivars and ranged between 5 and 24 days. Also, four cultivars did not show stem bending. On the contrary, five cultivars showed stem bending. Water relation is another important and complex factor that affecting vase life and postharvest quality of cut flowers. Cut flowers and foliage can have limited commercial value because they dehydrate during vase life as a result of decreased water uptake [10]. Cut flower and foliage develop water deficit even when placed in water [11, 12]. Occlusion in the xylem, air embolism (cavitation) [12], lignification and formation of suberin in the cut end of flower stem [6] are the important factors that affecting water relation and water uptake in cut flowers. Celikel *et al.,* (2011) [13] with an investigation on inhibitors of enzyme induced lignin and suberin formation in cut end of flowering stems such as peroxidase and polyphenol oxidases in *Acacia holosericea* and *Chameloucium uncinatum,* showed that enzyme inhibitors led to lesser deposition of phenolic compounds and consequently increasing in water uptake and vase life.

Therefore, this experiment was conducted on 15 important and commercial cultivars to assess the role of cultivars and their differences in water uptake and also investigation on relationship between genetic (cultivar) and water uptake and their effect on vase life and stem bending. In addition, in attention to cultivar dependent of stem bending disorder and also high number of new gerbera cultivars with different stem bending that there is a little information about their postharvest quality [14], the other goal of this study was the screening and introducing of the high quality cultivars as an applied and simple strategy for reduction of production cost and postharvest losses.

Corresponding Author: Nazari deljou Mohammad Javad, Department of Horticulture, Mahabad Branch, Islamic Azad University, Mahabad, Iran. Tel: +98-9183183638.

MATERIALS AND METHODS

Plant Material, Treatments and Environmental Conditions: Fifteen different cultivars of cut gerbera flowers ('Pinta', 'Dolores', 'Venezia', 'Deep Purple', 'Byoux', 'Diego', 'Classic Fabio', 'Gaby', 'Amati', 'Pre Extase', 'Alma', 'Lieke', 'Stanza', Candida' and 'Nineke') were obtained from commercial growers in June 2010 and transferred to the postharvest laboratory in Department of Biology, Faculty of Science, Bu-Ali Sina University, Hamedan, Iran. The experiment was arranged in completely randomized design with three replications and was done at least with 9 flowers for three replications. Flower stems were cut to 30 cm, weighted and placed in 400 ml distilled water. All experiments were performed in a postharvest room equipped with a controlled environment maintained at 20 ± 1°C, 60 ± 5% relative humidity and 20 ìmol/m^2/s light intensity for 12 h/day by cool-white fluorescent lamps. Vase life was recorded as the time period when more than one third of the outer petals of inflorescence start to be brown/wilted. Fresh weight of flowers was recorded daily and increase or decrease of fresh weight was compared to that of day 0 as initial fresh weight (IFW %) over 10 days. Cumulative uptake of vase water was estimated by measuring the vase water remaining after every 24 h and total loss in vase water was expressed as ml g^{-1} FW d^{-1} [15, 16].

Determination of Stem Bending: The stem bending in gerberas was determined and classified based on Celikle and Reid (2002) method [5]. Scape curvature was measured daily using a protractor and expressed with respect to the angle on Day 0 of vase life. The gerberas were rated as follows: 0 for bending up to 15°, 1 for bending between 15° and 25°, 2 for bending between 25° and 65°, 3 for bending between 65° and 90° and 4 for flowers that bent more than 90°.

Determination of Ion Leakage Percentage: Ion leakage percentage for estimation of membrane permeability was measured using an electrical conductivity meter based on Poovaiah (1973) method [17]. Petal samples were cut into 1 cm segments and placed in individual stoppered vials containing 25 ml of deionized water after two washes with distilled water to remove surface contamination. These samples were incubated at room temperature (25°C) on a shaker (150 rpm) for 30 min. Electrical conductivity of solution (EC1) was read after shaking. Samples were then placed in thermostatic water bath at 95°C for 15 min and the second reading (EC2) was determined after cooling the solutions to room temperature. Ion leakage percentage was calculated as EC1/EC2 and expressed as percent.

Statistical Analysis: Data were statistically analyzed using one-way analysis of variance with SAS statistical software (SAS version 8.2; SAS Institute (1991) and mean separation for the main effects and the interactions were tested by Duncan's multiple range tests. Effects were tested at $P < 0.05$.

RESULTS

Water Uptake and Fresh Weight: Cumulative water uptake by each cultivar is expressed as ml/g FW (Table 1). During the first 10 days period, there were significant variations between cultivars in water uptake. The highest water uptake was observed in 'Dolores', 'Nineke' and 'Amati' with 5.64, 5.28 and 5.19 ml/g FW, respectively; but the lowest water uptake was observed in 'Stanza', 'Diego' and 'Gaby' with 3.09, 3.42 and 3.53 ml/g FW, respectively. Cultivars such as 'Amati', 'Nineke' and 'Dolores' had a relatively higher water uptake rate (Figure 1) for longer time period than the other cultivars such as 'Stanza', 'Diego', 'Pinta' and 'Gaby' (Figure 2) which has lower water uptake rate for shorter time, that finally decreased sharply.

Ion Leakage Percentage: Ion leakage percentage varied significantly between cultivars ($P<0.05$). 'Pinta' (7.01), 'Byoux' (6.37) and 'Stanza' (6.02) cultivars showed the highest percentage of ion leakage and 'Venezia' (3.89), 'Alma' (4.46) and 'Dolores' (4.47) showed the lowest (Table 1).

Table 1: Water uptake, ion leakage percentage and growth rate of 15 different commercial cultivars

Cultivar	Water uptake (ml/g FW)	Ion leakage percentage	Growth rate (cm)
Pinta	4.46^{bcd} †	7.01^{a}	1.58^{f}
Dolores	5.64^{a}	4.47^{cd}	3.5^{cde}
Venezia	4.22^{bcde}	3.89^{d}	5.16^{abc}
Deep Purple	3.75^{de}	5.09^{bcd}	3.41^{de}
Byoux	3.75^{de}	6.37^{ab}	2.91^{ef}
Diego	3.42^{de}	4.83^{bcd}	3.4^{de}
Classic Fabio	4.13^{cde}	5.44^{abcd}	2.16^{ef}
Gaby	3.53^{de}	4.82^{bcd}	5^{abcd}
Amati	5.19^{abc}	6.1^{abc}	5^{ab}
Pre Extase	3.56^{de}	5.06^{bcd}	2.91^{ef}
Alma	4.33^{bcd}	4.46^{cd}	4.66^{abcd}
Lieke	3.66^{de}	6.44^{ab}	3.75^{bcde}
Stanza	3.09^{e}	6.02^{abc}	2.33^{ef}
Candida	4.09^{cde}	5.73^{abcd}	2.66^{ef}
Nineke	5.28^{ab}	6.02^{abc}	6^{a}

† Means followed by the same letter do not differ significantly using Duncan's Multiple Range Test ($P \leq 0.01$).

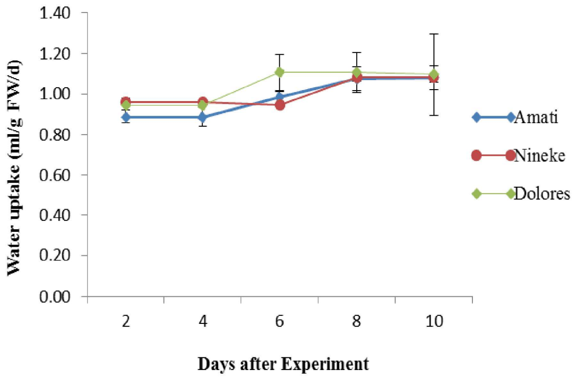

Fig. 1: High water uptake rate of *Gerbera jamesonii* cultivars. Each value is average of three replications.

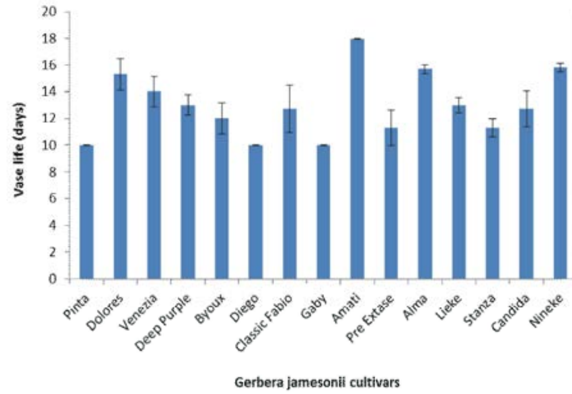

Fig. 3: Vase life of different cultivars of *Gerbera jamesonii.* Value are means with standard errors (n = 9).

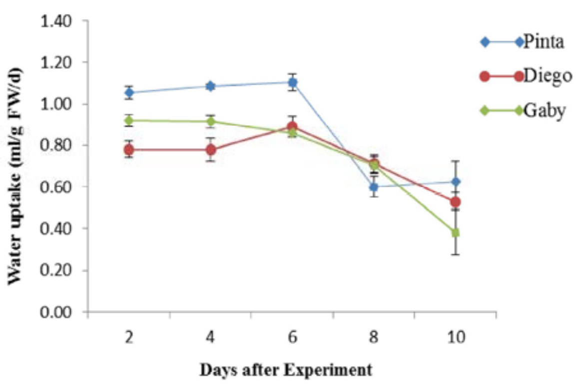

Fig. 2: Low water uptake rate of *Gerbera jamesonii* cultivars. Each value is average of three replications.

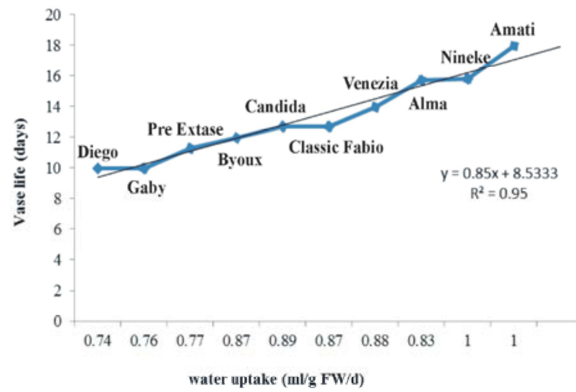

Fig. 4: Interaction between Vase life and water uptake rate of different cultivars of *Gerbera jamesonii.* Each value is average of three replications.

Vase Life: The cultivar screening showed interesting results for vase life. The vase life varied between cultivars and ranged between 10 to 18 days. Results showed that 'Amati', Nineke, 'Alma' and 'Dolores' had the vase life of 18, 15.8, 15.7 and 15.3 days respectively and 'Pinta', 'Diego' and 'Gabi' cultivars had 10 days vase life (Figure 3). It is interesting to investigate that the cultivars with the high water uptake rate had a long vase life indicating the postharvest longevity of those cultivars (Figure 4).

Growth Rate of Flowering Stem: Growth rate of the stem of the flower varied significantly ($p<0.05$) between cultivars. The highest growth rate after harvesting was observed in 'Nineke' with 6 cm and the lowest was observed in 'Pinta' with 1.47 cm (Table 1).

Stem Bending Percentage: There was a significant variation between cultivars in postharvest stem breaking

Table 2: Stem bending percentage of 15 different commercial cultivars

Cultivar	0-15?	15-25?	25-65?	65-90?	>90?
'Pinta'	0.00	0.00	0.00	33.3	66.7
'Dolores'	66.70	0.00	0.00	0.00	33.3
'Venezia'	16.60	16.70	0.00	0.00	66.7
'Deep Purple'	0.00	16.7	0.00	0.00	83.3
'Byoux'	83.60	0.00	0.00	0.00	16.6
'Diego'	100.00	0.00	0.00	0.00	0.00
'Classic Fabio'	66.70	0.00	0.00	16.3	16.3
'Gaby'	0.00	0.00	0.00	0.00	100
'Amati'	100.00	0.00	0.00	0.00	0.00
'Pre Extase'	50.00	0.00	0.00	0.00	50
'Alma'	83.40	0.00	0.00	0.00	16.3
'Lieke'	33.30	0.00	0.00	0.00	66.7
'Stanza'	16.70	0.00	16.6	0.00	66.6
'Candida'	100.00	0.00	0.00	0.00	0.00
'Nineke'	83.30	0.00	0.00	0.00	16.7

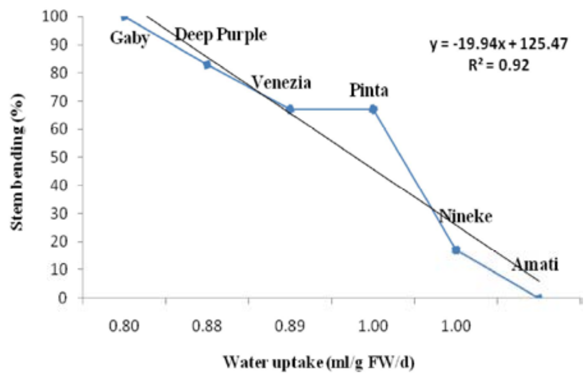

Fig. 5: Interaction between water uptake and stem bending of *Gerbera jamesonii* cultivars. Each value is average of three replications.

and stem bending based on curvature angle in 5 different rates (Table 2). The results showed that 100% of 'Amati'and 'Candida', 83% of 'Nineke' and 67% of 'Dolores' cultivars obtained rate 0 which was given to stems without bending or bending less than 15° and categorized as the cultivars that are resistant to stem bending. While 'Gaby' with 100%, 'Deep Purple' (83%), 'stanza' (66%) and 'Lieke' (67%) obtained rate 4; bending more than 90° and categorized as the cultivars that are sensitive to stem bending. Data for other cultivars in relation to stem bending is presented in Table 2. As shown in figure 5 the results highlighted that the cultivars with high water uptake rate had the lower stem bending.

DISCUSSION

The results of the present study revealed that, there were significant differences between gerbera cultivars for vase life (10-18), stem bending (0-100%), water uptake and ion leakage. Some cultivars had high flower wilting and high stem bending, some cultivars had low flower wilting, while showed high stem bending and finally some cultivars had longer vase life and lower stem bending percentage. In general, based on vase life and stem bending criteria, three different groups can be categorized for gerbera quality; 1-high quality cultivars, 2-moderate quality cultivars and 3-low quality cultivars. Cultivar differences in stem bending and vase life have been reported in gerbera [3, 4, 9] and roses [18]. The results showed that some gerbera cultivars such as 'Amati', 'Nineke' and 'Dolores' with low stem bending and longer vase life had high water uptake rate; on the contrary, some gerbera cultivars such as 'Gaby', 'Deep Purple', 'Stanza' and ' Lieke' with high stem bending and shorter vase life had lower water uptake rate. Water stress is a function of the water content at harvest and the rates of water uptake and water loss after harvest [11, 19, 25]. Cut gerbera flower after harvest is very sensitive to water uptake [20]. Van Meeteren (1978) [20] reported that 3 days before stem bending, water uptake and fresh weight of gerbera cut flower stem decreased sharply and finally led to stem neck. Also, many other researches have been reported that there is a close relationship between vase life and water stress in anthurium [21] and gerbera [4], which is in agreement with this study. In other words, as shown in figures 1, 2, 4 and 5, cultivars with steady rate of water uptake had a longer vase life; while other cultivars with unsteady water uptake rate had a shorter vase life. Elibox and Umaharan (2011) [22] suggested that cultivar differences in vase life may be mediated though difference in their ability to maintain a high water uptake rate; which is in agreement with these findings.

Based on the results presented in this study, the wide ranges of stem bending percentage (0-100%) in the cultivars (Table 2) suggested that this disorder is a cultivar dependent disorder. For example, 'Amati', 'Diego', 'Candida', 'Byoux', 'Nineke' and 'Dolores' cultivars had the lowest stem bending, while 'Gaby', 'Deep Purple', 'Stanza', 'Pinta', 'Venezia' and 'Lieke' had the highest stem bending among cultivars studied. The causes of stem bending in gerbera are not yet completely clear. Although the genetic variation may be the main reason for stem bending various other factors such as plant growth regulator, nutrient elements and storage temperature has direct effect on stem bending [3, 6, 7]. As investigated in the present study, decline in water absorption by cut flower stem seems to play a major role in stem break [20]. Meeteren (1978) [20] reported that in cut gerbera flowers, fresh weight decreased sharply 3 days before stem break occurred and this was accompanied by a decline in absorption of water by flower. The close relationship between water uptake, fresh weight and stem bending (Figures 1, 2 and 5), indicates that decline in water uptake accompanied by decrease of fresh weight, subsequently caused stem bending. The results of the present experiment were in line with these findings. Ion leakage percentage was another factor that varying significantly between cultivars (Table 1). Changes in the rate of ion leakage from tissue samples demonstrate changes in membrane permeability [23, 24]. Tissues with normal permeability properties can retain solutes uptake [20]. Hence, vase life was accompanied by ion leakage percentage (Table 1). For example 'Alma' and 'Dolores' cultivars with low ion leakage percentage (4.46 and 4.47%) had long vase life (15.7 and 15.3 days respectively) while 'Pinta' with 10 days vase life showed much more ion leakage percentage (7.01%). The results of the present experiment were in line with these findings.

CONCLUSION

The present study has shown that the vase life and stem bending in gerbera cut flower vary with the cultivars hence; genetic background plays a major role. Cultivars ability in high water uptake and low percentage of ion leakage are the main factors that lead for stem strength and straightness and for the long vase life which indicates the postharvest longevity. It is well known fact that a critical factor of the postharvest quality is longevity which relate with the vase life. Hence, the present work states that when screening cultivars for the postharvest quality of gerbera, the rate of water uptake and percentage of ion leakage could be used as feasible methods in evaluating cultivars. Our data indicated that cultivars such as 'Amati', 'Nineke' and 'Dolors' had both longer vase life and lower stem bending; while, other cultivars such as 'Gaby' and 'Pinta' had both shorter vase life and high stem bending. The results will be useful for breeders when breeding to improve postharvest loses. Therefore, for high postharvest quality, particularly, decrease of postharvest stem bending, screening and cultivation of chosen cut flower gerberas, (in attention to high number of new gerbera cultivars that there is no sufficient information about their postharvest quality) should be used as a proper strategy.

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