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Full Length Research Paper

Postharvest evaluation of vase life, stem bending and screening of cultivars of cut gerbera (*Gerbera jamesonii* Bolus ex. Hook f.) flowers

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Vase life and stem bending are the main factors for evaluation of postharvest quality of cut gerbera flowers. Recently, many new gerbera cultivars with different vase life and especially stem bending have been produced. This experiment was conducted to assess the postharvest quality in 21 different important cultivars, screening and selection of cultivars have the highest vase life and the lowest stem bending as an applied and proper strategy using a basic pulse treatment (HQS 600 ppm, citric acid 300 ppm and sucrose 4%); because of very high variation in new cultivars and also cultivar dependent of stem bending in gerbera. The result showed that there are significant differences between cultivars for vase life, stem bending, ion leakage and water uptake. 'Tropic Blend', 'Cacharelle' and 'Aventura' cultivars had maximum vase life and 'Onedin', 'Ecco' and 'Entourage' had minimum vase life. Stem bending varied from 0 to 100% between different cultivars. The results led to the conclusion that screening, introducing and finally, cultivation of selected cultivars with high qualities can be used to minimize the postharvest disorders such as stem break in gerbera, and then to minimize the production costs.

Key words: Cultivar screening, *Gerbera jamesonii,* postharvest quality, stem bending, vase life.

INTRODUCTION

Gerbera (*Gerbera jamesonii* Bolus ex. Hook f.) belongs to Asteraceae family, the largest family of flowering plants, and is one of ten popular cut flowers in the world and according to the global trends in floriculture, it occupies the forth place in cut flowers (Choudhary and Provad, 2002).

Maturity, freedom from defects, stem length, strength and straightness are important quality criteria in gerberas. The main postharvest disorder of cut gerbera flowers in addition to flower wilting is stem break that occurs 10 cm below the capitulum (Wilberg, 1973). Stem break, a sudden bending of the stem, occurs in many gerbera cultivars and is a practical problem affecting the sale of the flowers (Meeteren, 1978). The causes of stem bending in gerbera are not yet completely clear, but the important factors that affects this postharvest disorder are genetic factors; other factors include some phytohormones, mineral elements, water imbalance caused by bacteria activity in xylem vessels of cut flower, preharvest condition and storage temperature after harvest and during handling (Mancarlli et al., 1995; Botondi et al., 1998; Gerasopoulos and Chebli, 1999; Reid, 2001; Celikle and Reid, 2002; Emongor, 2004; Ferrante et al., 2007). *G. jamesonii* has more than 300 cultivars differing in weight, diameter, color and inflorescence (Garibaldi and Jona, 1989). Recently, high number of new cut gerbera varieties for example new varieties with leafy stems was produced and commercially cultured throughout the world. In addition to various cultural requirements such as nutrition and temperature, there are different vase life potential and stem bending as determinant factors for postharvest quality of new varieties. In earlier reported researches for increasing of postharvest quality in gerberas, different preservative and treatments such as silver nitrate have been recommended Such treatments may be in addition to increasing costs, have lateral effects, and affect environmental health.

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Nowke and Rudnicki (1990) presented information on difference in vase life among cultivars of some cut flower species. According to them 'Rosario' cultivar of *Alestromeria* had a longer vase life (17 days) than 'Pink panther' and 'Marleen' cultivar of *gerbera* (20.5 days) than 'Agnes' (8.3 days). Ferrante et al. (2007) in a cultivars screening experiment and PAL enzyme activity 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.

So recognition and selection of cultivars without or with minimum stem break and high vase life could be used as a proper strategy, because stem break is a cultivar dependent disorder (Ferrante et al., 2002). In addition to new cultivars with different levels of stem bending, there is no more information about their vase life and post-harvest qualities. So in this experiment, 21 different important cultivars differing in color and form of inflorescences, high marketability and high cultivation area in Iran were selected and arranged for screening and introduction of cultivars with best postharvest quality, subsequently introducing these cultivars to growers and reducing the production costs and also decreasing the postharvest disorders.

MATERIALS AND METHODS

Plant material, treatments and environmental conditions

Twenty one different cultivars of cut gerbera flowers (Dune, Popov, Martinique, Onedin, Aventura, Primrose, Monet, Basic, Entourage, Derim, Ecco, Candela, Cacharelle, Cabana, Stanza, Maniquin, Sazo, Double dutch, Sunway, Rozalin and Tropic Blend) were obtained from commercial growers in autumn 2009 and transferred to the postharvest laboratory in Department of Horticulture, Faculty of Agriculture, Tehran University. The experiment was arranged in completely randomized design with four replications and was done at least with 12 flowers for four replications. Flower stems were cut to 30 cm, weighted and placed for 24 h in pulse treatment of 300 ml vase solution with 300 ppm citric acid [C_6H5O_7-$(OOH)_3$], 600 ppm 8-hydroxyquinoline sulfate (8-HQS) (Sigma Chemical Co.) and 4% sucrose. All experiments were performed in a postharvest room equipped with a controlled environment maintained at 20 ± 1°C, 60 ± 5% relative humidity and 20 µmol/m^2/s light intensity for 12 h/day by cool-white fluorescent lamps. After the pulse treatment, all flowers were placed in 400 ml distilled water in glass tubes and each three days, distilled water was renewed. 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 FW/d. Water content (WC) of the petals was expressed as percentage of dry weight. Dry weight was determined after a 24 h-exposure of the petals at 80°C.

Determination of ion leakage percentage

Ion leakage percentage for estimation of membrane permeability was measured using an electrical conductivity meter based on Pooviah (1973) method. 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.

Determination of stem bending

The stem bending in gerberas was determined and classified based on Celikle and Reid (2002) method. 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°.

Statistical analysis

Data were statistically analyzed using one-way analysis of variance and Duncan's multiple range tests at the $P < 0.05$.

RESULTS

Water uptake and fresh weight

Table 1 show amounts of water uptake by each cultivar which is expressed as ml/gFW/d. There were significant differences between several cultivars during initial 10 days of experiment. The highest water uptake was observed for cultivars of 'Cacharelle', 'Double dutch' and 'Dune' with 0.58, 0.61 and 0.61, ml/gFW/d, respectively; but the lowest water uptake was observed for 'Onedin' with 0.27 ml/gFW/d, respectively. Water uptake in many cultivars with high vase life such as 'Aventura', 'Chacharelle' and 'Sazo' was more than 'Onedin' and 'Ecco' cultivars (Figure 3). Also, fresh weight of many cultivars such as 'Aventura' and 'Chacharelle' during 10 days after the experiment was more than that of 'Onedine' (Figure 4).

Flower water content

The results showed that there are significant differences between flower water content in several cultivars with the ranges of 17.47 to 54.8. The 'Aventura', 'Ecco' and 'Cacharelle' cultivars showed the highest and 'Cabana', 'Maniquin' and 'Basic' cultivars showed the lowest flower water content (Table 1).

Ion leakage percentage

Ion leakage percentage differs from one cultivar to

Table 1. Water uptake, ion leakage percentage, growth rate and water content of 21 different cultivars.

Cultivar	Ion leakage percentage	Water content (%)	Water uptake (ml/gFW/d)	Growth rate (cm)
Dune	4.63^{ij}	33.84^{efg}	0.61^{a}	7.53^{a}
Popov	11.58^{a}	48.31^{abcd}	0.42^{fg}	6.27^{bc}
Martinique	7.11^{cdefg}	42.74^{abcde}	0.35^{j}	3.54^{efg}
Onedin	11.42^{a}	43.29^{abcde}	0.27^{k}	3.84^{def}
Aventura	6.05^{fghi}	54.80^{a}	0.55^{bc}	2.7^{gh}
Primrose	6.92^{defg}	35.5^{defg}	0.52^{cd}	3.96^{def}
Monet	7.47^{cdef}	37.42^{defg}	0.41^{g}	5.6^{c}
Basic	7.72^{cde}	17.47^{h}	0.53^{c}	4.31^{de}
Entourage	11.71^{a}	41^{bcdef}	0.41^{gh}	3.92^{def}
Derim	10.83^{a}	40.29^{bcdef}	0.46^{ef}	3.5^{efg}
Ecco	9.44^{b}	52.69^{ab}	0.47^{e}	1.6^{i}
Candela	12.05^{a}	42.02^{abcde}	0.37^{hij}	3.04^{fg}
Cacharelle	6.04^{fghi}	51.08^{abc}	0.58^{ab}	3.54^{efg}
Cabana	3.94^{j}	27.8^{fgh}	0.41^{gh}	1.62^{i}
Stanza	5.21^{hij}	37.98^{cdefg}	0.34^{j}	1.9^{hi}
Maniquin	6.11^{fgh}	25.33^{gh}	0.37^{ij}	1.47^{i}
Sazo	5.84^{ghi}	45.15^{abcde}	0.39^{ghi}	6.7^{ab}
Double dutch	6.28^{efgh}	44.27^{abcde}	0.61^{a}	3.48^{efg}
Sunway	6.66^{defgh}	40.08^{bcdef}	0.49^{ed}	3.92^{def}
Rozalin	8.42^{bc}	38.49^{cdef}	0.51^{cd}	4.66^{d}
Tropic Blend	7.77^{cd}	42.43^{abcde}	0.34^{j}	4.66^{d}
Significance (P < 0.001)	***	***	***	***

The means with similar letters are not significant at $p < 0.05$.

another cultivars (P<0.001). 'Candela', 'Entourage', 'Derim', 'Onedin' and 'Popov' cultivars showed the highest and 'Sazo', 'Stanza', 'Dune' and 'Cabana' cultivars showed the lowest ion leakage percentage (Table 1).

Vase life

The cultivar screening showed good results for vase life. The vase life varied between cultivars and ranged from 9 to 21 days. Results showed that ‘Aventura’ and ‘Tropic blend’ with 21 days vase life, 'Dune', 'Sazo', 'Cacharelle', 'Candela' and 'Sunway' cultivars with 20 days vase life and ‘Primrose’ with 19 days vase life had maximum durability and 'Onedin' had minimum durable with 9 days vase life (Figure 1).

Growth rate of flowering stem

There are significant differences between several cultivars, and the highest growth rate was observed for ‘Dune’ with 7.53 cm and the lowest growth rate was observed for ‘Maniquin’ with 1.47 cm (Table 1).

Stem bending percentage

The cultivar screening showed that postharvest stem break differs from one cultivar to another (Figure 2). Table 2 shows stem bending percentage of 21 cultivars based on curvature angle in 5 different rates. The results showed that 100% of 'Popov', 'Primrose' and 'Derim' cultivars obtained rate 0 that is stems without bending or bending less than 15°; cultivars that are resistant to stem break. While 'Rozalin' with 67% and 'Ecco', 'Entourage', 'Basic' and 'Onedin' with 58% obtained rate 4, that is, bending more than 90°; cultivars that are sensitive to stem break. Data for other cultivars in relation to stem bending is presented in Table 2.

DISCUSSION

Gerbera has more than 300 cultivars with different color and inflorescence shape. They show different vase life and stem bending (Garibaldi and Jona, 1989; Ferrante et al., 2007). Based on our results, many cultivars such as 'Aventura', 'Tropic Blend', 'Dune', and Cacharelle’, ‘Sazo’, ‘Candela’ and ‘Primrose’ were chosen and introduced as the best cultivars with the highest vase life Based on research done by Meeteren (1987), there is a close relationship between vase life and water uptake in cut flowers. As shown in Table 1, the high vase life of 'Aventura', 'Dune' and 'Cacharelle’ cultivars is associated with the high water uptake. On the other hand, ‘Onedin' with minimum vase life has lower water uptake. These

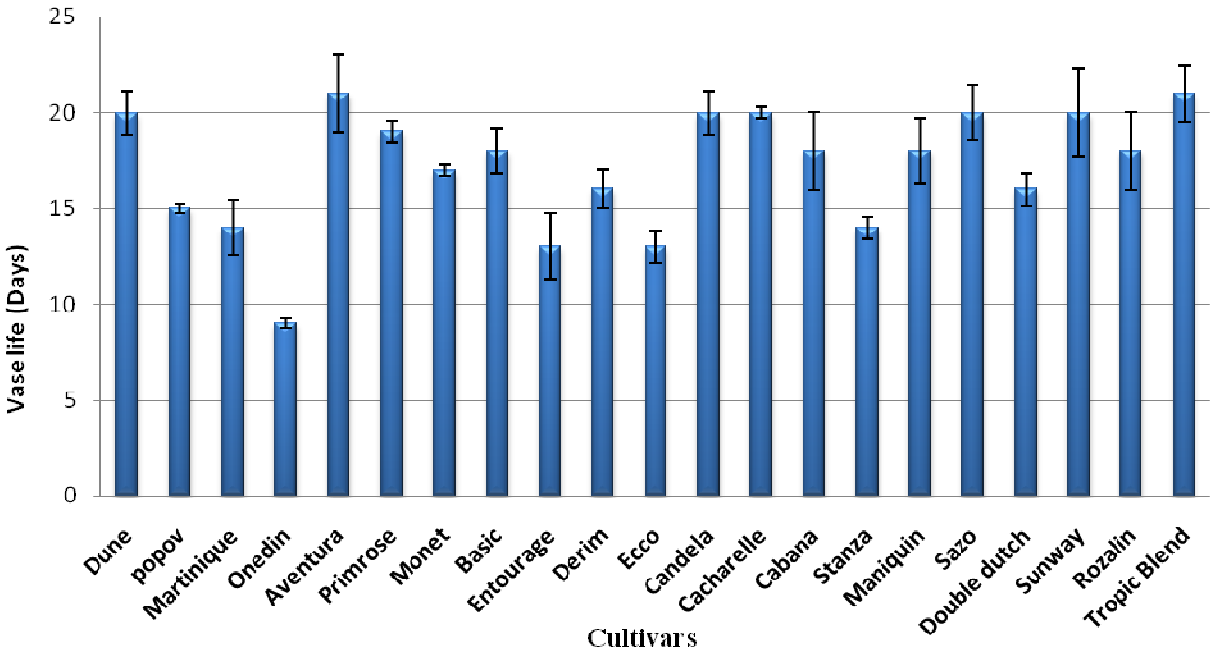

Figure 1. Vase life of 21 different commercial cultivars. Value are means with standard errors (n = 12).

Figure 2. Ecco, Entourage and Double Dutch cultivars with different postharvest stem breaks.

results are in agreement with Meeteren (1987). Changes in the rate of ion leakage from tissue samples demonstrate changes in membrane permeability (Baur and Workman, 1964; Bir and Bramlage, 1973). Tissues with normal permeability properties can retain solutes uptake (Meeteren, 1978). So, as shown in Table 1, high vase life was accompanied by low ion leakage percentage. For example 'Dune' and 'Cacharelle' cultivars with 20 days vase life had 4.63 and 6.04% ion leakage, respectively; while 'Onedin' with 9 days and 'Ecco' with 13 days vase life showed much more ion leakage percentage (11.42 and 9.44%, respectively). The results of the present

Table 2. Stem bending percentage of 21 different commercial cultivars.

Cultivar	0-15º	15-25º	25-65º	65-90º	>90º
Dune	17.00	50.00	0.00	0.00	33.00
Popov	100.00	0.00	0.00	0.00	0.00
Martinique	92.00	8.00	0.00	0.00	0.00
Onedin	17.00	0.00	17.00	8.00	58.00
Aventura	83.00	0.00	0.00	0.00	17.00
Primrose	100.00	0.00	0.00	0.00	0.00
Monet	58.00	0.00	0.00	0.00	42.00
Basic	42.00	0.00	0.00	0.00	58.00
Entourage	33.00	0.00	0.00	0.00	58.00
Derim	100.00	0.00	0.00	0.00	0.00
Ecco	8.00	8.00	25.00	0.00	58.00
Candela	83.00	8.00	0.00	0.00	8.00
Cacharelle	75.00	8.00	0.00	0.00	17.00
Cabana	58.00	17.00	0.00	0.00	25.00
Stanza	67.00	0.00	8.00	17.00	8.00
Maniquin	67.00	0.00	17.00	8.00	8.00
Sazo	92.00	0.00	0.00	0.00	2.00
Double dutch	67.00	8.00	8.00	0.00	17.00
Sunway	83.00	17.00	0.00	0.00	0.00
Rozalin	33.00	0.00	0.00	0.00	67.00
Tropic Blend	17.00	50.00	8.00	0.00	25.00

experiment were in line with these findings (Table 1). Data on flower water content is shown in Table 1. ‘Aventura’ and ‘Cacharelle’ cultivars with low ion leakage percentage had high water content. Meeteren (1978) reported that water content can cause decrease water-retaining capacity of the petals. The onset of the decline in water content was depended on the cultivar and associated with increase of ion leakage. It is necessary to mention that in cultivars such as ‘Ecco’ that had high water content and also high ion leakage probably occurs due to different physiological behavior from one cultivar to another. So in the present study, physiological behavior in this manner may be observing. For example, determination of ion leakage percentage on the 6th day associated with different vase life in different cultivars at the same time (Table 1).

The causes of stem bending in gerbera are not yet completely clear. Although the genetic background may be the main reason, this postharvest disorder affected various factors such as plant growth regulator, nutrient elements and storage temperature (Botondi et al., 1998; Celikle and Reid, 2002; Emongor, 2004 and Ferrante et al., 2007). Based on the results presented in this study, the wide ranges of stem bending percentage in the cultivars (Table 2) suggested that this disorder is cultivar depen-dent and this finding is in agreement with Ferrante et al. (2007). For example, ‘Aventura’, ‘Dune’, ‘Popov’, ‘Martinique’, ‘Primrose’, ‘Derim’, ‘Cacharelle’, ‘Sazo’, ‘Double dutch’ and ‘Sunway’ cultivars had the lowest stem bending, while ‘Rozalin’, ‘Ecco’, ‘Entourage’, ‘Basic’ and ‘Onedin’ had the highest stem bending among cultivars. Moreover, decline in water absorption by cut flower stem seems to play a major role in stem break (Meeteren, 1978). Meeteren (1978) 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. As shown in Figures 3 and 4, there is a close relationship between water uptake, fresh weight and stem break, so that decline in water uptake accompanied by decrease of fresh weight, subsequently caused stem break.

Conclusion

The results of this study led to the conclusion that for high postharvest quality, particularly, decrease of postharvest stem break, screening and cultivation of chosen cut flower gerberas should be used as a proper strategy, and subsequently, decreasing production costs and also increasing environmental health. Our data indicated that many cultivars such as ‘Aventura’, ‘Cacharelle’, ‘Sunway’, ‘Sazo’, ‘Candela’, ‘Primrose’ and ‘Double dutch’ had both high vase life and low stem break, while many cultivars

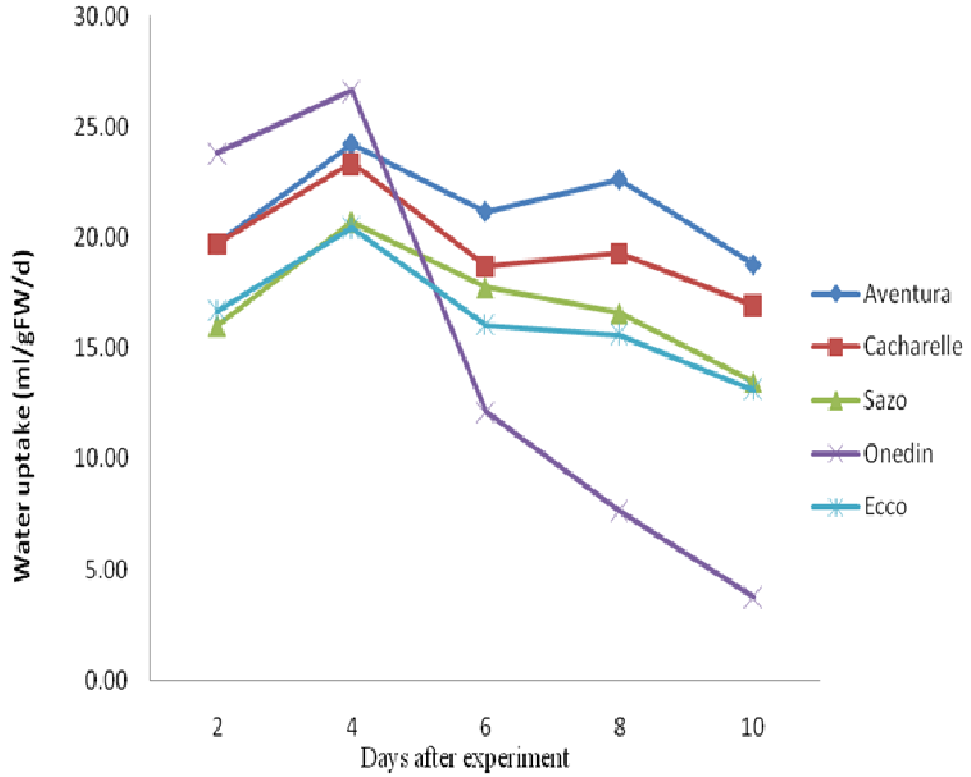

Figure 3. Water uptake of the high quality (Aventura, Sazo and Cacharelle) and low quality cultivars (Ecco and Onedin). Each value is average of four replications.

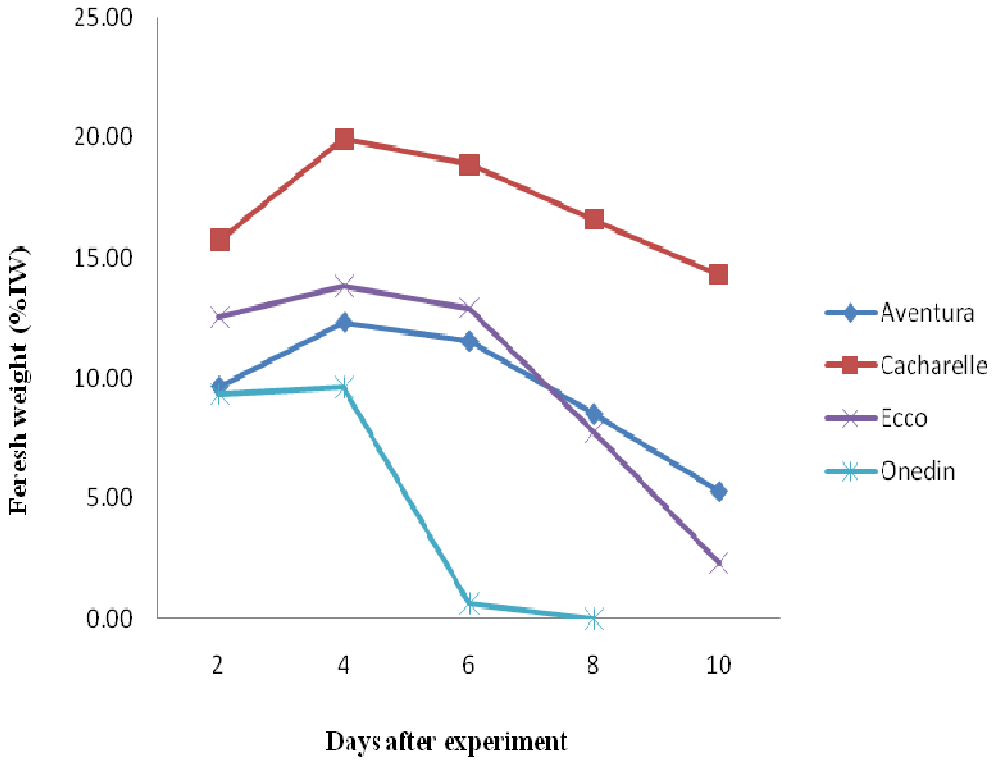

Figure 4. Fresh weight of the high quality (Aventura and Cacharelle) and low quality cultivars (Ecco and Onedin). Each value is average of four replications.

such as ‘Rozalin’ and ‘Basic’ with high vase life had high stem break disorder. On the other hand, ‘Popov’ cultivar without stem break had moderate vase life, and other cultivars such as ‘Ecco’, ‘Onedin’ and ‘Entourage’ had both minimum vase life and high stem break.

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