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Seasonal Variations in the Vase Life of Cut Gerbera Flowers Are Involved in the Release of Electrolytes from Flower Stems to Vase Water

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Abstract

Seasonal changes in vase life and the electrical conductivity and turbidity of vase water were studied in cut gerbera using two cultivars, namely, 'Picture Perfect' and 'Pinta.' Sugars and electrolytes released from cut stems are reported to be high in 'Picture Perfect' but lower in 'Pinta.' From May to July, when the electrical conductivity and turbidity of vase water were relatively high, the vase life of cut 'Picture Perfect' was relatively short. From May to July, the vase life of cut 'Pinta' was not reduced. Moreover, the electrical conductivity and turbidity of vase water were relatively low throughout the year. Isothiazolinone germicide (a mixture of 5-chloro-2-methyl-4-isothiazolin-3-one and 2-methyl-4-isothiazolin-3-one; CMIT/MIT) treatment reduced the turbidity of vase water in 'Picture Perfect.' 'Picture Perfect' had a large central cavity in the stem, whereas 'Pinta' had a very small central cavity. The vase life of cut 'Picture Perfect' was found to have a significant seasonal variation. The amounts of compounds, including electrolytes, released by cut 'Picture Perfect' stems may explain the variation in vase life.

Discipline: Horticulture
Additional key words: central cavity, electrical conductivity, turbidity

Introduction

Cut gerbera flowers are believed to have a short vase life. In a questionnaire survey of general consumers, more than 80% of the respondents answered that the vase life of cut gerbera flowers is within 1 week and approximately 25% of them answered that it is within 3 days (Tonooka 2020). By contrast, the vase life of cut gerbera is reported to be over 1 week, which is different from the general consumer perception (Jones & Hill 1993, Ogasawara et al. 2012). Wilting petals and bending flower stems indicate that cut gerbera flowers are losing their ornamental value (Tonooka et al. 2019, Wernett et al. 1996). Wernett et al. (1996) reported that the vase life of cut gerbera flowers was relatively long when their ornamental value was lost due to wilting whereas it was relatively short when their ornamental value was lost due to stem bending. According to the results of the aforementioned questionnaire survey, 71% of the respondents believed that bending flower stems reduce the ornamental value of cut gerbera flowers (Tonooka 2020).

In many plants, the deterioration of water relations reduces the vase life of cut flowers (Halevy & Mayak 1981, van Doorn 1997). Bacterial proliferation in vase water, air emboli, and physiological reactions to stem cutting cause vascular occlusion, impairing water relations (Durkin 1979, Marousky 1969, van Doorn et al. 1989, van Doorn 1990, Zagory & Reid 1986). Bacterial proliferation in cut rose flowers causes vascular occlusion and reduces vase life (Ichimura et al. 2003, Put & Jansen 1989, van Doorn & de Witte 1994, Zagory & Reid 1986). Impairment of water relations also reduces the vase life of cut gerbera (van Meeteren 1978). The addition of bacteria to vase water promotes flower stem bending and reduces the vase life of cut gerbera (van Doorn & de Witte 1994). Antimicrobial compounds inhibit bacterial proliferation in vase water, extending the vase life of cut gerbera (Tonooka et al. 2019). These findings suggest that

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bacterial proliferation reduces the vase life of cut gerbera.

The vase life of cut gerbera varies depending on the cultivar (Tonooka et al. 2019, Wernett et al. 1996). Resistance to bacteria is a factor that influences the cultivar variations in the vase life of cut gerbera (van Doorn & de Witte 1994). Antimicrobial treatment inhibits bacterial proliferation and extends the vase life of cut gerbera (Jones & Hill 1993). Tonooka et al. (2019) reported a correlation between vase water turbidity and bacterial number in cut gerbera. Additionally, electrolytes and sugars are released from the cut gerbera into vase water (Tonooka et al. 2021). The amounts of electrolytes and sugars released from cut stems increase the turbidity of vase water (Tonooka et al. 2021). Moreover, the amounts of electrolytes and sugars released from cut stems vary by cultivar: they are lower in 'Pinta' and higher in 'Picture Perfect' (Tonooka et al. 2021).

Environmental conditions during production have an impact on the vase life of cut flowers (Halevy & Mayak 1979). The vase life of cut rose flowers varies according to season (In et al. 2009, In & Lim 2018, Pompodakis et al. 2005). The vase life of cut roses is affected by relative humidity during production: the vase life of cut roses is relatively short under high relative humidity (In et al. 2007, In & Lim 2018). The short vase life has been caused primarily by malfunctioning stomata (Torre & Fjeld 2001). Similarly, the vase life of cut gerbera varies by season: vase life is shorter in winter than in summer (Perik et al. 2012). Furthermore, stems of cut gerbera grown in winter are prone to bending (Perik et al. 2012). However, the factors influencing the vase life of cut gerbera are unknown.

In the present study, we investigated the seasonal variations in vase life and the electrical conductivity and turbidity of vase water in cut gerbera flowers using two cultivars, namely, 'Picture Perfect' and 'Pinta' and found that cut 'Picture Perfect' showed significant seasonal variations. Furthermore, we investigated the effects of antimicrobial compound treatment on vase life and the electrical conductivity and turbidity of vase water in cut 'Picture Perfect.'

Materials and methods

1. Plant materials

Gerbera (*Gerbera jamesonii* Bolus ex Hook.f.) 'Picture Perfect' and 'Pinta' were grown using a soilless culture system. Two- to three-year-old gerbera plants were individually planted in June in 15-cm plastic pots filled with medium (Kinopot; Oji Forest & Products, Tokyo, Japan), which were placed on top of 21-cm plastic pots filled with calcined diatomaceous earth grains (Isolite CG No. 1; Isolite Insulating Products, Osaka, Japan) (Fig. 1). The plants were grown in a greenhouse of the Shizuoka Prefectural Agricultural and Forestry Research Institute under natural day light conditions. The temperatures at which ventilation or heating began were set at 25°C and 15°C, respectively. Liquid fertilizer (Umeda & Tonooka 2020) was supplied at 80 mL-100 mL per plant through a drip tube throughout the year. Gerbera flowers were harvested on January 20, February 15, March 17, April 14, May 17, June 16, July 14, August 16, September 15, October 20, November 24, and December 22, 2010, when most outer tubular florets had opened.

2. Evaluation of vase life

The flowers were cut to 40 cm length immediately after harvesting. Cut gerbera flowers were placed individually in a test tube (diameter of 40 mm and length of 130 mm) containing 100 mL of distilled water. The

Fig. 1. Basal part of gerbera grown in soilless culture (left) and gerbera plants grown using a soilless culture system in a greenhouse (right)

solution contained 0.25 mL·L^{-1} isothiazolinone antimicrobial compound, CMIT/MIT (Legend MK, Rohm and Haas Japan, Tokyo, Japan), which contained an active ingredient of 5.7 mg·L^{-1} 5-chloro-2-methyl-4-isothiazolin-3-one and 2 mg·L^{-1} 2-methyl-4-isothiazolin-3-one. Nine flowers were used per treatment in the evaluation of vase life. The cut flowers were kept at 23°C with 70% relative humidity, light period of 12 h (6:00-18:00), and 10 µmol·m^{-2}·s^{-1}. Vase life was determined from the start of vase life to the time when the following symptoms occurred: bending of flower stem surpassed 90°, abscission of one ray petal, breakage just below the flower head, or wilting of the petals. The percentage of fresh weight to initial fresh weight was used to calculate the relative fresh weight.

3. Measurement of electrical conductivity

The electrical conductivity of vase water 48 h after the start of experiment was measured using a conductivity meter (DS-12, Horiba, Kyoto, Japan).

4. Measurement of turbidity

An aliquot (2 mL) of vase water was sampled 7 days after the experiment began. The turbidity of vase water was measured at 660 nm using a spectrophotometer (UV150-02, Shimadzu, Kyoto, Japan).

5. Observation of central cavity

The stems of 'Picture Perfect' and 'Pinta' were cut horizontally at 40 cm from the flower head using a pair of pruning shears. The cut surface of the remaining flower stalk was then trimmed using a razor, and the central cavity of the stem was examined under a microscope.

6. Statistical analysis

Student's t-test and Tukey–Kramer's multiple range test were performed using the SigmaPlot software (v.12.5; Systat Software, San Jose, CA, USA).

Results

1. Seasonal variations in vase life and the electrical conductivity and turbidity of vase water

The vase life of cut 'Picture Perfect' varied significantly by season (Fig. 2). 'Picture Perfect' had a significantly shorter vase life in May, June, and July than in March, October, November, and December.

The vase life of cut 'Pinta' varied significantly by season. Vase life was significantly shorter in April, May, and July than in March, October, November, and December.

The electrical conductivity of vase water varied seasonally in 'Picture Perfect.' The electrical conductivity

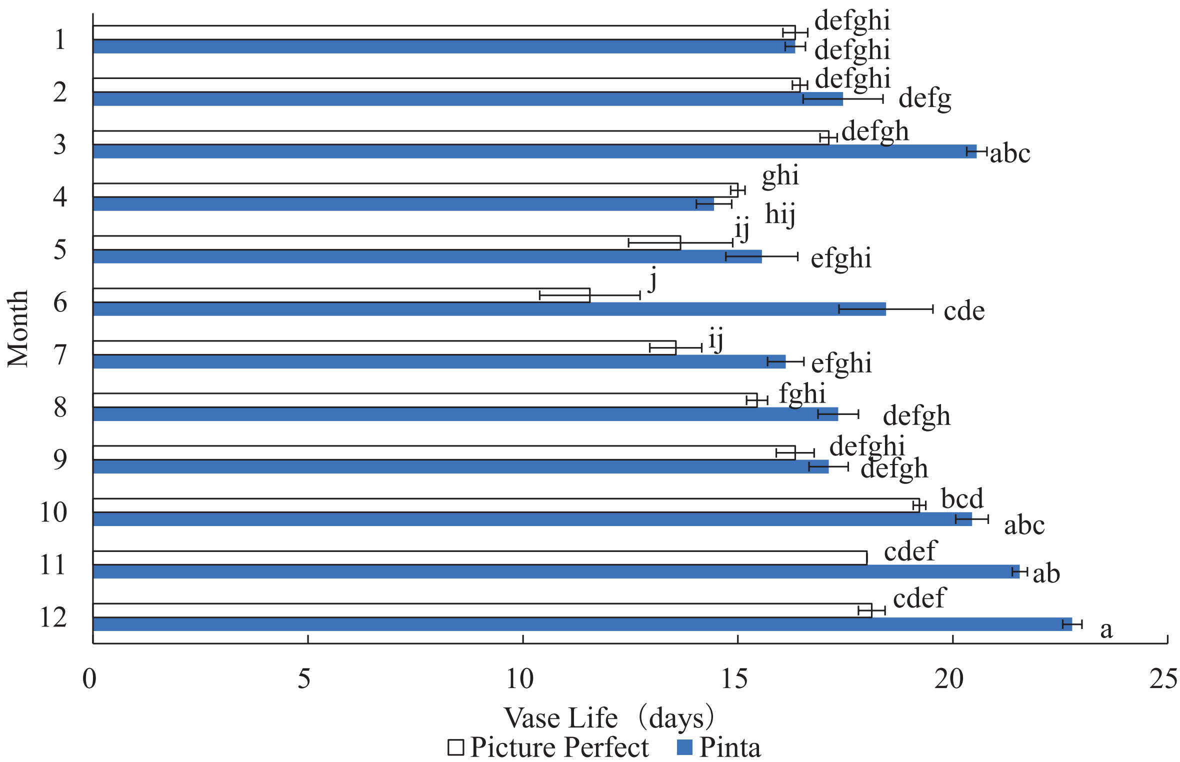

Fig. 2. The vase life of gerbera 'Picture Perfect' and 'Pinta' harvested at different months
Values are the means of nine replicates ± SE. Different letters indicate a significant difference ($P < 0.05$) using Tukey–Kramer's multiple range test.

of vase water was significantly higher from May to July than from January to March, August, October, and November in 'Picture Perfect' and from January to May and from August to December in 'Pinta' (Fig. 3). Throughout the year, the electrical conductivity of vase water was higher in 'Picture Perfect' than in 'Pinta.'

The turbidity of vase water varied significantly in 'Picture Perfect' with the turbidity of vase water being significantly higher in May and June than in April, October, and November (Fig. 4). By contrast, the turbidity of vase water in 'Pinta' varied slightly. Moreover, turbidity was significantly higher in 'Picture Perfect' than in 'Pinta' in May, June, July, and September.

2. Effect of CMIT/MIT on vase life and turbidity of vase water in 'Picture Perfect'

The effect of CMIT/MIT on vase life and turbidity of vase water was investigated to determine whether bacterial proliferation is involved in the seasonal variations in the vase life of cut 'Picture Perfect.' CMIT/MIT treatment significantly extended vase life in May, June, July, and September (Fig. 5). CMIT/MIT treatment significantly reduced the turbidity of vase water in all months, except for April (Fig. 6).

3. Morphology of the stem cavity in 'Picture Perfect' and 'Pinta'

There were individual differences in the size of the central cavity in both cultivars (Fig. 7). In 'Picture Perfect,' the central cavity showed a circular shape. By contrast, the central cavity in 'Pinta' was small and indeterminate.

Discussion

Electrolytes and sugars released from cut stems into vase water promote bacteria proliferation, reducing the vase life of cut gerbera flowers (Tonooka et al. 2019). We investigated the seasonal variations in the electrical conductivity and turbidity of vase water and vase life using 'Picture Perfect' and 'Pinta.' Moreover, the effect of antimicrobial compound treatment on vase life and the electrical conductivity and turbidity of vase water in cut

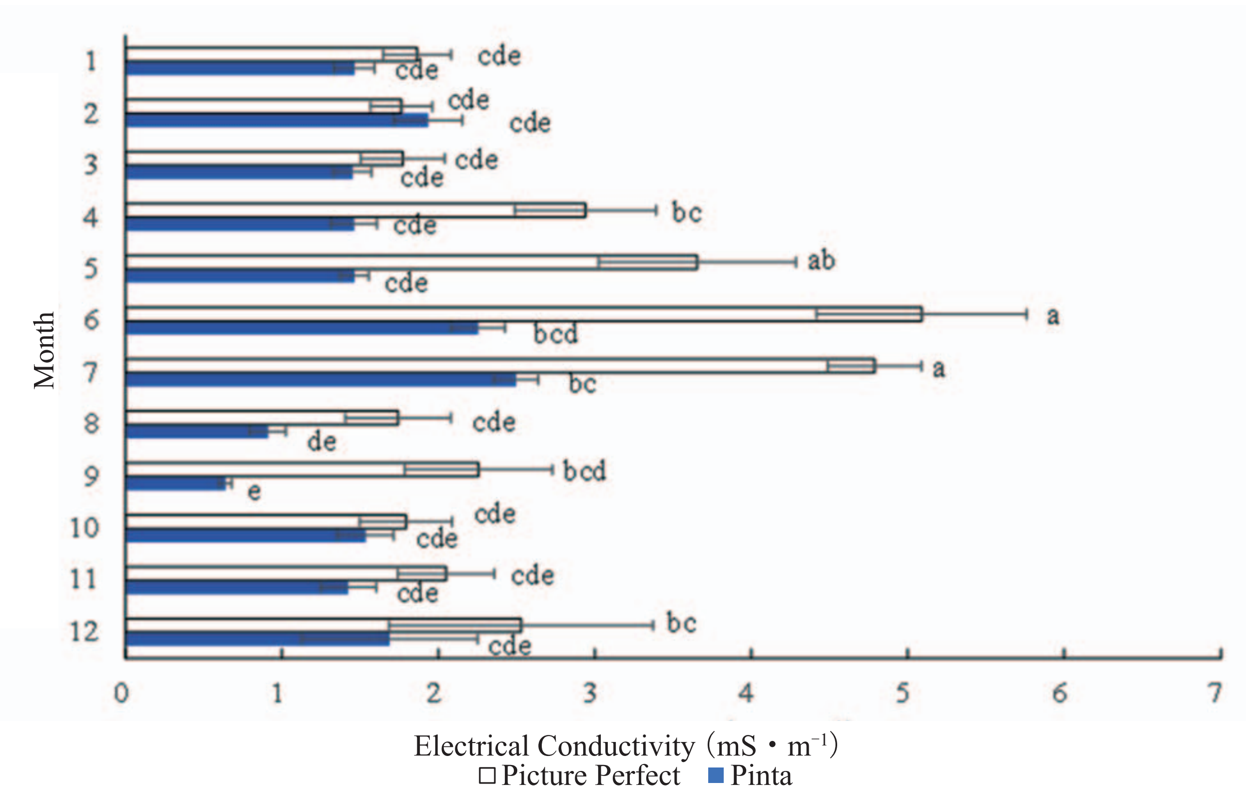

Fig. 3. The electrical conductivity of vase water in gerbera 'Picture Perfect' and 'Pinta' harvested at different months
Values are the means of nine replicates ± SE. Different letters indicate a significant difference ($P < 0.05$) using Tukey–Kramer's multiple range test.

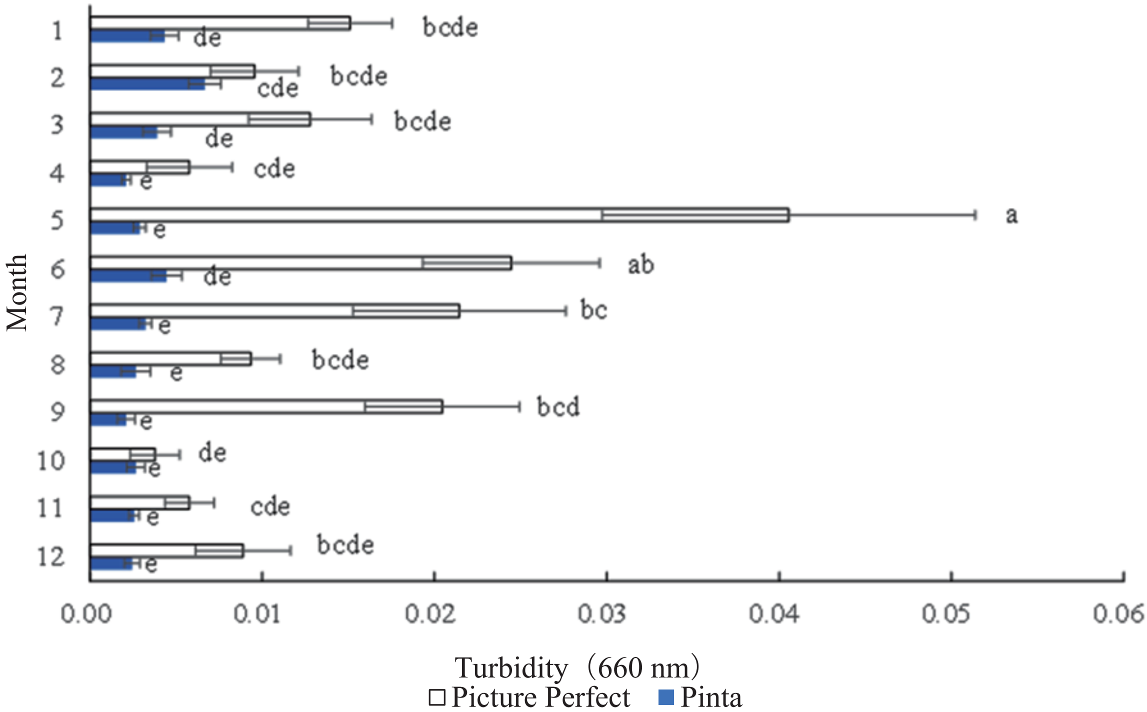

Fig. 4. The turbidity of vase water in gerbera 'Picture Perfect' and 'Pinta' harvested at different months
The turbidity of vase water was measured 7 days after the start of treatment. Values are the means of nine replicates ± SE. Different letters indicate a significant difference ($P < 0.05$) using Tukey–Kramer's multiple range test.

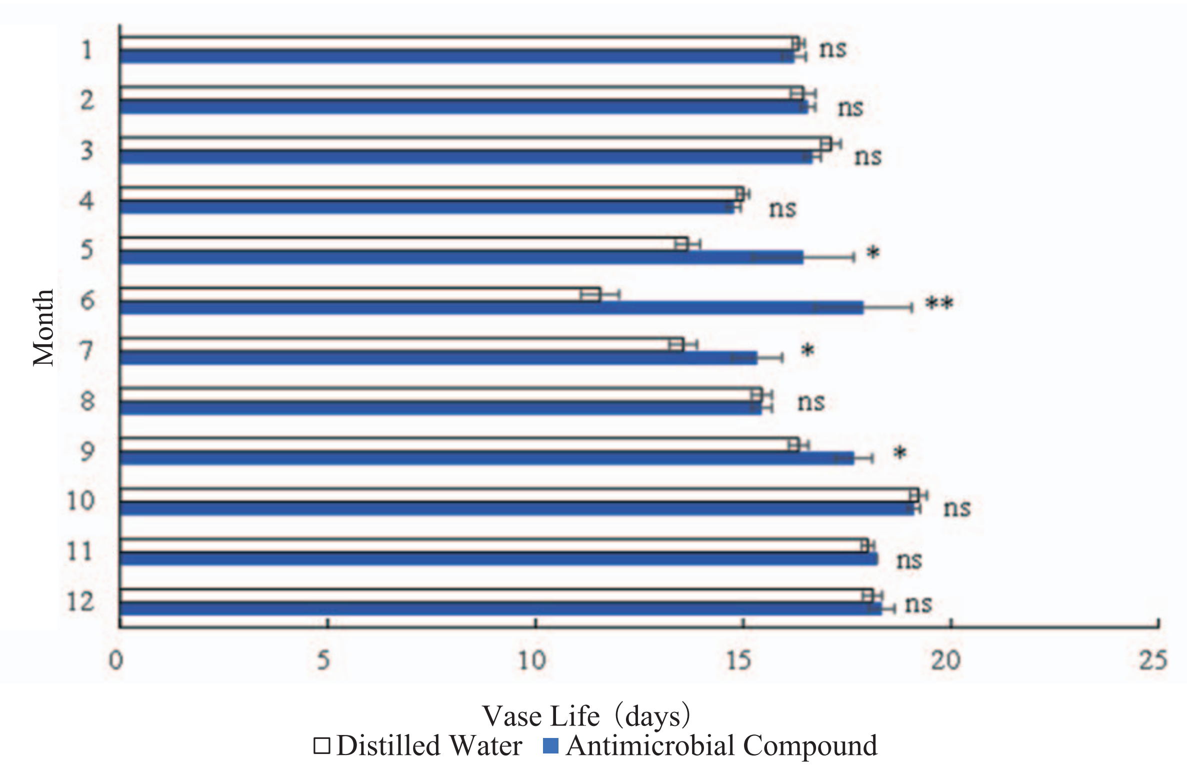

Fig. 5. Effect of CMIT/MIT treatment on the vase life of gerbera 'Picture Perfect' harvested at different months
Values are the means of nine replicates ± SE. *, **, and ns indicate significant differences at $P < 0.05$, significant differences at $P < 0.01$, and nonsignificance by t-test, respectively.

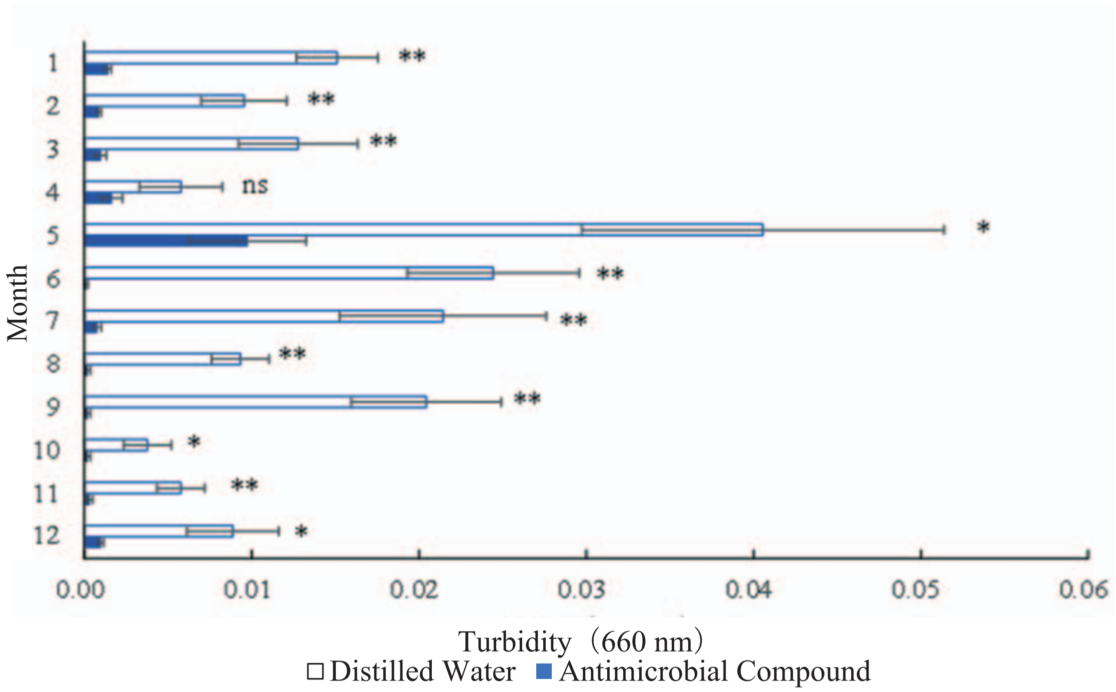

Fig. 6. Effect of CMIT/MIT treatment on the turbidity of vase water in gerbera 'Picture Perfect' harvested at different months

Values are the means of nine replicates ± SE. *, **, and ns indicate significant differences at $P < 0.05$, significant differences at $P < 0.01$, and nonsignificance by *t*-test, respectively.

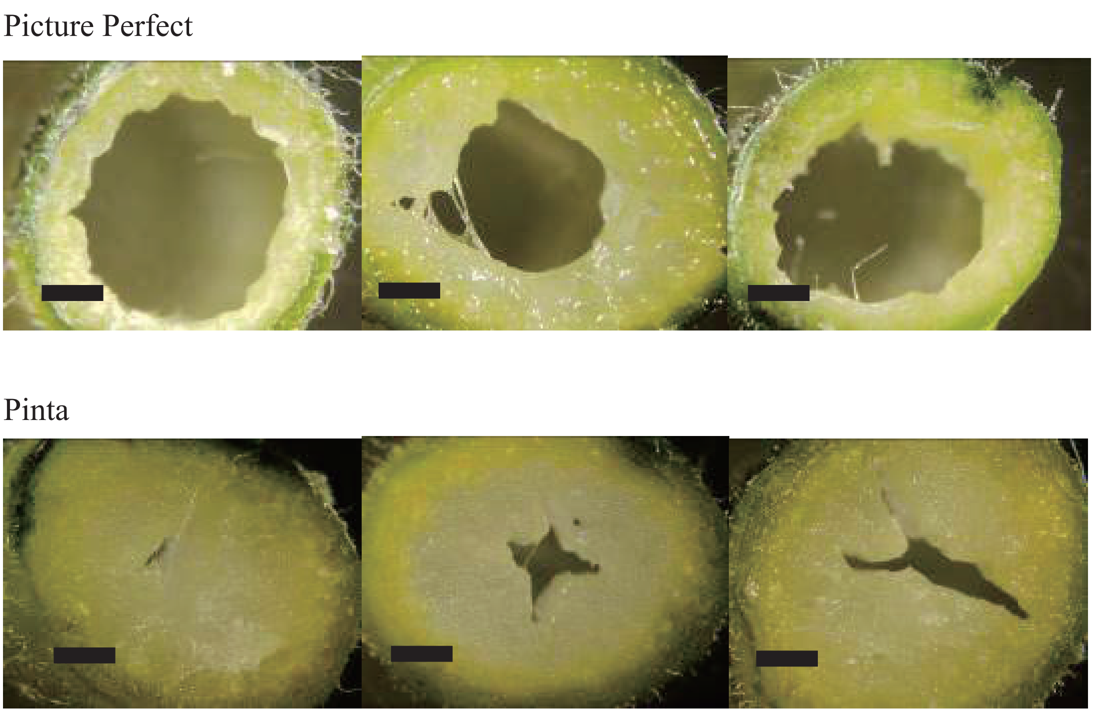

Fig. 7. Morphology of the stem central cavity in gerbera 'Picture Perfect' and 'Pinta' in June

The central cavity of three different stems for each cultivar was observed at 40 cm from the flower head. Upper panels: 'Picture Perfect.' Lower panels: 'Pinta.' The scale bars represent 1 mm.

‘Picture Perfect’ gerbera was investigated.

The vase life of cut ‘Picture Perfect’ varied according to season. The vase life of cut ‘Picture Perfect’ was significantly shorter in May, June, and July than in the other months (Fig. 2). The electrical conductivity and turbidity of vase water were investigated to clarify factors that affect the seasonal variations in vase life because these variables affect the vase life of cut gerbera (Tonooka et al. 2019). In comparison with other months, the electrical conductivity of vase water in ‘Picture Perfect’ was relatively high in May, June, and July (Fig. 3). Tonooka et al. (2021) reported a strong relationship between electrical conductivity and sugars released from cut stems into vase water. Therefore, large amounts of sugars may be released into vase water during these months. Bacterial growth is known to require electrolytes and sugars. Furthermore, during these months, the turbidity of vase water was relatively high.

Tonooka et al. (2019) previously reported that the turbidity of vase water was higher in ‘Picture Perfect’ than in ‘Pinta’ when the flowers were harvested in June. The turbidity of vase water was higher in ‘Picture Perfect’ than in ‘Pinta’ throughout the year (Fig. 4). There is a high correlation between vase water turbidity and bacterial count (Sato et al. 1983). There is also a correlation between electrical conductivity and the amount of sugar released from cut stems into vase water (Tonooka et al. 2021). Therefore, the seasonal variations in the vase life of cut ‘Picture Perfect’ appear to be attributed to the differences in bacterial proliferation, which is affected by the amounts of electrolytes and sugars released from cut stems into vase water. Bacteria on the stems at harvest may affect the vase life of cut gerbera. However, to best our knowledge, there are no reports on the seasonal variation in bacterial number on gerbera cut flowers. The measurements of bacterial number on stems may contribute to our understanding of the seasonal variations in bacterial number in vase water associated with the vase life of cut gerbera.

The electrical conductivity of vase water in ‘Picture Perfect’ was significantly higher in May to July than in the other months (Fig. 3). Gerbera stems have a central cavity (Perik et al. 2012). At harvest, the stems contained a large central cavity, starting at approximately 4 cm from the root–shoot junction and ending approximately 6 cm below the floral head (Perik et al. 2012). The electrical conductivity of vase water with cut gerbera was higher when cut back diagonally than when cut back horizontally (Tonooka et al. 2021). Moreover, the electrical conductivity of vase water with cut gerbera was higher when stems with the central cavity were cut back than when stems without the central cavity were cut back (Tonooka et al. 2021). These results suggest that electrolytes are released into vase water from the surface of the central cavity as well as the cut end. This explanation was supported by results that the central cavity was greater in ‘Picture Perfect’ than in ‘Pinta’ (Fig. 7). Because the central cavity appears to be important for electrolyte elution, we hypothesize that the central cavity becomes larger in May to June when the amount of electrolyte elution is high.

Bacterial proliferation in vase water reduces the vase life of cut gerbera (Tonooka et al. 2019). Antimicrobial compound treatment reduces the turbidity of vase water and extends the vase life of cut gerbera (Tonooka et al. 2019). In our study, the turbidity of vase water in CMIT/MIT-treated flowers was relatively low (Fig. 6), which is consistent with previous findings reported by Tonooka et al. (2019). It has been reported that CMIT/MIT treatment significantly extended the vase life of five out of seven cultivars (Tonooka et al. 2019). Treatment with CMIT/MIT extended the vase life of cut ‘Picture Perfect’ in May, June, July, and September but not in other months (Fig. 5). The ineffectiveness of CMIT/MIT in extending vase life during these months appears to be due to less bacterial proliferation.

The vase life of cut ‘Pinta’ varied significantly by season (Fig. 2). Vase life was significantly shorter in April, May, and July than in March, October, November, and December. However, the electrical conductivity of vase water in this cultivar was relatively low throughout the year (Fig. 3), suggesting that the seasonal variation in vase life cannot be attributed to electrical conductivity. Therefore, the seasonal variation in the vase life of cut ‘Pinta’ differs from that of cut ‘Picture Perfect.’ In Netherlands, the vase life of cut gerbera ‘Tamara’ has been reported to be longer in summer than in winter (Perik et al. 2012), which contradicts our results using ‘Picture Perfect’ and ‘Pinta.’ However, the factors that cause the seasonal variations in the vase life of cut ‘Tamara’ have not been studied. The different characteristics of these cultivars may produce different results. Moreover, the seasonal variations in vase life may be caused by different climate conditions during production. The climate in the Netherlands differs from that of Iwata, Japan, in that summer is not as hot and winter is typically cloudy in the Netherlands whereas summer is very hot and winter is cold but fine in Iwata, Japan.

Although the results in the present study were collected in one year, the electrical conductivity of vase water in ‘Picture Perfect’ was reported to be comparable, which was high in June, July, and August in another year (Tonooka et al. 2021). Moreover, we confirmed that the electrical conductivity of vase water in this cultivar was low from January to March 2011 (unpublished data). Therefore, the reproducibility of the results appears to be guaranteed.

In conclusion, there were seasonal variations in vase life and the electrical conductivity and turbidity of vase water in 'Picture Perfect.' However, there were minor seasonal variations in 'Pinta.' CMIT/MIT treatment reduced the increase in electrical conductivity and turbidity of vase water in 'Picture Perfect' from May to July, when they would have increased otherwise. Therefore, a variation in the vase life of cut 'Picture Perfect' may be attributed to the amount of compounds, including electrolytes, released from the cut stems.

References

Durkin, D. J. (1979) Effect of millipore filtration, citric acid, and sucrose on peduncle water potential of cut rose flower. *J. Am. Soc. Hort. Sci.*, **104**, 860-863.

Halevy, A. H. & Mayak, S. (1979) Senescence and postharvest physiology of cut flowers, part 1. *Hortic. Res.*, **1**, 204-236.

Halevy, A. H. & Mayak, S. (1981) Senescence and postharvest physiology of cut flowers, part 2. *Hortic. Res.*, **3**, 59-143.

Ichimura, K. et al. (2003) Shortage of soluble carbohydrates is largely responsible for short vase life of cut 'Sonia' rose flowers. *J. Jpn. Soc. Hortic. Sci.*, **72**, 292-298.

In, B. C. & Lim, J. H. (2018) Potential vase life of cut roses: Seasonal variation and relationships with growth conditions, phenotypes, and gene expressions. *Postharvest Biol. Technol.*, **135**, 93-103.

In, B. C. et al. (2007) Multivariate analysis of relations between preharvest environmental factors, postharvest morphological and physiological factors, and vase life of cut 'Asami Red' roses. *J. Jpn. Soc. Hortic. Sci.*, **76**, 66-72.

In, B. C. et al. (2009) An analysis of the causes of the seasonal fluctuations in vase life of cut roses. *Hortic. Environ. Biotechnol.*, **50**, 446-450.

Jones, R. B. & Hill, M. (1993) The effect of germicides on the longevity of cut flowers. *J. Am. Soc. Hortic. Sci.*, **118**, 350-354.

Marousky, F. J. (1969) Vascular blockage, water absorption, stomatal opening, and respiration of cut 'Better times' roses treated with 8-hydroxyquinoline citrate and sucrose. *J. Am. Soc. Hort. Sci.*, **94**, 223-226.

Ogasawara, Y. et al. (2012) Questionnaires about handling of cut flowers to retailers and effects of cutting stems under water on the rehydration and vase life of major cut flowers. *Hort. Res. (Japan)*, **11**, 577-583 [In Japanese with English abstract].

Perik, R. R. J. et al. (2012) Bending in cut *Gerbera jamesonii* flowers relates to adverse water relations and lack of stem sclerenchyma development, not to expansion of the stem central cavity or stem elongation. *Postharvest Biol. Technol.*, **74**, 11-18.

Pompodakis, N. E. et al. (2005) Effect of seasonal variation and storage temperature on leaf chlorophyll fluorescence and vase life of cut roses. *Postharvest Biol. Technol.*, **36**, 1-8.

Put, H. M. C. & Jansen, L. (1989) The effects on the vase life of cut *Rosa* cultivar 'Sonia' of bacteria added to the vase water. *Sci. Hortic.*, **39**, 167-179.

Sato, S. et al. (1983) *Shokubutsubyourigakujikkenhou (Experimental methods in plant pathology)* 94-95. Kodansha Scietific. Tokyo [In Japanese].

Tonooka, M. (2020) Postharvest technology of cut gerbera flowers. *Agric. Hort. (Nogyo-oyobi-Engei)*, **95**, 692-696 [In Japanese].

Tonooka, M. et al. (2019) The effects of bacteria in vase water on the vase life of cut gerbera cultivars. *Hort. Res. (Japan)*, **18**, 167-172 [In Japanese with English abstract].

Tonooka, M. et al. (2021) The effect of cutting on turbidity and sugars in vase water and the vase life of cut gerbera flowers. *Hort. Res. (Japan)*, **20**, 101-108 [In Japanese with English abstract].

Torre, S. & Fjeld, T. (2001) Water loss and postharvest characteristics of cut roses grown at high or moderate relative air humidity. *Sci. Hortic.*, **89**, 217-226.

Umeda, S. & Tonooka, M. (2020) Influence of season, cultivar, and age on the yield components of *Gerbera jamesonii* over two years. *Bull. Shizuoka Res. Inst. Agric. For.*, **13**, 1-6 [In Japanese with English abstract].

van Doorn, W. G. (1990) Aspiration of air at the cut surface of rose stems and its effect on the uptake of water. *J. Plant Physiol.*, **137**, 160-164.

van Doorn, W. G. (1997) Water relations of cut flowers. *Hort. Res.*, **18**, 1-85.

van Doorn, W. G. & de Witte Y. (1994) Effect of bacteria on scape bending in cut *Gerbera jamesonii* flowers. *J. Am. Soc. Hort. Sci.*, **119**, 568-571.

van Doorn, W. G. et al. (1989) Role of endogenous bacteria in vascular blockage of cut rose flowers. *J. Plant Physiol.*, **134**, 375-381.

van Meeteren, U. (1978) Water relations and keeping-quality of cut *Gerbera* flowers. 1. The cause of stem break. *Sci. Hortic.*, **8**, 65-74.

Wernett, H. C. et al. (1996) Postharvest longevity of cut-flower *Gerbera*. I. Response to selection for vase life components. *J. Am. Soc. Hort. Sci.*, **121**, 216-221.

Zagory, D. & Reid, M. S. (1986) Role of vase solution microorganisms in the life of cut flowers. *J. Am. Soc. Hort. Sci.*, **111**, 154-158.