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Postharvest Shipping Time Adjustment of Cut Spray Carnation Flowers

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Abstract

In order to establish the shipping time adjustment technique for cut spray carnation flowers, we examined the vase life of cut flowers stored by dry and wet methods. The vase life period of cut spray carnation flowers was defined as the period from the start of the experiment to the loosing ornamental value of 50% of the whole flower bud. The addiction of a glucose to the vase solution prolonged the vase life of the cut flowers from December to March, but there was no effect in May. Although more than three days shipping timing adjustment was difficult at 23℃, 14 days storage at 5℃ was possible. Varietal differences in vase life after 14 days storage at 5℃ was observed. Availability of two weeks shipping time adjustment was confirmed at the actual user level.

Introduction

Import of cut carnation flowers in Japan has been increasing during last decade. More than half of domestically distributed cut carnation flowers are imported from many countries including Colombia（70.8%), China（17.6%), Ecuador（7.9%）in 2017 [1]. The monthly import volume of cut flowers varies considerably, with import peaks in March, August and December, indicating that imported cut carnation flowers demands are related to Japanese traditional events（Higan, Obon and Oshyougatu）rather than increased demand for Mother's day. On the other hand, the monthly fluctuation of the total market volume of cut carnation flowers is not as large as imports. This indicates that domestic production of cut carnation flowers is covering a solid domestic demand. In order for the domestic production of cut carnation flowers to compete with imported cut flowers, it is necessary to supply cultivars with a wide range of petal color and flower shape which meet consumer demands in a timely manner. However, current domestic cut carnation flower production depends on small scale growers in various parts of Japan, and they ship their products to many flower auctions located in both large, urban centers and local, small cities. This complex distribution channel makes it difficult to adjust shipping on a large scale. This means that shipping time adjustment at the grower level is required to meet the changing market demands. Appropriate management techniques for shipping time adjustment are important for stably supply of high quality cut flowers.

Many studies have been conducted on storing cut carnation flowers in a boxed state（dry condition）[2,3,4,5]. The results show that cut carnation flowers can be stored for some weeks under low temperature conditions. However, it is also true that cut carnation flowers stored under inappropriate conditions often lead to the problem of short vase life at the consumer stage. The idea of storing cut carnation flowers harvested at early stage of flowering and shipping them according to market demands also has been proposed [6,7]. This proposal has not been put into practical use because a special facility for flowering is needed. Fukai et al. [8] demonstrated the preservation of cut standard carnation flowers for a long time is possible, by which the cut flowers were harvested at the standard stage of flowering and kept in a vase solution（wet condition）at low temperature.

The aim of this study is to propose the appropriate management of cut spray carnation flowers for postharvest shipping time adjustment.

Materials and Method

Plant materials

Cut carnation flowers were obtained from a nursery（Agricultural producers' cooperative corporation, Koukaen）in Japan. According to the commercial harvest standard, the cut flowers were treated with preservative（silver thiosulphate）in Koukaen before shipping. The cut carnation flowers had stem lengths of 60 to 70 cm with four to six flower buds（three

flowers were in the showing petal stage).

General method of cut flower longevity evaluation

All cut flowers were cut to 45 cm and kept in 300 ml flask with vase solution consisting of 50 mg/L aluminum sulfate and 0.5 ml/ L Legend MK (bacteriostatic agent, ca. 1.5% isothiazolin, Rohm and Haas Co.,) with and without 1% glucose (GLA and LA)[9]. The cut flowers were maintained under a light intensity of 20 μmol/m^2/s, provided by fluorescent lamps (FL40SPG, Panasonic Inc.) with a 16-h photoperiod at 23 ± 1℃ with RH 65～85%.

Fresh weight of cut flowers, water uptake and number of opened flowers were recorded every day. Each treatment had three replications that consisted of three flowers per flask (total nine cut flowers).

Experimental design

Exp. I Effect of glucose in vase solution on vase life of cut spray carnation flowers

Cut flowers (cv. Lealea) were obtained monthly from January to June. All cut flowers were harvested in the same greenhouse. The cut flowers were kept in both GLA and LA. Fresh weight of cut flowers and number of flower buds were recorded.

Exp. II Effect of shipping time adjustment conditions on vase life of cut spray carnation flowers

II-1. Dry and wet storage at 23℃

Cut flowers (cv. Lealea) were obtained in January. The cut flowers were cut to 60cm and kept in LA with newspaper covering (wet condition) or put in a carton box (dry condition). All flowers were kept at 23 ± 1 ℃ for three or seven days. After the storage, cut flowers were recut to 40 cm and kept in GLA.

II-2 Dry and wet storage at 5℃

Cut flowers (cv. Lealea) were obtained in April. The cut flowers were cut to 60cm and kept in LA or GLA with newspaper covering (wet conditions) or put in a carton box (dry condition). Flowers were kept at 5℃ for three and seven days in wet and dry conditions, and for 14 days in wet condition. After storage, cut flowers were recut to 40 cm and kept in GLA.

Exp. III Effect of glucose in storage and base solution on vase life of cut spray carnation flowers

Cut flowers (cv. Lealea) were obtained in both January and May. Cut flowers were kept LA or GLA at 5 ℃ for 2weeks and then kept in LA or GLA at 23 ℃ to evaluate vase life. Flowers without storage were also used as the control.

Exp. IV Cultivar differences in vase life of cut spray carnation flowers stored 2 weeks at 5℃

Ten cultivars of cut spray carnation flowers (Citrus, Feminir, Ruban, Lillian, Mini-tiara Pink, Tsubasa, Kippi, Mao, Lealea, Red liver) were used. The flowers were obtained 21st April, kept in LA at 5℃ for 2 weeks, then put into carton box, and kept at room temperature for 2 days (assumed an actual transportation period). Then all cut flowers were cut to 45cm and kept in GLA.

Exp. V Demonstration of shipping adjustment

Cut flowers (cv. Lealea) were harvested in the grower's greenhouse (Koukaen) on 26th March. The 25 cut flowers were put in flower sleeve and kept in preservative solution (MISAKI-Pro, OAT Agrio Co. Ltd.) and stored at 9-10 ℃ under dark conditions for two weeks. Another group of cut flowers were harvested on 9th April. Both stored and fresh cut flowers were sent to Flower Auction Japan co. Ltd. (FAJ) by a truck without temperature control. Vase life test was performed in a room controlled at 25℃, RH 60% and 12 hr of 1000lux illumination with inflorescence lumps in FAJ. All cut flowers were kept in Chrysal Flower Foods (Chrysal Japan Co. Ltd.). The test started from 11th April and the performances of the cut flowers were evaluated for 15 days.

Results and Discussion

1. Basic vase life characteristics of cut spray carnation flowers

1-1. Determination of vase life of cut spray carnation flowers

Carnation is a typical ethylene sensitive flower and autocatalytic ethylene production occurs within several days after full opening of the flower [10]. The use of ethylene biosynthesis blocking agents, such as silver thiosulfate complex (STS), is quite effective to prolong flower longevity of cut carnation flowers. Petal senescence of the STS-treated carnation flower displays discoloration and/or drying of petals, but not senescence symptoms caused by ethylene such as in-rolling.

The criteria for vase life of cut spray carnation flower varies from institutes because cut spray carnation flowers have different number of flowers on the stems depending on cultivars. Satho et al. (2005)[11] focused on the number of flowering flowers on a stem and proposed setting the vase life period as a period in which 40% or more flowers are blooming. To confirm the relationship between the fresh weight of the cut flow-

ers and flowering rate (number of opened flowers / total number of flower buds x 100), the fresh weight of cut flowers, the absorption of water and the number of opened flowers were recorded. Opened flower is defined as outer petals opened to horizontal position. Flowering ratio was calculated by use of total number of flower buds of three cut flowers in a flask.

Fresh weight of cut flowers increased considerably during the first week, kept stable then started to decrease after the third week (Fig. 1). The flowering rate reached a maximum at about day 10, decreased from the 3rd week and was below 50% at day 25. During this period, the amount of water absorption was stable at 0.15 ml/gFW of cut flower/day. The results showed fresh weight changes did not relate flowering rate and appearance of the flowers (Fig. 2). The flowering ratio well reflects the actual appearance of cut flowers. Based on this result, the period from the start of the experiment until the flowering rate falls below 50% (solid line in Fig. 1) is defined as vase life in this study. Because the use value of cut flowers starts immediately after consumers purchase, it is reasonable to add the period until the flowering rate reaches 50% to the vase life proposed by Satho et al. (dotted line in Fig. 1).

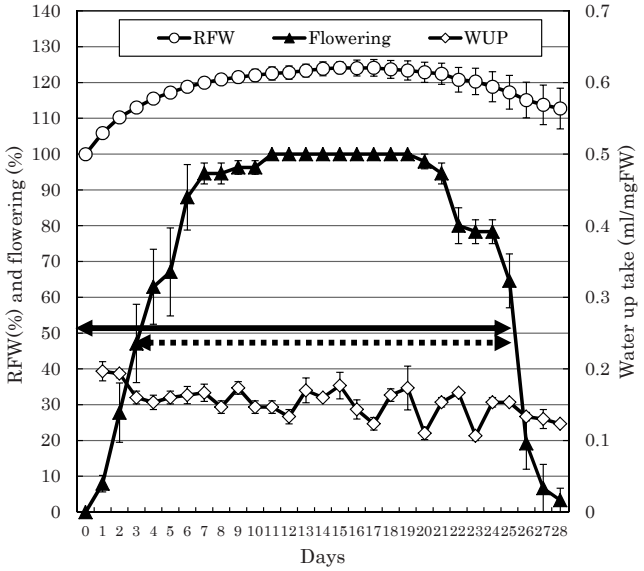

Fig. 1 Relationship flowering performance and daily changes of fresh weight and water uptake in cut spray carnation flowers

1-2. Effect of glucose in a vase solution and harvest time on vase life of cut spray carnation flowers

Seasonal changes in fresh weight of cut flowers, number of flower buds, and vase life were observed (Fig. 3). Fresh weight of cut flowers (45cm) at start of vase life test increased January to April and kept the same level until June. Number of flower buds/stem showed same tendency as fresh weight. The results indicate that cut flowers produced after April have thick stems compared with winter season cut flowers. Vase life during January to March was much longer than those during April to June Cut flowers kept in GLA showed longer vase life than those kept in LA during January to March but no difference in vase life was observed during April to June Sugar in a vase solution is effective to open the flower buds of carnation [6] and prolong the vase life [12]. As the commercial harvest standard, cut carnation flowers are harvested at an earlier stage of flowering in spring to early summer in comparison with winter season products. Results showed that cut flowers which assumed to be harvested earlier stage of flowering showed shorter vase life and they did not react well to glucose in a vase solution. This contradiction might be related to sugar contents of cut flowers.

Day 1 Day 7 Day 14 Day 21

Fig. 2 Appearance of spray carnation flowers kept in GLA (cv. Lealea)

2. Effect of shipping time control management conditions on vase life of cut spray carnation flowers

2-1. Dry and wet storage at 23℃

During three and seven days of storage fresh weight of cut flowers changed to 79 and 108%（3 days），62 and 110 %（7 days）in dry and wet conditions, respectively.

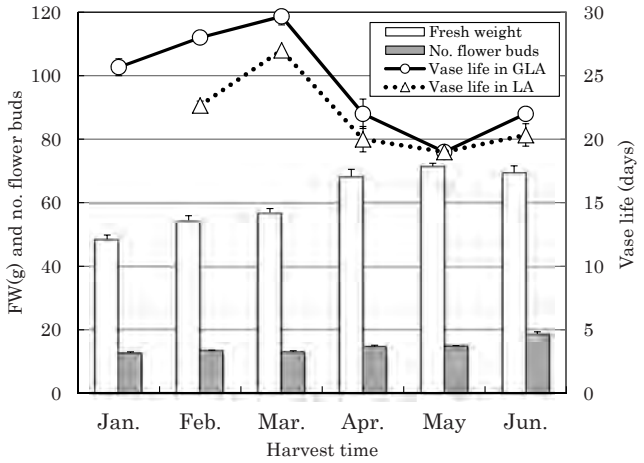

Fig. 3 Changes in cut flower characteristics and vase life by harvest times

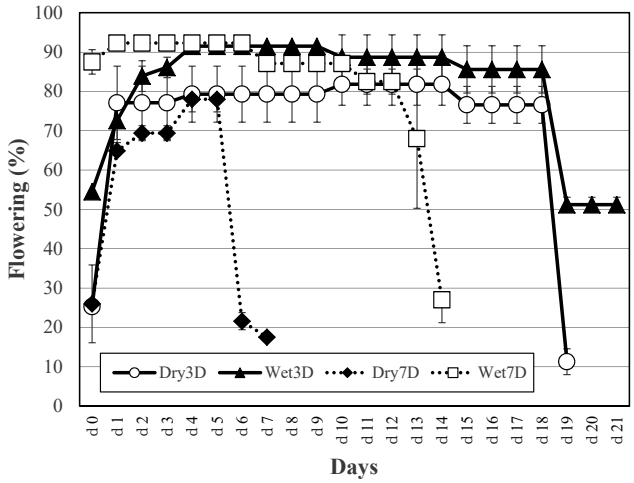

Fig. 4 Flowering of cut spray carnation flowers stored different conditions at 23℃

Initial flowering rate was about 25%. During the storage flowering rates of cut flowers kept in wet conditions increased to 55 and 87% in three and seven days of storage, respectively（Fig. 4）. On the other hand, cut flowers kept in dry conditions did not open during storage regardless storage term. Cut flowers kept in wet conditions reached maximum flowering rate in a few days. Cut flowers kept in wet conditions for seven days showed a decrease of flowering rate after day 7 and finished on day 13 whereas those stored for three days finished on day 21. Cut flowers kept in dry conditions showed lower maximum flowering rate and shorter vase life（7 and 18 days in seven and three days storage）compared with cut flower kept in wet conditions. Control cut flowers（without storage）showed 27 days of flower longevity（data not shown）.

The results demonstrate that term of storage at 23℃ must be shorter than three days in cut spray carnations flowers.

2-2. Dry and wet storage at 5℃

Fresh weight of cut flowers decreased in dry conditions but increased in wet conditions during 5℃ storage. The changes was much smaller than those at 23℃（Table 1）. No difference in flowering was observed regardless wet and dry conditions when cut flowers were stored for 3 or 7 days（Fig. 5）. Opening of flowers stored dry condition progressed slightly earlier than those of wet stored cut flowers. All flowers showed about three weeks vase life. The results indicated that glucose in a storage solution did not enhanced fresh weight increase of cut flowers during storage and prolong flower longevity. Cut flowers stored in wet condition for two weeks showed equivalent vase life as cut flowers stored shorter periods（Fig. 6）.

The results showed that temperature is a key factor to store cut spray carnation flowers successfully. Low temperature（5 ℃）storage is recommended for long term storage of cut spray carnation flowers.

Table 1 Effect of dry and wet storage at 5℃ on vase life of cut spray carnation flowers

Storage methods	Fresh weight changes during storage			Flower longevity（days）after storage		
	3 days	7 days	14 days	3 days	7 days	14 days
Dry	91.9 a	85.6 a	NT	22.3 ns	20.5 ns	NT
Wet（LA）	101.6 b	102.6 b	103.3 ns	21.3 ns	22.0 ns	20.3 ns
Wet（GLA）	102.5 b	103.5 b	103.5 ns	22.0 ns	21.6 ns	21.3 ns

Figures in Table are vase life（days）.

NT: not tested.

Means values followed by different letters between treatment represent significant differences by Tukey's mutiple range test（$p<0.05$）

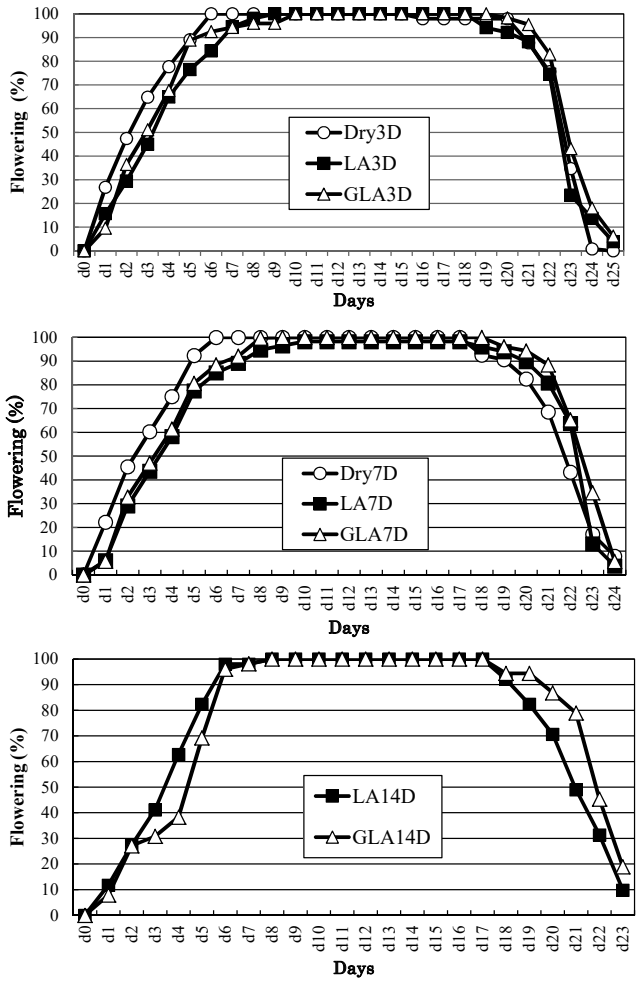

Fig. 5 Flowering of cut spray carnation flowers stored different conditions at 5℃

Fig. 6 Flowers performance on day 14
The flowers were stored in wet condition for two weeks and then kept in GLA.
Left: Flowers kept in LA during storage.
Right: Flowers kept in GLA during storage.

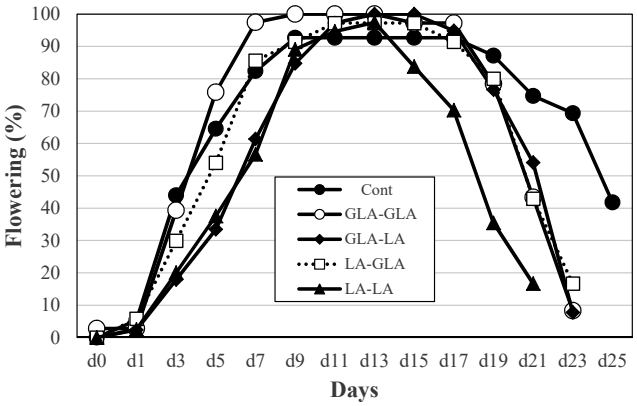

Fig. 7 Effects of glucose supply during storage and vase life test

3. Effect of glucose in storage and base solution on vase life of cut spray carnation flowers

In experiment 2-2 no positive effects of glucose in a storage solution were observed. In this case, all cut flowers were kept in GLA after storage. It is assumed that consumer may keep cut flowers in a tap water without using a preservative solution containing sugar. In this experiment cut flowers were kept in storage solution with and without glucose (LA or GLA) at 5 ℃ for two weeks and then kept in vase solution with and without glucose (GLA or LA) at 23℃ . The experiments were repeated in January and May. Because the same tendency in the results was obtained, the results of January were presented in this paper.

When glucose was supplied in both storage and vase solutions (GLA-GLA) the blooming progressed faster and reached the maximum flowering rate earlier than those in other conditions (Fig. 7). LA-GLA cut flowers showed second earlier time to the maximum flowering rate. Cut flowers fed glucose during storage showed the same vase life as cut flowers that were fed glucose all the time even though they were kept in a vase solution without glucose. These three treatments (GLA-GLA, GLA-LA, LA-GLA) showed nearly same vase life of about 21 days. On the other hand, cut flowers kept in solution without glucose all term (LA-LA) showed an earlier drop of flowering rate, resulting short flower longevity (17days). The results indicated that glucose in a vase solution is effective to open the flower of carnation as reported previously [6,7]. The present results demonstrate that if consumers use commercial cut flower preservatives containing sugar, supply of sugar during storage is not necessarily required, whereas if the consumers do not use the cut flower preservatives, supply of sugar during storage improves cut flower

Table 2 Genotype differences in vase life of cut spray carnation flowers

Cultivars	No. flower buds*	Max flowering (%)	Days to MF**	Vase life (day)	
Citrus	16.0 ± 1.2	96.1 ± 2.0	2.3 ± 0.3	21.0 ± 0.0	
Feminir	17.7 ± 0.3	96.1 ± 4.0	11.3 ± 0.3	17.3 ± 0.3	
Ruban	22.0 ± 0.6	90.4 ± 5.1	3.3 ± 1.2	13.3 ± 0.7	
Lillian	15.7 ± 0.7	89.4 ± 2.0	8.0 ± 1.5	17.0 ± 0.6	
Mini-tiara Pink	58.7 ± 4.5	31.6 ± 1.1	5.0 ± 0.0	12.7 ± 0.3	***
Tsubasa	19.3 ± 1.2	94.2 ±3.0	7.0 ± 1.5	17.7 ± 0.3	
Kippi	19.0 ± 0.0	63.2 ± 0.0	4.5 ± 0.3	7.3 ± 2.7	
Mao	13.3 ± 0.3	100 ± 0.0	2.0 ± 0.0	17.7 ± 0.0	
Lealea	17.7 ± 0.7	98.2 ± 1.8	5.3 ± 0.9	15.7 ± 0.3	
Red liver	15.0 ± 0.0	95.5 ± 2.2	6.3 ± 2.4	16.7 ± 0.3	

* Total number of flower buds / flask (three cut flowers)
** MF: maximum flowering rate
*** vase life was calculated by days to less than 50% of maximum flowering rate.

performance. The effectiveness of sugar supply during low temperature storage is consistent with the case of cut standard carnation flowers [8].

Stem rot was observed in a flower kept in GLA in the experiment of May. The same phenomenon was observed sometimes throughout three years of this study. It occurred only in flowers kept in GLA and mostly between April and June. It always appeared about two weeks after start of the experiment. The site of stem rot occurrence was not at the cut end of the cut flower, but at a part somewhat higher than that. We observed stems carefully and recorded the process of the stem rot occurrence. When the cut carnation flowers were kept in a flower vase, lower leaves were removed. After removing the leaves, scars can be made, and at the beginning of experiment it was under the surface of the vase solution containing bacteriostatic agent. After that, as the solution decreased, the wound part was exposed to the air, and then fungus grow, resulting in the occurrence of stem rot. Once stem rot occurs, even if that the part falls below the surface of solution after adding vase solution, the progress of stem rot can not be stopped. The frequency of the stem rot is not very high, but it is also true that it can happen. However, because that reproduction of the stem rot under experimental conditions is not easy, the elucidation of its true cause and measures still remain unclear.

4. Cultivar differences in vase life of cut spray carnation flowers stored two weeks at 5℃

Considerable cultivar differences in vase life of cut flower were observed in 10 spray carnation cultivars stored for two weeks at 5℃ (Table 2). During two weeks of storage, most flowers opened to some extent, resulting in shorter days to

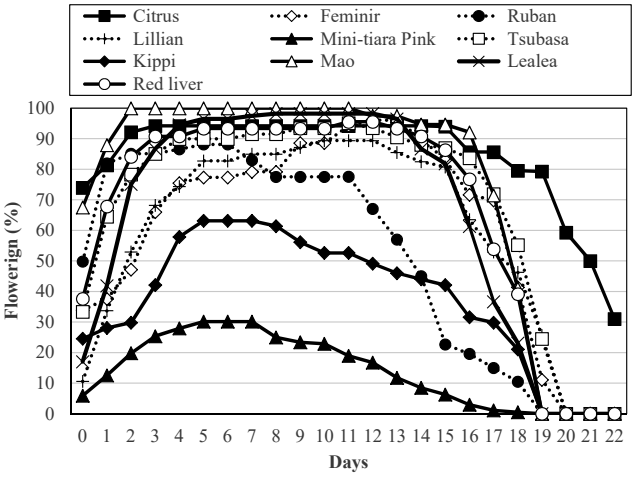

Fig. 8 Genotype differences in flowering of cut spray carnation flowers stored in GLA at 5℃ for two weeks.

maximum flowering percentage (Fig. 8). Most of the cultivars showed more than two weeks vase life in spite of the fact that two days dry storage at room temperature was applied before start of vase life test. The cultivars showed less than two weeks vase life were 'Ruban', 'Mini-tiara', and 'Kippi'. 'Ruban' showed earlier drop of flowering percentage and both 'Mini-tiara' and 'Kippi' showed lower maximum flowering percentage. In the case of 'Mini-tiara', the vase life was estimated in days to less than 50% of maximum flowering rate because of larger number of flower buds per stem. Disbudding before shipping might be required to reduce non-sense flower buds (flower buds without potential to open) in 'Mini-tiara'. The results demonstrate that most spray carnation genotypes can be adopted for two week shipping management at 5 ℃ whereas some cultivars showed lower adoptability for storage.

Fig. 9 Appearance of cut spray carnation flowers just before vase life test in the demonstration.
Left: cut flowers stored two weeks.
Right: cut flowers without storage.

Table 3 Vase life of cut spray carnation flowers in demonstration test

Date of harvest	Storage term	Vase life (days)
26th March	2 weeks	15.0
9th April	0	15.0

5. Demonstration shipping management

The cut flowers stored for two weeks were a bit more open when they arrived at the market in comparison with fresh cut flowers (Fig. 9). There was no difference in cut flower performance between flowers with and without storage (Table 3). Because this demonstration was conducted according to the usual manner of cut carnation flower producers. Therefore, a higher storage temperature (10 ℃) was adopted. Our preliminary experiments also showed no differences in cut flower performance after storage in both 5 and 10 ℃ (data not shown). Commercial preservatives used in the demonstration contained both sugar and bacteriostatic agent as same as GLA.

The results of the demonstration support the results obtained in the laboratory. Cut spray carnation flowers can be adopt two weeks shipping time adjustment when the flowers were kept in a preservative solution at 5 or 10℃ .

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スプレーカーネーション切り花の出荷調整技術

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要　約

スプレーカーネーション切り花の出荷時期調整技術を確立するため，乾式および湿式で出荷調整した切り花の品質保持を検討した．スプレーカーネーション切り花の品質保持期間は、生け花開始から全花蕾の50％が終了するまでと定義した．生け水へのグルコース添加は冬季から３月までの切花では品質保持期間を延長したが，４月以降では効果がなかった．23℃での３日以上の出荷調整は困難であるが５℃湿式では14日間の出荷調整が可能であった．出荷調整後の品質保持期間に品種間差異は認められたが，多くの品種で低温下での出荷調整が可能であった．実需者レベルでの実証試験でも２週間の出荷調整が可能であった．