STUDIES ON THE KEEPING QUALITY OF CUT FLOWERS

II On the Floral Preservative 'Kagawa Solution' and Its Practical Use for Cut Carnation

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Summary

The present experiments were designed to make clear the effect of KS and modified KS on the keeping quality of cut carnations and the practical use of these floral preservative solutions.

1. The continuous use of KS (300 ppm 8-HQ, 500 ppm B-9, 20 ppm 6-BA and 3% Sucrose) caused discoloration and collapse of stems, and darkening of red petals. However, KS-1 (75 ppm 8-HQ, 125 ppm B-9, 5 ppm 6-BA and 3% Sucrose) could evade these faults without shortening of vase life.

2. Among the solutions tested, KS-2 (300 ppm 8-HQ, 500 ppm B-9, 20 ppm 6-BA and 6% Sucrose) was most effective for the short time treatment.

3. When cut carnations in bud were treated with KS-1 continuously, vase life was longer than that of cut carnations in bloom.

4. KS-2 treatment for 12 and 24 hours has prolonged the vase life of cut carnations in bloom and half in bloom harvested in spring season, while no effect could be observed in summer season.

5. Combination of low temperature storage with continuous treatment with KS-1 was effective to keep the good quality and prolong vase life of cut carnations except in summer.

The following combination with KS-1 may be recommended,

(1) Storage within 1 week; cut carnations in bloom and half in bloom at 0°C.

(2) Storage about 2 weeks; cut carnations in bud at 10°C, cut carnations half in bloom at 0°C.

Introduction

Extension of vase life and improvement of post harvest development and maintenance of good quality in cut flowers are highly desirable[11], and several physical or chemical means are availed to keep good quality of cut flowers. For example, low temperature storage[3], controlled atmospheric storage[7] and hypobaric storage[1] are conceivable for physical means, and for chemical means floral preservatives are employed in general. At present, numerous floral preservatives[2,6,8,10] are devised and most of them are composed of bactericidal substances, respirable substrates, inhibitors of ethylene production and growth regulating substances.

The floral preservative Kagawa solution[5] (300 ppm 8-HQ, 500 ppm B-9, 20 ppm 6-BA and 3% Sucrose) which was based on the solution devised by Larsen and Scholes[6] and was abbreviated KS in the present study for convenience has some faults as follows. When cut carnations are treated continuously with KS, they are apt to cause stem discoloration, stem collapse and darkening of red flower petals.

The present experiments were performed in order to make clear the appropriate concentration of KS for cut carnations and the practical use of it.

Materials and Methods

Cut carnations of cv. "Scania 3C" were used for winter and spring experiments, and those of cv. "Yosooi" were used for summer experiments. Both cultivars were obtained from commercial carnation grower in Takamatsu City in the morning on the day of treatment. Carnations were harvested at about 50 cm length, and leaves on the stem of approximately 10 cm above the base were taken off. The cut ends of five cut flowers were placed in aquaous solutions of the floral preservative mixtures (KS and modified KS, Table 1) and deionized water in a Erlenmeyer's flask or a Wagner pot. Quality, diameter and fresh weight of flowers were examined at the appropriate time every day. Mean diameter value of flowers was indicated as average of the diameters of 5 flowers, and was shown as average of the widest length and narrowest length of each flower diameter. The number of days from the treatment to the first signs of wilting of the petals was referred as the vase life.

Table 1. KS and modified KS in the experiments

Substance	KS	KS–1	KS–2
8-Hydroxyquinoline	300 ppm	75 ppm	300 ppm
N-dimethylamino succinamic acid	500	125	500
6-Benzyladenine	20	5	20
Sucrose	3 (%)	3 (%)	6 (%)

Results and Discussion

1. Appropriate concentration of KS for continuous use

Continuous treatment of cut carnations with KS usually resulted in the production of the largest flowers with the longest vase life, but it easily caused stem discoloration, collapse of stem tissues to some extents, easy breaking of node, darkening of red color in petals, and loss of freshness.

The first experiment started on January 13, 1974 showed that vase life of cut carnations was shortened by diluting the concentration of KS, but vase life and flower diameter were improved by means of modification in sucrose concentration of diluted KS to 3% (Fig. 1).

The second experiment was started on February 17, 1974, and the results are given in Figs. 2 and 3. When sucrose concentration was adjusted to 3% in the modified KS, the lower the concentration of other KS components was, the shorter the vase life of cut carnations was. The immersed part of stems in undiluted and half diluted KS turned brown. Some microorganisms made muddy the 1/8, 1/10 dilute solutions and deionized water. In these experiments, flowers in the KS and modified KS lots became deep color and the petals were stiffer than those in deionized water control. It was considered from these results that 1/4 KS (except sucrose) was the best preservative solution for the continuous use.

Subsequent experiments were made for the determination of the appropriate sucrose concentration for continuous use of KS. The results in Fig. 4 indicate that vase life of cut carnations in 3% sucrose solutions of modified KS was longer (30–40%) than that in the other solutions. The flower diameter in every preservative solution was larger than that in deionized water, and at higher temperature it was larger (1 cm) than that at lower temperature. However, no difference in the flower diameter in the same temperature was shown between the sucrose

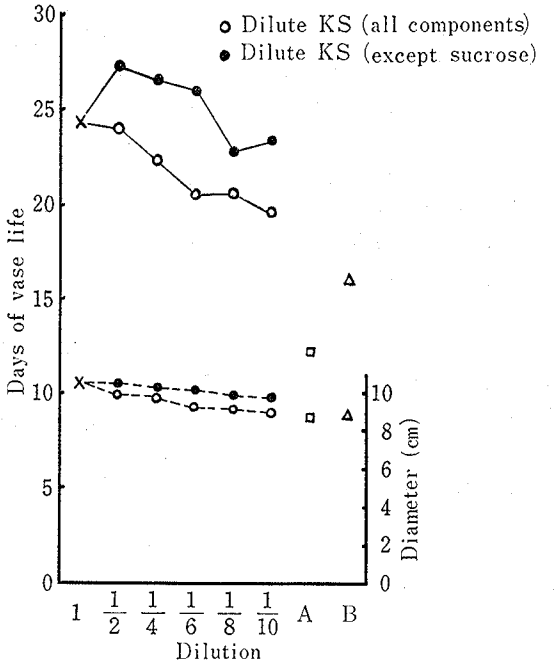

Fig. 1. Vase life and flower diameter of cut carnation "Scania 3C" in dilute KS at 7±4°C.
A: Deionized water
B: 3000 fold Amobam solution

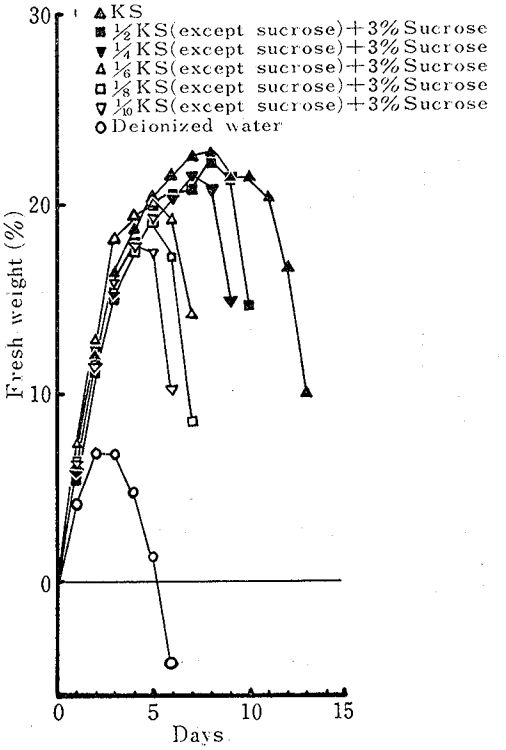

Fig. 3. Effect of continuous treatment with various dilute KS on the fresh weight of cut carnation "Scania 3C" at 25°C. 0 point indicates fresh weight at the treatment.

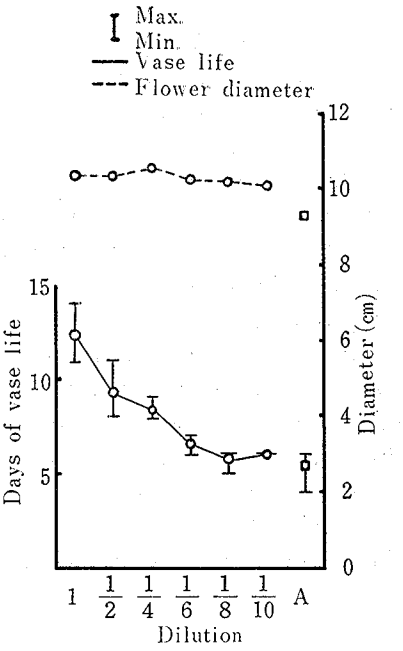

Fig. 2. Vase life and flower diameter of cut carnation "Scania 3C" in dilute KS at 25°C.
A: Deionized water

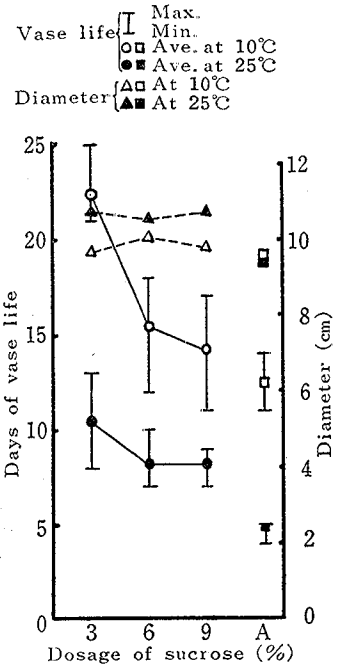

Fig. 4. Effect of concentration of sucrose in 1/4 KS (except sucrose) on vase life and flower diameter of cut carnation "Scania 3C" at 10 and 25°C.
A: Deionized water

concentrations. It is likely that sucrose concentration much affected vase life, but little affected flower diameter and flower color. Preservative solution modified to 1/4 KS (except sucrose) was most effective for the continuous use; hence this solution is abbreviated KS–1.

2. Appropriate concentration of the floral preservative KS for the short time treatment

Basal stems of cut carnations in bloom of "Scania 3C" were immersed in six test solutions (3, 6, 9% sucrose in both KS and KS–1) and deionized water at 10°C and 25°C for 2 hours, and then rinsed out and immersed again in deionized water of Wagner pots at 10°C and 25°C temperature, respectively.

Vase life at 10°C was approximately three times longer than that at 25°C, and undilute KS was more effective than KS–1 at both temperatures (Fig. 5). Flower diameter and flower color were little affected by temperature and sucrose concentration. In the case of the short time treatment, it is clear that 6 and 9% sucrose in KS effectively affected vase life, but 9% sucrose in KS shortened vase life at high temperature.

Modified KS containing 6% sucrose is most effective for the short time treatment; hence this solution is abbreviated KS–2.

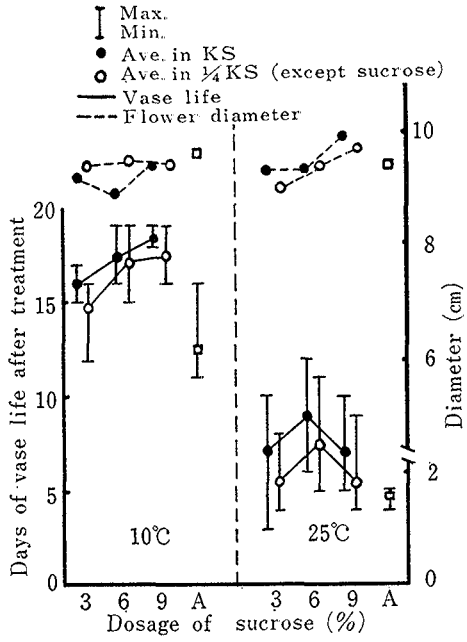

Fig. 5. Effect of concentration of KS and sucrose on vase life and flower diameter of cut carnation "Scania 3C" in short time (2 hours) treatment at 10°C and 25°C.
A: Deionized water

3. Effect of continuous treatment with KS–1 on the keeping quality of different cut stage carnations

Cut carnations in three stages of bloom were used, those were in bloom (6 cm diameter), half in bloom (4.5 cm), and in bud (2.0 cm). They were harvested on May 12, 1974 and were put in KS–1 and deionized water at 23±3°C. In KS–1 and deionized water, vase life of cut car-

nations of cut stage in bud was longer than that of other cut stages (Fig. 6). Number of days in commercial value in KS–1, commercial value means over 6 cm flower diameter in bloom, was 13.8 days for cut stage in bloom, 12.6 days for half in bloom, 11.0 days for in bud, respectively. In deionized water, it was 7.8 days for cut stage in bloom, 6.2 days for half in bloom, 2.4 days for in bud, respectively. Flower diameter of all flowers in KS–1 lot was larger than that in deionized water, and the increasing tendency of flower diameter was remarkable for cut stage in bud (Fig. 7). The same trend as in flower diameter was shown (Fig. 8). In this experiment, cut carnations in bud came into in bloom even in deionized water, but the term after 6 cm in flower diameter was only a few days. Cut carnations in bud in KS–1 had the longest vase life and the term after 6 cm of flower diameter was 3 days longer than that in bloom in deionized water control, and they came into full bloom. Though it is a customary practice to harvest only in bloom for growers, these results indicate the feasibility of the extension of harvest time of cut carnations.

4. Effect of the short time treatment with KS–2 on the keeping quality of different cut stage carnations

The first experiment was started on May 26, 1974, with "Scania 3C". The flower diameter of each cut stage was 6.3 cm in bloom, 2.8 cm half in bloom, 2.0 cm in bud, respectively. After the treatment with KS–2 for several hours, these cut carnations were placed in deionized water at 23±3°C.

The second experiment was started on August 16, 1974, with "Yosooi". The flower diameter of each cut stage was 5.2 cm in bloom, 2.1 cm half in bloom, 1.4 cm in bud, respectively. After the treatment with KS–2 for several hours, they were placed in deionized water at 30±1.5°C. Vase life and flower diameter are given in Table 2.

In regard to vase life, there were some differences between the experiments. In the spring experiments, vase life of each cut stage became longer in proportion to the time in 24 hours. In

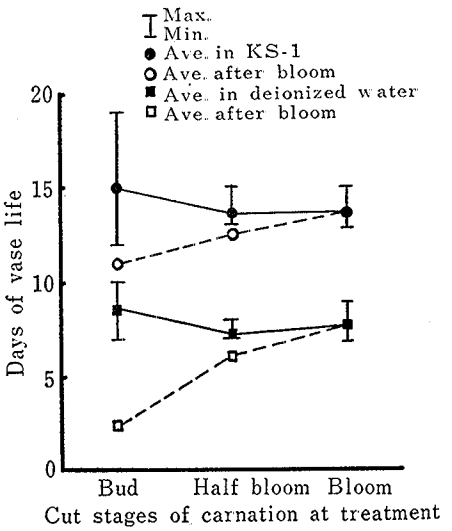

Fig. 6. Effect of continuous treatment with KS–1 on vase life of three different cut stages of carnation "Scania 3C" at 23±3°C.

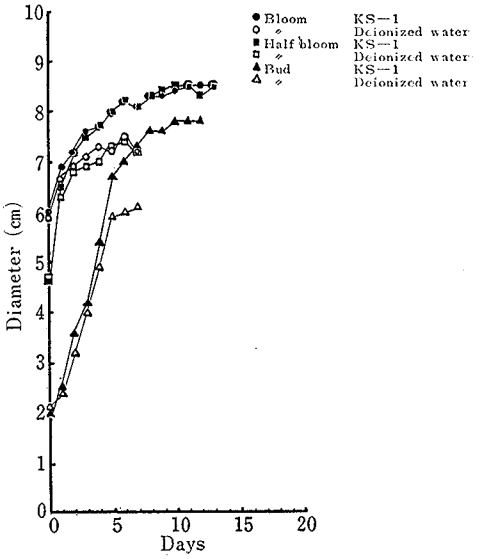

Fig. 7. Effect of continuous treatment with KS–1 on flower diameter of three different cut stages of carnation "Scania 3C" at 23± 3°C.

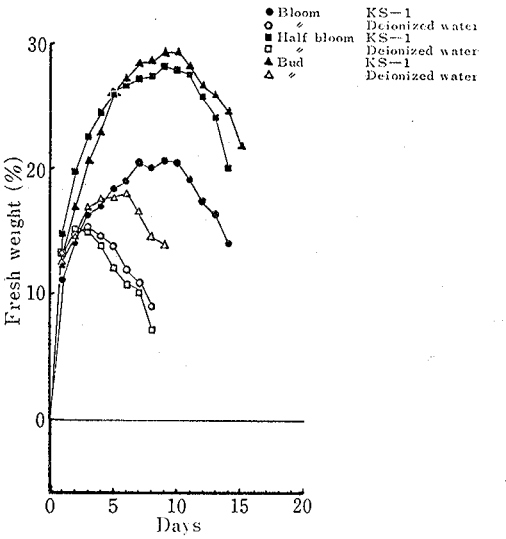

Fig. 8. Effect of continuous treatment with KS-1 on the fresh weight of three different cut stages of carnation "Scania 3C" at 23±3°C. 0 point indicates fresh weight at the treatment.

the summer experiments, there was little effect of the treatment on vase life.

These results suggest that the short time treatment of KS-2 is useful for cut carnations half in bloom and in bloom at any season other than summer.

Table 2. Effect of hours under treatment with KS-2 on vase life and flower diameter of cut carnation "Scania 3C" and "Yosooi" at room temperature

Cv. / Date	Cut stage	Hours under treatment: 0	0.5	1	2	4	12	24	48	96
Scania 3C, 26 May	Bud	8.0 / 5.9	10.2 / 6.0	11.0 / 5.9	11.2 / 6.0	9.0 / 6.2	13.2 / 6.5	12.0 / 6.3	7.6 / 6.3	6.6 / 7.3
	Half bloom	7.2 / 6.9	8.4 / 6.8	8.6 / 7.1	9.0 / 7.1	9.6 / 7.5	9.4 / 7.2	9.6 / 7.3	7.0 / 7.5	6.6 / 7.5
	Bloom	5.8 / 8.0	6.8 / 7.7	6.8 / 7.6	7.0 / 7.7	7.4 / 7.6	9.6 / 7.8	8.0 / 7.8	7.8 / 8.0	4.2 / 8.1
Yosooi, 16 August	Bud	* / 1.9	* / 2.0	* / 1.7	* / 1.9	* / 1.8	* / 2.9	* / 2.6		
	Half bloom	4.6 / 5.3	4.2 / 5.3	4.6 / 5.4	3.8 / 5.7	3.8 / 6.1	4.2 / 6.2	3.6 / 6.4		
	Bloom	2.6 / 6.0	3.0 / 5.7	3.0 / 6.3	3.0 / 6.0	3.0 / 6.3	4.0 / 6.7	3.8 / 6.9		

Days of vase life / Flower diameter (cm)

* Could not bloom.

Flower diameter is indicated on the 7th day after treatment.

5. Effect of the combination of low temperature storage with the floral preservative solutions on the keeping quality of cut carnations in the three different cut stages

The first experiment was started on May 12, 1974, with "Scania 3C". The flower diameter of each cut stage was 6.3 cm in bloom, 4.1 cm half in bloom, 2.1 cm in bud, respectively. Stor-

age temperatures were 0°C and 10°C, storage periods were 7 days and 14 days, and floral preservative solutions were as follows, (1) KS-1 during the storage periods, (2) KS-2 for 2 hours before the storage, (3) KS-2 for 2 hours after the storage and (4) KS-2 for 2 hours both before and after the storage. Cut carnations treated with KS-2 before the storage were brought into some polyethylene film bags (0.1 mm in thickness) to prevent from drying during storage. After the storage, cut carnations of all lots were placed in deionized water at 23±3°C.

As shown in Table 3, vase life of cut carnations ranged between 7.4 days and 5.0 days in the lots of KS-1. There are great dispersion and no definite tendency in the lots of the other

Table 3. Effect of the combination of low temperature storage with KS-1 and KS-2 treatment on keeping quality of cut carnation "Scania 3C" of three different cut stages in spring

Cut stage	Storage temperature (°C)	Storage period (Days)	KS-1, C	KS-2, B	KS-2, A	KS-2, B+A**
Bud	—	0		Control	8.4/6.1*	
	0	7	6.6/5.7	6.2/4.5	7.3/4.5	7.6/4.7
		14	7.4/6.9	9.4/4.3	8.2/5.7	8.4/3.5
	10	7	7.0/7.2	6.2/3.9	6.6/4.9	7.4/4.0
		14	5.0/7.7	5.2/5.1	3.4/2.9	5.7/4.5
Half bloom	—	0		Control	7.2/7.4	
	0	7	6.6/7.1	8.8/7.2	6.2/6.8	6.6/6.8
		14	7.2/7.4	6.6/6.3	8.4/7.2	6.8/6.3
	10	7	6.0/7.9	5.6/6.6	3.8/6.0	4.0/6.4
		14	5.8/8.4	3.6/6.5	1.8/6.1	2.8/6.5
Bloom	—	0		Control	7.8/7.5	
	0	7	6.2/7.6	4.6/6.9	5.8/7.1	5.4/5.9
		14	6.8/7.7	3.8/6.7	4.8/6.9	5.8/6.8
	10	7	6.0/8.2	2.4/7.0	3.0/7.0	3.2/7.0
		14	6.0/8.7	2.0/6.8	1.0/6.9	2.6/6.8

* Days of vase life / Flower diameter (cm)

** KS-1, C: KS-1 continuously.
KS-2, B: KS-2 for 2 hours before storage.
KS-2, A: KS-2 for 2 hours after storage.
KS-2, B+A: KS-2 before and after storage for 2 hours each.

preservative solution. In the lots of KS–1 treatment during the storage, cut carnations of 14 days storage at 0°C had longer vase life than that of 7 days, but cut carnations of 7 days storage at 10°C had longer vase life than that of 14 days. Cut carnations in bud stage were failed to bloom in the KS–2 plot. There was a clear relationship between storage temperature and flower diameter in all cut stages. The cut carnations of 10°C storage had greater flower diameter than those of 0°C. There were no changes of flower color among all lots in KS–1, but most flowers in KS–2 were turned dark red and many flower petals were incurved.

The second experiment was started on August 10, 1974, treating "Yosooi" with KS–1 or deionized water. The flower diameter of each cut stage was 3.8 cm in bloom, 1.7 cm half in bloom, 1.4cm in bud, respectively. In this experiment, storage temperatures were 0°C and 10°C, and storage periods were 3 days, 7 days and 14 days. After the storage, cut carnations were kept in deionized water at 29.7±2°C. All cut carnations in bud were failed to bloom regardless the treatments (Table 4). Vase life of cut carnations treated in bloom and half in bloom was shorter than that of control. Flower diameter of cut carnations in bloom and half in bloom in KS–1 was

Table 4. Effect of combination of low temperature storage with KS–1 or deionized water treatment on keeping quality of cut carnation "Yosooi" of three different cut stages in summer

Cut stage	Storage temperature (°C)	Storage period (Days)	Deionized water	KS–1
Bud	—	0	Control * 2.1	
	0	3	* 2.1	* 1.8
		7	* 2.4	* 1.7
		14	* 2.4	* 3.1
	10	3	* 2.3	* 2.4
		7	* 1.9	* 2.8
		14	* 2.2	* 3.9
Half bloom	—	0	Control 4.8 / 4.6	
	0	3	2.8 / 5.3	3.4 / 5.0
		7	1.6 / 4.2	2.2 / 5.3
		14	0.8 / 3.8	1.2 / 4.6
	10	3	2.0 / 4.2	3.4 / 4.8
		7	0.4 / 3.8	2.4 / 5.0
		14	**	0.6 / 4.8
Bloom	—	0	Control 4.2 / 6.0	
	0	3	2.2 / 5.8	3.0 / 5.5
		7	1.0 / 5.6	3.2 / 5.6
		14	0.6 / 5.2	2.4 / 5.8
	10	3	1.6 / 5.2	1.8 / 5.4
		7	0.2 / 4.4	1.2 / 5.4
		14	**	0.6 / ***

Days of vase life / Flower diameter (cm)

Flower diameter is indicated on the 7th day after storage.

* Could not bloom.

** Wilted during storage.

*** Wilted.

slightly greater than that in deionized water. Flower color of some petals was dappled and the dapples were remarkable in 14 days storage at 0°C.

As mentioned above, KS–1 treatment during storage has made possible to prolong vase life of cut carnations in spring season. But it was better when cut carnations in bud were stored at 10°C, and also in the case of cut carnations in bloom and half in bloom, it may be recommended to store at 0°C for the reason that the flowers stored at 10°C become in bloom too early. In summer season, it was impossible to prolong vase life of cut carnations by means of any treatment during storage.

Many floral preservative solutions have been devised. When these floral preservative solutions are used at high concentrations, however, sometimes they may cause discoloration and collapse of stems[4]. The Kagawa solution also has similar faults. When KS is used continuously for cut carnations, these faults were evaded by means of the dilution of KS concentration (except sucrose) to 1/4.

In the present experiments, cut carnations in bud in spring season could come into bloom by means of the continuous treatment with KS–1 and the short time (12–24 hours) treatment with KS–2, but in summer season cut carnations in bud could not bloom by the same treatments with KS–2. Moreover in the summer experiments, in which the effect of combination of low temperature storage with the floral preservative solution was examined, cut carnations in bud could not bloom by means of any treatment. And also, in spring cut carnations in bud could be stored during 1 to 2 weeks at 10°C and during 2 weeks or more at 0°C without shortening of vase life and loss of quality. These differences of the results between the experiments in spring and in summer may be due to the seasonal differences of environmental conditions and quality of test materials. Further studies are necessary for preservative characters of the cultivars used in the experiments.

In general, cut carnations have been customarily harvested in bloom, but cut carnations half in bloom and in bud are able to bloom by effective use of floral preservative solutions[2,4]. Parups[9] reported that the extension of vase life in the cut rose cv. "Forever Yours" was the longest when the preservative was used during the consumer period, and this extension in vase life was less when used during the simulated wholesale and retail marketing periods. Our results suggest that combination of cut stage of flower with storage by preservative solutions may extend the harvest time for growers, and the use of floral preservative solutions during the consumer periods gives warranty of good quality of cut flowers at least for several days.

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切花の品質保持に関する研究

II 切花保存液 'Kagawa solution' の切花カーネーションに対する実用性について

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要 旨

本実験は切花の日持と品質向上に効果的な切花保存液 Kagawa solution（以下 KS と略記）について，切花カーネーションを材料として実用化について検討し，以下のような結果を得た．

1. 300ppm 8-HQ, 500ppm B-9, 20ppm 6-BA, 3%Sucrose からなる KS にカーネーションを連続して挿すと，茎の浸漬部が褪変し，茎組織がもろくなり節から折れやすくなる．また赤色系では花弁が暗赤色になるなどの障害を生じたが，Sucrose 以外の成分の濃度を $\frac{1}{4}$（75ppm 8-HQ, 125ppm B-9, 5ppm 6-BA）とし，Sucrose を3%にした KS-1 を用いることにより，日持を減ずることなく障害を避けることができた．

2. 短時間吸収させる場合は，KS の Sucrose 濃度のみを6%にした KS-2（300ppm 8-HQ, 500ppm B-9, 20ppm 6-BA, 6%Sucrose）が最も効果的であった．

3. つぼみで採花したカーネーションを KS-1 に連続して挿すとよく開花し，開花後の日持も慣行通り採花したものよりも長くなった．

4. KS-2 を12～24時間吸収させることにより，つぼみ，半開，開花状態で採花したいずれの切花の日持も長くなったが，夏季の場合はつぼみ，半開の切花には効果がなかった．

5. 夏季の高温期以外は，冷蔵期間中 KS-1 を吸収させることにより，出庫後の切花の品質，日持を開花状態で採花した切花と同程度に保つことができた．その場合は以下の組合せが効果的であった．

（1） 1週間内の貯蔵；開花および半開採花，0°C.

（2） 約2週間の貯蔵；つぼみ採花，10°C，半開採花，0°C.

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