Variation with the cultivar in the vase life of cut rose flowers

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Summary

Variations in the way of flower opening and vase life of cut rose (*Rosa hybrida* L.) flowers among 25 cultivars were investigated. The way of flower opening varied among 25 cultivars; the cut flowers of some cultivars did not open completely. The vase life markedly varied among the cultivars; it was the shortest in 'Bridal Pink' (3.8 days) and the longest in 'Calibra' (14.5 days). To elucidate the factors that affect the variation in the vase life of cut roses with the cultivar, 10 major cultivars in Japan, were used. There was no correlation between vase life and petal thickness or transpiration rate of the cut flowers. To investigate whether vascular occlusion or sugar content is involved in the variation of the vase life, we continuously treated the cut flowers with 200 mg·liter^{-1} 8-hydroxyquinoline sulfate (HQS) on 20g·liter^{-1} sucrose with both of them. Treatment with HQS, sucrose and sucrose plus HQS significantly extended the vase life of two, two and four cultivars, respectively. However, none of the chemicals extended the vase life of 'Delilah', 'Calibra', 'Konfetti', 'Pareo[90]' and 'Rote Rose'. The vase life of these cultivars except for 'Rote Rose' was longer than 8 days. These results also suggest that a short vase life in some cultivars is attributed to vascular occlusion and/or shortage of sugars.

Key Words: Cultivar variation, 8-hydroxyquinoline sulphate (HQS), *Rosa hybrida*, sucrose, vascular occlusion, vase life.

Introduction

The length of vase life is one of the most important factors for quality of cut flowers. The vase life varied among various cultivars in carnation (Wu et al., 1991; Onozaki et al., 2001), *Eustoma* (Shimizu and Ichimura, 2002) and gerbera (Wernett et al., 1996). Although roses are very important cut flowers, there has been few studies on cultivar variations in the vase life of cut rose flowers; Van Doorn and D'hont

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(1994) reported that the vase life of cut roses markedly varied among four cultivars including ‘Frisco’.

The vase life of cut rose flowers often terminates by bending the floral axis just below the flower head, which is called bent-neck. The development of such symptoms is considered to be caused by vascular occlusion, which inhibits water supply to the flowers (Mayak et al., 1974; De Stigter, 1980; Van Doorn, 1997). Vascular occlusion is caused by multiplication of bacteria (Burdett, 1970; Zagory and Reid, 1986; Van Doorn et al., 1989; Jones and Hill, 1993), air emboli (Durkin, 1977; Van Doorn, 1990) or unknown physiological responses (Marousky, 1969). Van Doorn and D’hont (1994) reported that resistance to bacteria and dry storage is involved in cultivar variation in the vase life of cut roses.

Ueyama and Ichimura (1998) reported that aluminum sulfate and 2-hydroxy-3-ionen chloride polymer extended the vase life of cut roses. Since these compounds inhibit transpiration from leaves, we speculate that transpiration rate may be related to cultivar variations in the vase life of cut roses.

Rose flowers are usually harvested at the bud stage. For flower opening, large amount of soluble carbohydrates is required as the substrate for respiration and synthetic materials as well as osmolytes. Some vase solutions including sucrose extend the vase life of cut roses (Marousky, 1969; Gilman and Steponkus, 1972; Parups and Chan, 1973; Kaltaler and Steponkus, 1976). From these findings, we could speculate that the content of soluble carbohydrates in cut flowers is related to the length of vase life.

Treatment with sucrose in combination with 8-hydroxyquinoline sulfate (HQS) extends the vase life of cut rose flowers (Ichimura et al., 1999). This effect is due to supply of carbohydrates as well as inhibition of vascular occlusion by HQS. However, whether this treatment improves the vase life of all rose cultivars remains unclear. Treatment with HQS alone also extends the vase life of cut rose flowers (Burdett, 1970; Gilman and Steponkus, 1972). If treatment with HQS extends the vase life, vascular occlusion may be responsible for short vase life because HQS inhibits vascular occlusion of cut rose stems (Gilman and Steponkus, 1972; Ichimura et al., 1999). Sucrose alone has not been usually used because sugar treatment without germicides promotes bacterial proliferation, leading to shortening of the vase life. However, if treatment with sucrose alone extends the vase life of a cut rose cultivar, shortage of carbohydrates is considered to be involved in the short vase life.

In the present study, we investigated the variation in the vase life of cut rose flowers among 25 cultivars including ‘Rote Rose’, ‘Noblesse’, ‘Pareo^{90}’ and ‘Tineke’, which are major cultivars in Japan at present. We also investigated whether treatment with sucrose, HQS or their combination extends the vase life of cut flowers of various rose cultivars.

Materials and Methods

Rose (*Rosa hybrida* L.) cultivars Bianca, Black Tea, Bridal Pink, Calibra, Carto Blanch, Danya, Delilah, Dukat, Gold Strike, Grand Gala, Jerfalrei, Julia, Konfetti, Laser, Leonidas, Marilyn97, Meikruza, Noblesse, Orange Unique, Pareo^{90}, Rote Rose, Saphir, Sonia, Stardom and Tineke, harvested at normal harvest maturity (stage 1 or 2 as described by Ichimura and Ueyama, 1998), were obtained from a commercial grower at Ano and Ise, Mie Prefecture, Japan.

To examine the variations in vase life and the way of flower opening with the cultivar, we harvested rose flowers in May and immersed their cut ends in tap water. We kept them below 5°C in darkness for 1 day, and then transported them to the laboratory. The flower stems were trimmed to 45 cm, and all leaves except for the upper three were removed. Three cut flowers were placed in 500-ml beakers each with 500 ml of distilled water. Six flowers were used for each treatment. The cut flowers were kept at 23°C under 70% relative humidity. A 12-hr photoperiod was maintained, with 10 μmol·m^{-2}·sec^{-1} irradiance from cool-white fluorescence lamps.

To examine cultivar variations in petal thickness and transpiration rate and the effect of sucrose and/or HQS on vase life, we harvested the rose flowers on December, and immersed the cut ends of the flower stems in tap water for 1-2 hr after harvest. The cut flowers were then transported to the laboratory and used for experiments within 3 hr. The flower stems were trimmed to 40 cm, and all leaves except for the upper three were removed. Three cut flowers were placed in each of 500-ml beakers with 500ml of distilled water (control), 200mg·liter^{-1} HQS, 20g·liter^{-1} sucrose (Suc) or 20g·liter^{-1} sucrose plus 200mg·liter^{-1} HQS (Suc + HQS). Nine flowers were used for each treatment. The cut flowers were kept as described above.

The degree of flower opening, based on the standards described by Ichimura and Ueyama (1998) was observed daily. The fresh weight of cut flowers and the amount of water uptake were measured daily. The amounts of water uptake were corrected by subtracting evaporation of water from a beaker without cut flowers. The amount of water loss was calculated by subtracting the increase in fresh weight from the amount of water uptake. Transpiration rate was given by the amount of water loss divided by initial fresh weight. Vase life was the period from the time of harvest to the time when either the petals lost turgor, the neck was bent or the petals had abscised. The thickness of petals was measured by a digimatic outside micrometer (Mitsutoyo Corp., Kanagawa) on the day of harvest.

Results

Variations in flower opening and vase life among 25 cultivars

The way of flower opening varied among 25 cultivars (Table 1). ‘Bridal Pink’ flowers opened the fastest, followed by ‘Black Tea’. ‘Noblesse’ flowers reached stage 5 the latest, but most flowers did not completely open. In addition, most of flowers in some cultivars, such as ‘Grand Gala’ and ‘Jerfalrei’, wilted without complete flower opening.

The vase life of cut flowers markedly varied among 25 cultivars (Table 1). The vase life was the shortest in ‘Bridal Pink’ (4 days) , followed by ‘Jerfalrei’ (4.2 days). It was the longest in ‘Calibra’ (14.5 days), followed by ‘Gold Strike’ (13.0 days).

Variations in petal thickness and transpiration rate among 10 cultivars

Table 2 shows the thickness of petals and the transpiration rate of cut flowers in 10 cultivars. The petal thickness and the transpiration rate varied among cultivars. However, there was no significant correlation between vase life and thickness of petals (r=0.263). Similarly, there was no significant correlation between the vase life and the transpiration rate at the 1st (r=0.149) and 2nd (r=0.056) day.

Table 1. Variation with the cultivar in the way of flower opening of cut rose flowers.

Cultivar	Days to stage 5[z]	Rate of flowers reaching stage 6 (%)	Vase life (days)
Bianca	2.7 ± 0.2[y]	100	8.3 ± 1.0[y]
Black Tea	1.7 ± 0.2	100	5.3 ± 0.4
Bridal Pink	1.5 ± 0.2	100	4.0 ± 0.0
Calibra	2.2 ± 0.2	100	14.5 ± 0.8
Carto Blanch	2.0 ± 0.0	100	6.2 ± 0.3
Danya	2.8 ± 0.2	100	12.0 ± 1.2
Delilah	2.2 ± 0.2	100	11.0 ± 0.0
Dukat	2.5 ± 0.2	100	8.8 ± 0.3
Gold Strike	3.0 ± 0.0	100	13.0 ± 0.0
Grand Gala	–	0	6.7 ± 0.3
Jerfalrei	–	17	4.2 ± 0.3
Juria	2.8 ± 0.2	100	6.2 ± 0.3
Konffetti	4.0 ± 0.9	100	12.3 ± 0.4
Laser	2.8 ± 0.3	100	10.5 ± 0.2
Leonidas	3.3 ± 0.7	83	5.7 ± 0.2
Marilyn97	3.2 ± 0.2	100	7.2 ± 0.4
Meikruza	2.0 ± 0.0	100	8.3 ± 0.8
Noblesse	4.5 ± 0.5	83	11.8 ± 0.4
Orange Unique	2.2 ± 0.2	100	9.2 ± 0.2
Pareo[90]	2.7 ± 0.2	100	5.7 ± 0.4
Rote Rose	2.8 ± 0.3	100	6.7 ± 0.6
Saphir	3.0 ± 0.0	100	7.3 ± 0.2
Sonia	2.0 ± 0.0	100	5.8 ± 0.7
Stardom	2.0 ± 0.0	100	8.3 ± 0.2
Tineke	3.7 ± 0.4	100	6.8 ± 0.3
Significance[x]	***		***

[z]Most flowers did not reach stage 5.
[y]Values represent mean of 6 flowers ± S.E.
[x]***Significant at P<0.001 by analysis of variances.

Table 2. Variation with the cultivar in the petal thickness and transpiration rate of cut rose flowers.

Cultivar	Petal thickness (μm)	Transpiration rate (ml·g^{-1}FW)	
		1st day	2nd day
Bridal Pink	266 ± 17[z]	0.67 ± 0.06[z]	0.89 ± 0.10
Calibra	243 ± 4	1.39 ± 0.09	1.70 ± 0.08
Delilah	246 ± 3	0.69 ± 0.03	0.20 ± 0.01
Jerfalrei	252 ± 8	0.89 ± 0.01	1.23 ± 0.02
Konffetti	272 ± 7	0.30 ± 0.01	0.35 ± 0.03
Noblesse	250 ± 8	0.94 ± 0.06	1.35 ± 0.11
Pareo[90]	243 ± 5	0.73 ± 0.09	1.06 ± 0.11
Rote Rose	285 ± 7	1.29 ± 0.07	1.67 ± 0.18
Sonia	287 ± 2	0.84 ± 0.08	0.36 ± 0.03
Tineke	241 ± 5	0.56 ± 0.08	0.77 ± 0.07
Significance[y]	***	***	***

[z]Values represent mean of 3 experiments ± S.E.
[y]***Significant at P<0.001 by analysis of variance.

Effects of HQS, Suc and Suc + HQS on vase life, flower diameter and fresh weight

Treatment with HQS significantly extended the vase life of 'Bridal Pink' and 'Sonia', but shortened that of 'Pareo[90]' (Table 3). HQS did not increase flower diameter in any of the cultivars tested (Table 4). Treatment with sucrose extended the vase life of 'Noblesse' and 'Sonia', but shortened that of 'Delilah' and 'Konffetti'. Sucrose (Suc) did not increase the flower diameter in any of the cultivars. Treatment with Suc + HQS extended the vase life of four cultivars, 'Bridal Pink', 'Jerfalrei', 'Sonia' and 'Tineke', but shortened that of 'Pareo[90]'. This treatment (Suc + HQS) significantly increased flower diameter of four cultivars. On the other hand, none of the above chemicals significantly extended the vase life of five cultivars, 'Calibra', 'Delilah', 'Konffetti', 'Pareo[90]' and 'Rote Rose'.

Fresh weights of cut flowers in the control group initially increased during the first 3 - 5 days of the experimental period, and decreased thereafter (Fig.1). Treatment with HQS delayed the time when the fresh weight started to decrease in eight cultivars and increased the maximum fresh weight of cut flowers in seven cultivars. Treatment with Suc delayed the time when the fresh weight started to decrease in two cultivars, 'Noblesse' and 'Sonia', and increased the maximum fresh weight of cut flowers in five cultivars. Treatment with Suc + HQS delayed the time when the fresh weight started to decrease in all cultivars except for 'Pareo[90]' and increased the maximum fresh weight of all cultivars except for 'Pareo[90]'.

Table 3. Effect of HQS, Suc and Suc+HQS on the vase life of various cut rose flowers.

Cultivar	Vase life (days)			
	Treatment			
	Control	HQS	Suc	Suc+HQS
Bridal Pink	4.0 a[z]	6.2 b	4.0 a	9.0 c
Calibra	10.2 a	9.1 a	12.4 a	13.9 a
Delilah	12.9 bc	11.7 b	10.2 a	13.4 c
Jerfalrei	5.3 a	5.2 a	5.4 a	7.0 b
Konffetti	12.7 bc	13.2 c	9.3 a	12.2 b
Noblesse	5.9 ab	5.1 a	9.2 c	6.6 b
Pareo[90]	8.6 b	6.6 a	8.3 b	7.0 a
Rote Rose	3.8 a	4.0 a	4.3 a	4.3 a
Sonia	4.9 a	6.1 b	8.9 c	10.8 d
Tineke	5.6 a	9.0 ab	6.1 a	9.3 b
Significance[y]				
Cultivar	***			
Treatment	***			
Cultivar × Treatment	***			

[z]Values represent mean of 3 experiments, and those with the same letters in each cultivar are not significantly different ($P<0.05$) by the Tukey-Kramer's multiple range test.
[y]***Significant at $P<0.001$ by analysis of variance.

Discussion

In the present study, we found that the vase life of cut roses markedly varied among 25 cultivars; the vase life was the shortest in 'Bridal Pink', followed by 'Jerfalrei' and was the longest in 'Calibra' (Table 1). Van Doorn and D'hont (1994) also reported that there were marked variations in the vase life among four cultivars, 'Sonia', 'Madelon', 'Jacaranda' and 'Frisco'.

The vase life of cut roses is affected by various factors. Van Doorn and D'hont (1994) reported that 'Frisco' rose is resistant to bacteria, which is considered to cause vascular occlusion and shorten the vase life of this cultivar. HQS inhibits vascular occlusion of cut rose stems in some cultivars such as 'Sonia' (Ichimura et al., 1999), 'Forever Yours' (Burdett, 1970) and 'Red American Beauty' (Gilman and Steponkus, 1972). In our study, treatment with HQS significantly extended the vase life of cut 'Bridal Pink' and 'Sonia' roses (Table 3). Thus, vascular occlusion is likely to be a cause of the short vase life in

Table 4. Effect of HQS, Suc and Suc+HQS on the flower diameter of various cut rose flowers.

Cultivar	Flower diameter (mm)			
	Treatment			
	Control	HQS	Suc	Suc+HQS
Bridal Pink	106 a[z]	108 a	108 a	124 b
Calibra	71 a	74 a	70 a	75 a
Delilah	110 a	114 ab	116 ab	120 b
Jerfalrei	98 a	105 a	105 a	104 a
Konffetti	105 a	105 a	103 a	106 a
Noblesse	99 ab	97 a	117 b	114 ab
Pareo[90]	106 ab	108 ab	111 b	103 a
Rote Rose	82 a	93 a	87 a	99 a
Sonia	105 a	108 ab	108 ab	116 b
Tineke	105 a	112 ab	104 a	121 b
Significance[y]				
Cultivar	***			
Treatment	***			
Cultivar × Treatment	***			

[z]Values represent mean of 3 experiments, and those with the same letters in each cultivar are not significantly different ($P<0.05$) by the Tukey-Kramer's multiple range test.
[y]***Significant at $P<0.001$ by analysis of variance.

these cultivars.

The vase life of 'Sonia' was extended by treatment with Suc more than that with HQS (Table 3). HQS inhibits vascular occlusion and Suc supplies soluble carbohydrates. Therefore, shortage of soluble carbohydrate is a greater factor for the short vase life in 'Sonia' roses. Cut rose flowers are usually harvested at the bud stage, and therefore, a large amount of soluble carbohydrates is required for flower opening. Petal growth associated with flower bud opening results from cell expansion (Kenis et al., 1985), which requires the influx of water and osmolyte such as carbohydrates into petal cells (Evans and Reid, 1988; Van Doorn et al., 1991). Thus, treatment with Suc is considered to satisfy the supply of such soluble carbohydrates. The vase life of 'Noblesse' roses is extended by Suc, but not by Suc + HQS. Similarly, the vase life of 'Pareo[90]' flowers was shortened by HQS. Thus, HQS is not suitable for cut 'Noblesse' and 'Pareo[90]' flowers although no visible symptom of chemical injury was observed. Since they are major cultivars produced in Japan, other germicides are required for extending the vase life of cut rose flowers.

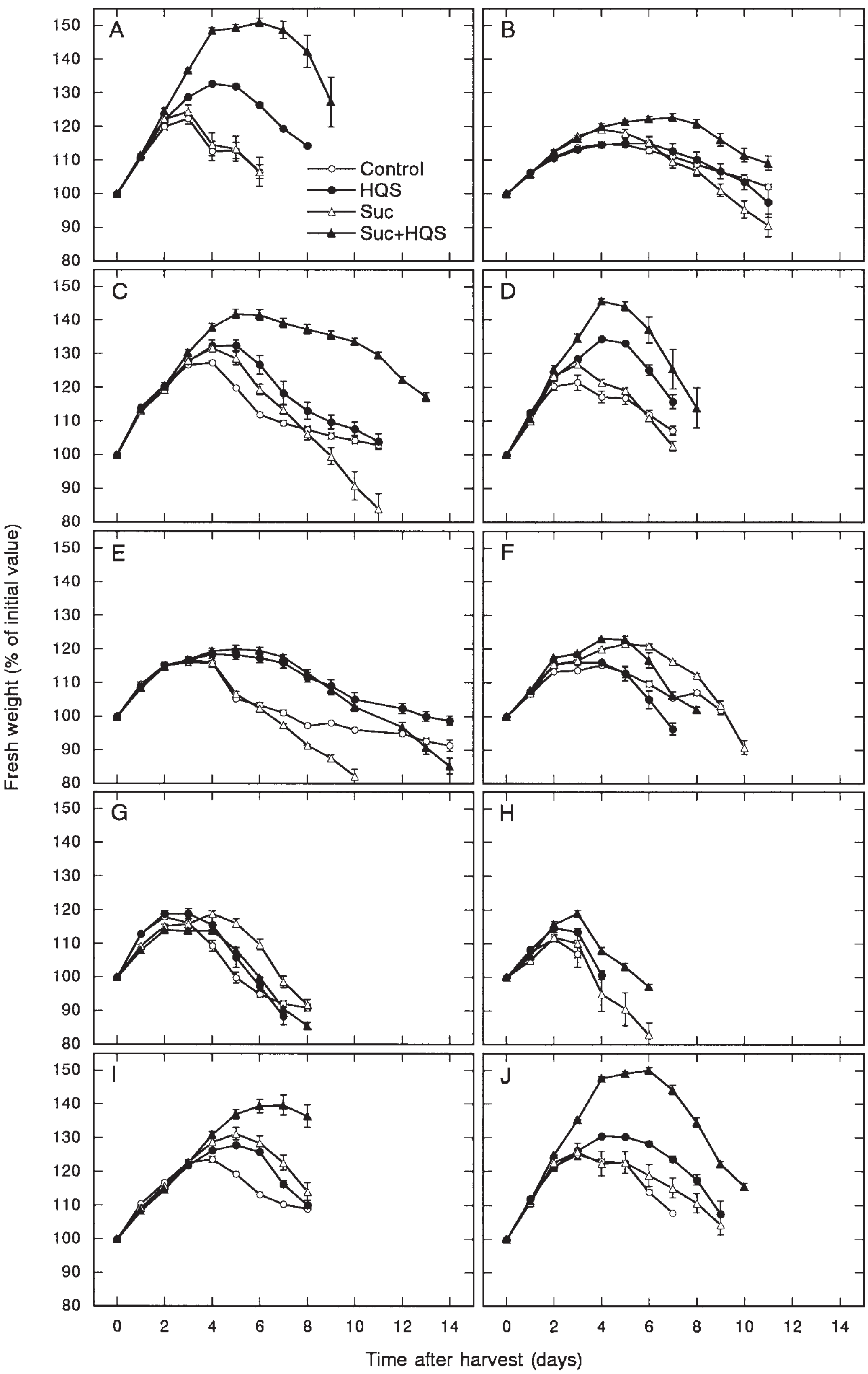

Fig. 1. Fresh weight of cut flowers treated with water (control), HQS, Suc or Suc+HQS in various cultivars. A, Bridal Pink; B, Calibra; C, Delilah; D, Jelfarlei; E, Konfetti ; F, Noblesse; G, Pareo[90]; H, Rote Rose; I, Sonia; J, Thineke. Values are means of 3 experiments ± S.E.

In addition to HQS, many germicides, such as silver nitrate and aluminum sulfate, have been shown to inhibit bacterial growth in cut rose stems (Van Doorn, 1997). Whether these chemicals are effective for various cultivars needs to be examined.

The treatment with Suc + HQS extends the vase life of cut ‘Sonia’ rose (Ichimura et al., 1999). This is due to inhibition of vascular occlusion and supply of soluble carbohydrates. In our study, the vase life of four cultivars was extended more by Suc + HQS (Table 3). Furthermore, their flower diameter was increased by Suc + HQS (Table 4). Therefore, it appears that shortage of soluble carbohydrate is a cause of the short vase life of these cultivars.

The vase life of cut flowers in several cultivars, such as Calibra, Nobelesse and Rote Rose, varied with the experiment (Tables 1 and 3). This is possibly due to different growing season, because the vase life of cut flowers is known to vary with the growing condition. Tamagawa et al. (2001) reported that the vase life of ‘Rote Rose’ flowers harvested in winter was relatively short, compared with that harvested in other seasons.

The way of flower opening varied among 25 cultivars. Flowers of ‘Bridal Pink’ opened earliest, whereas ‘Noblesse’ flowers opened the latest and frequently did not open completely (Table 1). In our study, ‘Noblesse’ flowers completely opened after the treatment with Suc. Thus, the absence of complete flower opening in ‘Noblesse’ is possibly due to the shortage of soluble carbohydrates. It is also reported that cut flowers of ‘Madelon’ rose do not open completely (Van Doorn et al., 1991; Kuiper et al., 1995). Shortage of soluble carbohydrates is involved in this phenomenon.

Since excess transpiration impairs water relations, this may be related to the short vase life of cut roses. This is supported by the finding that aluminum sulfate and 2-hydroxy-3-ionen chloride polymer, which inhibit transpiration, extend the vase life of cut roses (Ueyama and Ichimura, 1998). In our study, however, there was no correlation between vase life and transpiration rate. Other than these factors, ethylene may also be involved in determining the vase life of cut roses because rose flowers are sensitive to ethylene (Müller et al., 1998). Further studies are in progress to clarify this possibility.

In our study, the vase life of three cultivars was longer than 10 days without treatments with Suc or HQS (Table 3). Thus, these cultivars are desirable for the use of cut flowers. The reason why the vase life of these cultivars is long is to be investigated.

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バラ切り花の花持ちの品種間差とそれに関与する要因

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和文摘要

バラ切り花の開花と花持ちの品種間差を25品種を用いて調べた．開花速度には品種間差が認められ，完全に開花しない品種も存在した．花持ちにも著しい品種間差が認められ，最も長い品種はカリブラの14.5日であり，最も短い品種はブライダルピンクの3.8日だった．国内で生産されている主要10品種（カリブラ，コンフィティ，ジェルファルレイ，ソニア，ティネケ，デリーラ，ノブレス，パレオ90，ブライダルピンク，ローテローゼ）を用いて，花持ちに関与する要因について解析した．花持ち日数と花弁の厚さあるいは蒸散速度との間に有意な相関関係は認められなかった．糖の不足と導管閉塞が花持ちが短い原因になっているか調べるために，切り花を20g･liter^{-1}　スクロース，200mg･liter^{-1}　8-ヒドロキシキノリン硫酸塩（HQS）および両者を組み合わせた連続処理を行った．スクロース単独，HQS単独および両者を組み合わせた処理はそれぞれ，２，２および４品種の花持ちを有意に延長した．一方，花持ち日数が８日以上の品種とローテローゼでは，花持ちを延長することができなかった．これらの結果は，いくつかの品種において，花持ちの短い原因が導管閉塞または糖の不足，あるいはその両者に因っていることを示唆している．