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Postharvest Quality Management of Cut *Ranunculus* hybrid 'Yukitemari' flowers*

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Abstract

Postharvest quality management of cut ranunculus hybrid 'Yuki-Temari'（YT）flowers was investigated. Cut YT flowers harvested at flowering stage of main flower bud from a greenhouse（60 to 70 cm in stem length）were pretreated with or without some chemicals including STS, $CaCl_2$（0 to 2%）, uniconazole and gibberellin, then cut to 40 cm before flower longevity test. Effects of sucrose（0 to 5%）in a vase solution on cut flower performance were also investigated. All cut flowers were kept under a light intensity of 20 μmol/m^2/s provided by fluorescent lamps with a 16 h photoperiod at 24C with 65–85% RH for flower longevity evaluation. As with other ranunculus cultivars, the effect of STS on the flower longevity of cut YT flowers was not clear. The bent-neck was the most serious problem in postharvest performance of YT. Sucrose in a vase solution produced larger flowers but increased number of bent-neck flowers, resulting shorter flower longevity. The bent-neck occurred mainly 1 to 2 cm below flower bud. Both uniconazole and gibberellin did not affect pedicel elongation. Drastic reduction of bent-neck was achieved when the cut flowers were pretreated with 0.5 to 2% $CaCl_2$. When YT cut flowers were stored at 5°C for 7 days, the flower longevity was shorter than that of non-stored cut flowers.

Key words : bent neck, calcium chloride, sucrose

INTRODUCTION

Cut ranunculus flowers are popular as a spring flower in Japan. Many commercial cultivars with various flower colors and shapes have been bred to meet consumer demands. *Ranunculus* hybrid 'Yuki-Temari'（YT）(Registration No. 18186 in MAFF, Japan）was bred from crossing between *Ranunculus asiaticus* L and *Anemone coronaria* L in Kagawa Prefectural Agricultural Experimental Station [(1)]. White flower genotype selected from 'Tall Victoria'（*R. asiaticus* L）was used as a female plant and *A. coronaria* was a pollen parent. YT is a vegetative propagated cultivar, and virus-free mother plants are provided through shoot tip culture [(2)]. YT shows higher cut flower productivity compared with current *R. asiaticus* cultivars. Even if a cultivar is excellent in production, it still needs proper post-harvest management in order to gain a high reputation in the market.

It has been known that ethylene inhibitors such as STS are less effective to enhance flower longevity of cut ranunculus flowers [(3)], but other conditions have not been fully investigated in detail. Furthermore, there are many cultivars of ranunculus, and they have different styles as products, such as the number of branches and flower buds when shipped as cut flowers. The postharvest performance of cut flowers may also vary depending on the variety and product style. Therefore, post-harvest management needs to be developed for each cultivar. The aim of study is to clarify the postharvest characteristics of the new *Ranunculus* hybrid YT.

MATERIALS AND METHODS

Plant Materials

Cut flowers of YT harvested in a greenhouse in the Horticultural Center of Kagawa Prefecture in the morning were transferred to our laboratory on the same day except Exp. VI. The harvested cut flowers（60 to 70 cm in stem length）were pretreated with some medium mentioned below for 16 hr at 4°C, and then cut to 40 cm with two flower buds before exper-

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iments. Each cut flower had a main flower bud and some lateral flower buds.

General method of cut flower longevity evaluation

All cut flowers were kept under a light intensity of 20 μmol/m^2/s provided by fluorescent lamps (FL40SPG; Panasonic Inc.) with a 16 h photoperiod at 24°C for flower longevity evaluation. Each treatment had three replications that consisted of three flowers per 300ml flask（total nine cut flowers）. The end of vase life was determined when discoloration of the outer petals, detachment of the petals, or bent neck occurred.

Experimental design

1. Exp. I Effects of STS pretreatment and vase solutions on flower longevity

Cut YT flowers were pretreated with or without 0.2 mM silver thiosulfate complex（STS, KC-20, Chrysal Japan）for 16 hr at 4°C. The cut flowers were kept in distilled water, 0.5 ml/L Legend MK（anti-microbial agent; Rohm and Haas Co., USA）（MK）, and 0.5 ml/L Legend MK + 10 g/L sucrose（1SMK）, respectively. The cut flowers had an average of 5.7 flower buds（1.0 flowering stage, 1.8 calyx open stage, and 2.9 tight flower bud）. Fresh weights of flowers and absorption of the vase solution were recorded daily.

2. Exp. II. Relationship between flower stem elongation and developmental stage of flower bud at harvest

Five cut YT flowers without STS pretreatment were kept in 1SMK. Flower buds with different developmental stages; flowering stage, calyx open stage and tight flower bud（about 5mm diameter）, were chosen in each cut flower. First, marks were put every 5 mm from just under the flower bud on the chosen pedicles. After 8 days of incubation under same conditions as the flower longevity test the intervals of each mark were measured to determine which part of the pedicle was the most elongated.

3. Exp. III. Effects of some chemical pretreatment on prevention of bent neck

Cut YT flowers without STS pretreatment were kept with 1% $CaCl_2$, 25 mg/L uniconazole（Sumi seven P, Sumitomo Chemical Co. Ltd.）100 mg/L gibberellin（GA, Takeda Gibbera tablet, Takeda Pharmaceutical Co. Ltd.）or distilled water for 16 hr at room temperature and then kept in 1SMK at 24°C. Flowers with three developmental stages（flowering stage, calyx open stage and tight flower bud）were chosen from each cut flower and the length of the pedicels was recorded at day 0 and 7. Elongation of pedicels was evaluated by use of relative elongation rate（length of pedicel at day7 / those at day 0 x 100）. Number of flowers showed bent neck was recorded at day 7.

4. Exp. IV. Effect of calcium concentration on prevention of bent neck

Cut YT flowers without STS treatment were kept with 0, 0.5, 1 and 2% $CaCl_2$ for 16 hr at 4°C under dark conditions and then kept in 3% sucrose with 0.5 ml/L LMK（3SMK）at 24°C. Same treatment was repeated twice. In the first trial, fresh weight increase and flower longevity was evaluated. Number of flowers showed bent neck was recorded at day 8.

In the second trial, 10 flowers were chosen from each treatment on day 1. The pedicel just below flower bud was placed on the two fulcrums at an interval of 5 cm, and then central part thereof was pulled and the strength of the pedicel at the time of bucking（N）was measured using digital force gage（RX-2, Aikoh Engineering Co. Ltd.）. Because the thickness of each stem was different, the obtained N value was divided by the diameter of the stem to normalize.

5. Exp. V. Effect of sucrose concentration in a vase solution on flower longevity

Cut YT flowers without STS treatment were treated with 2% $CaCl_2$ for 16 hr at 4°C under dark conditions, and then the cut flowers were kept in solutions containing 0, 1, 3, and 5% sucrose with 0.5 ml/L LMK.

6. Exp. VI. Shipment adjustment of cut flowers

Cut YT flowers were obtained from a local flower auction. The cut flowers were treated with 2% $CaCl_2$ for 16 hr at 4°C under dark conditions, and then half of the cut flowers were attached gel（Eco Jelly®, Ecojelly co.Ltd.）at the cut end of flowers stem, and the other half had nothing. The cut flowers were put in both a normal carton box（N-CNT）and a carton box laminated with polyvinyl chloride（PO-CNT）and kept at 4°C for 7 days. After the storage, all cut flowers were kept in 3SMK.

RESULTS AND DISCUSSION

Effect of STS and Legend MK and sucrose in a vase solution on flower longevity of cut YT flowers

Fresh weight of cut flowers increased during first three days and then decreased rapidly in non-STS treated cut flowers kept in water（Fig. 1）. Water uptake of non-STS treated cut flowers kept in water decreased rapidly. Cut flowers in other treatments showed steady increase of fresh weight until day 5

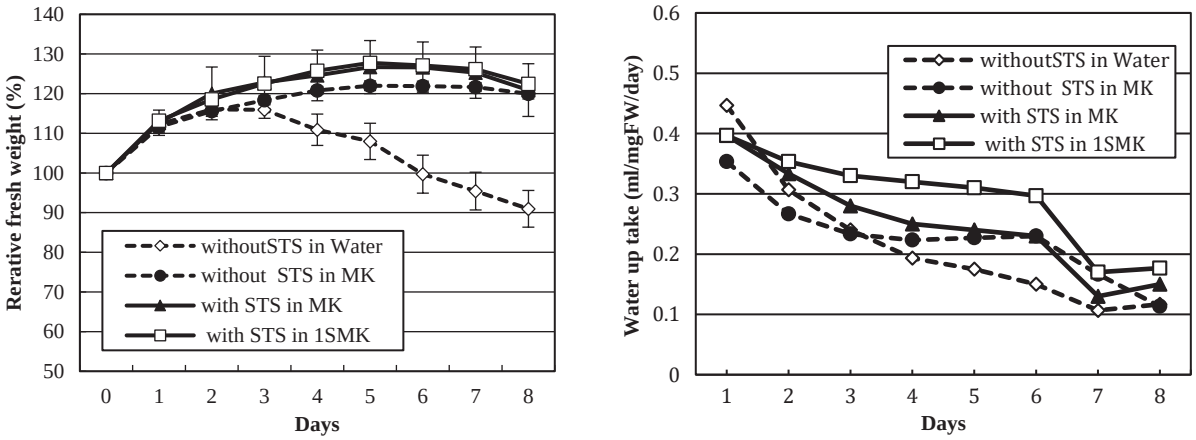

Fig. 1 Effects of STS pretreatment and vase solutions on fresh weight and water up tale of cut *Ranunculus* hybrid 'Yuki-Temari' flowers
Non STS treated cut flowers were kept in distilled water or 0.5 ml/L MK.
STS treated cut flowers were kept in 0.5 ml/L MK or 0.5 ml/L MK+1% sucrose.
Vertical bars in Figure represent SE (n=3).

Table 1 Effects of STS pretreatment and vase solutions on flower longevity of cut *Ranunculus* hybrid 'Yuki-Temari' flowers

	Without STS in Water	Without STS in MK	With STS in MK	With STS in 1SMK
Flower longevity	7.0 ab[z]	7.3 a	6.3 ab	5.3 b
Diameter of flower	66.6 c	78.0 b	76.8 b	86.4 a
No of bent neck / cut flower	0.44 b	0.44 b	0.67 b	2.11 a

[z] Figures followed by different letters indicate significant difference p=0.05.

or 6, then decreased slightly. Water uptake of the tree treatments decreased gradually until day 6. The results indicated that Legend MK in a vase solution was effective to keep fresh weight of cut flowers, suggesting that YT cut flowers are sensitive to bacteria proliferation in a vase solution. No positive effect of STS treatment on vase life extension of cut YT flowers was observed (Table 1). It has been well documented that ethylene dose not play important role in senescence of cut ranunculus flowers and effect of ethylene biosynthesis-blocking compounds is limited [4, 5, 6, 7]. Present result shows that the *Ranunculus* hybrid YT is not ethylene sensitive as same as other *Ranunculus asiaticus* cultivars.

Cut flowers kept in 1SMK showed higher level of daily water up take than others. Daily water up take of cut flowers kept in 1SMK was kept higher levels compared with other treatment until day 6, although the fresh weight increase of cut flowers kept in 1SMK as nearly same as those in MK, suggesting that transpiration of cut flowers kept in 1SMK was much higher than those in MK.

Sucrose in vase solution produced larger flowers but increased number of bent necked flowers, resulting shorter flower longevity (Table 1). The results show that vase solution containing sucrose with anti-microbial agent is effective to get larger flower, but bent neck is the most serious problem in postharvest performance of *Ranunculus* hybrid YT.

Relationship between pedicel elongation and developmental stage of flower bud

Pedicels of younger flower bud developmental stage elongated larger (Fig. 2). The lower part of pedicel, which was more than 3 cm below the flower bud, hardly elongated. The most elongated part was a pedicel of 1 cm from the flower bud. It was observed that the vent neck occurred mainly at part of 1 to 2 cm blow flower bud. The fact suggests that the bent neck might be caused by the decrease in the mechanical strength of the pedicel tissue due to pedicel elongation.

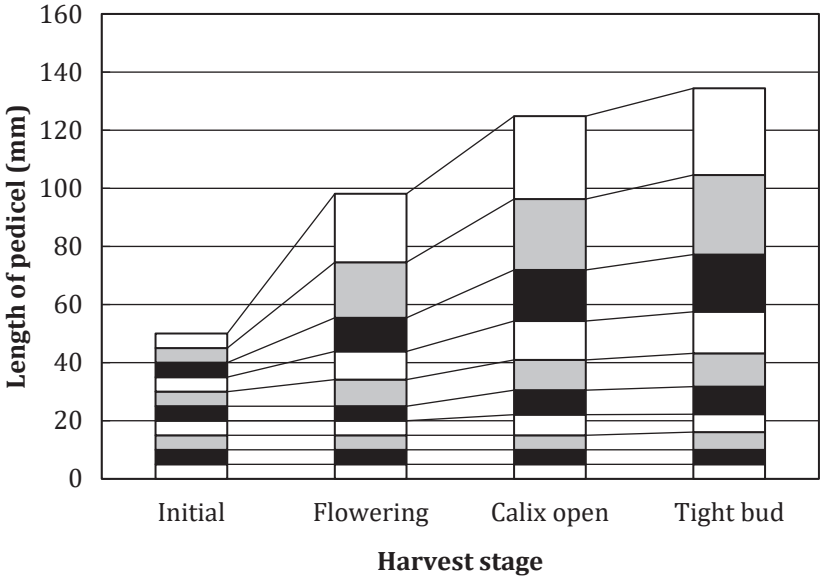

Fig. 2 Pedicel elongation by different flower bud developmental stage.
The different colored areas in the bars indicate the change in the length of the peduncle every 5 mm from just below the flower bud.

Table 2 Effects of some chemical pretreatments on prevention of bent neck in cut *Ranunculus* hybrid 'Yuki-Temari' flowers

Treatments	Relative pedicel elongation at day 7[z]			Bent neck (%)
	Flowering[y]	Calyx open	Tight flower bud	
1% $CaCl_2$	114.5 n.s.[x]	137.2 n.s.	137.0 n.s.	3.7
25 mg/L uniconazole	106.2	131.9	155.5	25.9
100 mg/L gibberellin	112.7	132.5	141.5	40.7
Control	115.1	140.3	158.9	37.0

[z] Length of pedicel at day 7 / length of pedicel at day 0 x 100.
[y] Developmental stage of flower bud at harvest.
[x] n.s. No significant differences among treatments

Effects of some chemical pretreatment on prevention of bent neck

No significant differences in pedicel elongation among treatments was observed regardless flower developmental stage (Table 2). GA pretreatment did not enhance pedicel elongation and strong anti-gibberellin agent uniconazole pretreatment did not inhibit the pedicel elongation. This result suggested that exogenous gibberellin and anti-gibberellin application dose not affect the pedicel elongation of YT at the later stage of floral development.

Drastic reduction of bent neck was achieved when the cut flowers were pretreated with 1% $CaCl_2$. The $CaCl_2$ pretreatment did not inhibit pedicel elongation. The facts suggested that the effect of $CaCl_2$ on prevention of bent neck was not due to inhibition of pedicel elongation but enhance of mechanical strength of the pedicel.

Bent neck is a serious problem in post-harvest performance in some cut flowers including rose, snapdragon, gerbera. Calcium pretreatment prevent the bent neck successfully in gerbera [8] and snapdragon [9].

Prevent of bent neck by calcium pretreatment

All cut flowers increased the fresh weight 11 to 13% during $CaCl_2$ pretreatment, indicating that 0.5 to 2% of $CaCl_2$ pretreatment did not inhibit water up take of the cut flowers during the pretreatment (Table 3). The incidence of bent neck decreased as the pretreatment $CaCl_2$ concentration was higher. Mechanical strength of pedicels also significantly increased

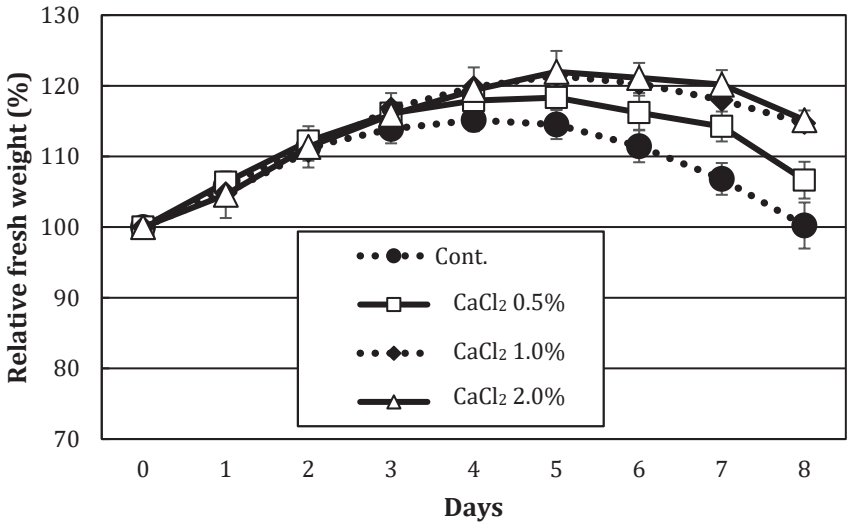

Fig. 3 Effects of $CaCl_2$pretreatment on fresh weight of cut *Ranunculus* hybrid 'Yuki-Temari' flowers.

Table 3 Effect of $CaCl_2$ pretreatment on bent neck and stem strength of cut *Ranunculus* hybrid 'Yuki-Temari' flowers

$CaCl_2$ (%)	Fresh weight increase (%)[z]	Bent neck (%)	Stem strength (N/mm)
0	111.6 ± 0.6 n.s.[Y]	71.6	1.29 ± 0.09 a[Y]
0.5	113.1 ± 1.0	37.3	n.t.[x]
1.0	112.9 ± 1.0	26.7	1.14 ± 0.13 a
2.0	111.9 ± 0.8	15.0	1.57 ± 0.09 b

[z] Relative fresh weight increase of cut flowers during $CaCl_2$ treatment.
[Y] n.s. No significant differences among treatments, figures followed by different letters indicate significant difference p=0.05.
[x] Not tested.

when cut flowers were pretreated with 2% $CaCl_2$. It was known that the calcium treatment increased the mechanical strength of the cell wall [10]. The calcium effects have been successfully applied to enhance the mechanical strength of tissue in apple [11], tulip [12] and gerbera [8].

Fresh weight of cut flowers pretreated with higher $CaCl_2$ was kept higher levels at later stage of flower longevity test (Fig. 3). The slow decrease in fresh weight by calcium treatment has also been reported in cut rose flowers [13] and cut snapdragon flowers [9]. In addition, in cut chrysanthemum flowers, transpiration was suppressed by calcium treatment [14], which is considered to be due to the effect of calcium on suppressing stomatal opening [15].

Present study demonstrated that 2% $CaCl_2$ pretreatment was very effective to prevent bent neck in cut YT flowers. The suppression of bent neck of cut YT flowers by calcium pretreatment was thought to be due to the increase of mechanical strength of pedicel. The increase of mechanical strength may be brought by maintain of turgor pressure in the cells consisting pedicel by improving the water balance of cut flower.

Effects of sucrose in a vase solution on flower longevity

The cut flowers kept in vase solutions contained 3 and 5% sucrose showed higher increase of relative fresh weight (Fig. 4). Flower longevities of cut flowers kept in 3 and 5% sucrose vase solutions were much longer than those in 0 and 1% sucrose vase solutions (Table 4). Cut flowers kept in a vase solution containing 3 or 5% sucrose showed satisfactory flowering of secondary flower buds. However, leaves of cut flowers held in a vase solution containing 5% sucrose showed yellowing, and a bent neck was observed in one of the nine flowers. It has been shown in many cut flowers that the addition of sugar with bacteriostatic agnet to the vase solution prolong the flower vase life [16]. Present result showed that vase

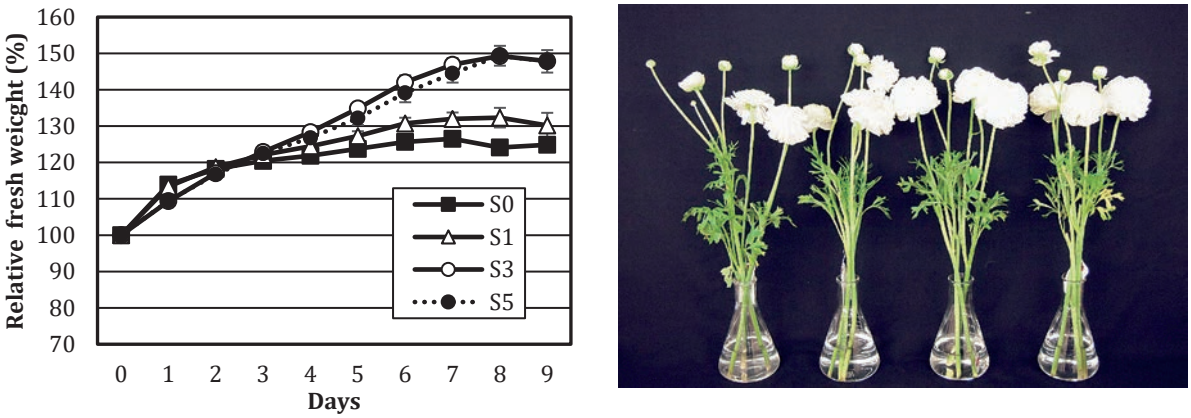

Fig. 4 Effects of sucrose in a vase solution on fresh weight of cut Ranunculus hybrid 'Yuki-Temari' flowers.
Right: relative fresh weight.
Left: Cut flowers on day 7 (from right to left, sucrose 0, 1, 3 and 5% respectively).

Table 4 Effects of sucrose in a vase solution on flower longevity of cut *Ranunculus* hybrid 'Yuki-Temari' flowers.

Sucrose 0%	Sucrose 1%	Sucrose 3%	Sucrose 5%
7.9 b[z]	7.8 b	9.0 a	8.5 a

[z] Figures followed by different letters indicate significant difference p=0.05.

Table 5 Effect of type of cardboard box and Eco-Jelly application on the flowering longevity of cut *Ranunculus* hybrid 'Yuki-Temari' flowers stored for 7 days.

Treatment	Eco Jelly	Weight change (%)	Flower longevity
N-CNT	without	76.9	3.9 a
	with	101.3	5.0 b
PO-CNT	without	88.2	5.0 b
	with	103.9	5.4 b
Control*	–	–	6.7 c

*No stored cut flowers.

solution containing 3% sucrose is suitable for cut YT flowers.

Shipment adjustment of cut YT flowers

During 7 days of storage, the fresh weight of cut flowers without Eco Jelly decreased, but increased when Eco Jelly was applied. The degree of change was greater in a normal carton box. The flower longevity of cut flowers was shorter in all treatments than in the control. The main reason for the end of flower longevity was petal wilting. Present results showed that cut *Ranunculus* hybrid 'Yuki-Temari' flower is a difficult product to adjust the shipping time by cold storage. When cut flowers are stored at low temperatures, the flowering stage of the buds is known to affect the postharvest performance of the cut flowers, and Shahri et al. [17] reported that premature flower buds of ranunculus can be stored at 5°C for 72 hours in both dry or wet conditions.

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ラナンキュラス‘雪てまり’切り花の品質保持

深井誠一・安河内皆子・鳴海貴子

和文要旨

ラナンキュラス「雪てまり」（YT）の切り花の収穫後の品質管理について検討した。温室で主花芽が開花したステージに収穫されたYTの切り花（茎の長さ60～70cm）を，STS，$CaCl_2$（0～2%），ウニコナゾール，ジベレリンなどの薬剤で前処理した後，40cmに切り揃えて品質保持試験を行った。また，いけ水に添加したスクロース（0～5%）が切り花の性能に及ぼす影響についても調査した。すべての切り花は，蛍光灯を用いて20 μmol/m^2/sの光強度および16時間の光周期，24℃，65–85% RHの条件で管理された検査室で，花の品質保持を評価した。他のラナンキュラス品種と同様に，STSがYTの切り花の花もちに与える影響は明らかではなかった。YT切り花の品質保持において，ベントネックが最も深刻な問題であった。スクロースをいけ水に添加すると，花径は大きくなるが，ベントネックの数が増え，切り花の寿命が短くなった。ベントネックは主に花から1～2cm下のところで発生した。ウニコナゾールとジベレリンは，いずれも花柄の伸長に影響を与えなかった。切り花を0.5～2%の$CaCl_2$で前処理すると，ベントネックが劇的に減少した。YTの切り花を5℃で7日間保存した場合，花の寿命は保存していない切り花よりも短くなった。