Improving the postproduction quality of Rose cut flowers

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Summary: In order to improve the post production quality of cut flowers of *Rosa hybrida* L. cv. Baroness, the effect of 8-hydroxyquinoline sulfate (8-HQS), silver thiosulfate (STS) and 1-methylcyclopropene (1-MCP) were investigated. 8-HQS was used at 200 and 400 ppm with or without sucrose at 50 g l^{-1}. STS was used at 0.2, and 0.4 mM with or without sucrose at 50 g l^{-1}. 1-MCP was used at 0.3, 0.5 and 0.7 g m^{-3} for 6h.
The postproduction quality was improved as a result of using any chemical treatment comparing with untreated control. All the treatments of 8-HQS increased the vase life and minimized the percentage of weight loss of rose cut flowers compared to the control. The vase life was larger when 8-HQS was combined with sucrose. The best treatment of 8-HQS was 400 ppm 8-HQS + 50 g l^{-1} sucrose. STS treatment led to prolong the vase life and minimized the percentage of weight loss compared to the control. In addition, the effect was better when sucrose was added to STS. The treatment of STS at 0.4 mM + 50 g l^{-1} sucrose was the best one. 1-MCP treatment prolonged the vase life and lowered the percentage of weight loss at any level compared with untreated control. The best treatment in this concern was 1-MCP at 0.5 g m^{-3} for 6h. The chlorophyll content (chl.*a* and chl.*b*) of the leaves for the best treatment of each chemical was higher than the control. The treatment of STS at 0.4 mM + 50 g l^{-1} sucrose gave the best results in this respect.

Key words: 1-MCP, 8-HQS, chlorophyll, roses, , STS, vase life, weight loss

Introduction

Rose is the strongest component of domestic cut flower production in different countries all over the world. The market for these locally grown roses in the various countries has been good (AIPH 2003). In addition, cut rose is the most important sector of floriculture *(Boronkay & Jámborné* 2003). So, understanding the variable postharvest performance of rose is important not only for ensuring maximum life of those that presently are of commercial importance, but also for developing new selections with improved postharvest quality. Postharvest life of rose flowers has been engaged the attention of growers and researchers for many years *(Pertwee* 2003). A major cause of deterioration in cut flowers is the blockage of xylem vessels by microorganisms that accumulate in the vase solution or in the vessels themselves. When the stem is blocked, continuing transpiration by the leaves results in net loss of water by the flower and stem tissues *(Knee* 2000). In roses, this often leads to the bent neck disorder *(Van Doorn* et al, 1997). In order to control microorganism growth to prevent the block of xylem, the chemicals most commonly used are salts of 8-HQ *(Nowak & Rudnicki* 1990).

Bhattacharjee (1994) placed cut rose flowers in distilled water or a preservative solution containing 300 ppm 8-hydroxyquinoline citrate (HQC)+ 10.000 ppm sucrose and he found that the preservative solution extended the vase life and increased the water uptake of cut rose flowers. Pulsing cut flowers of rose with STS improved the vase life and quality of flowers *(Bhattacharjee & De* 1998). The treatment of 200 ppm 8-HQS extended the vase life of rose cut flowers *(Ichimura* et al 1999). Maximum vase life was observed in HQC solution when cut ends of stems of rose flowers were placed in HQC solution *(Knee* 2000 ; *Tiwari* et al 2002 a). The preservative solution containing 3% sucrose and 200 ppm 8-HQS extended vase life and inhibited flower senescence and bent neck in rose cut flowers *(Kim* et al 2002).

Cut flowers produce small amounts of ethylene just after harvest. Meanwhile, there is a sharp increase in ethylene production a few days later. Moreover, cut flowers are often exposed to ethylene during production, transport, storage or retail marketing. Some deleterious effects of ethylene exposure include leaf yellowing, flower (or petal) drop, irregular opening and premature death *(Nowak & Rudnicki* 1990). Since the 1970s, the best weapon against ethylene has been STS which can at least double the vase life of cut flowers *(Reid* et al 1999). Pulsing with AgNO3 (300 ppm) strikingly enhanced vase life and solution uptake of rose cut flowers *(Singh & Tiwari* 2002). There was an increasing trend in the fresh weight and vase life of rose cut flowers when STS was used *(Chikkasubbanna & Yogitha* 2002 & *Tiwari* et al 2002 b). Because STS contains silver, which is considered a potential environmental pollutant, there has been some restriction on its commercial use *(Serek & Reid* 1993, *Cross* 1996). A new tool, 1-methylcyclopropene (1-MCP), has been added to the list of options for extending the vase life of cut flowers. 1-MCP, has been marketed under the trade name EthylBloc discovered by Prof. E.C. Sisler, North Carolina State University, Raleigh, North Carolina, United States. 1-MCP is a gas in its natural state (as is ethylene), which provides opportunities and challenges in commercial use. EthylBloc is a powder form, which is added

to water to release the gas. 1-MCP is a non-toxic inhibitor of ethylene action which acts as a competitive and irreversible inhibitor of binding of ethylene to its receptor *(Sisler* et al 1996). Even at very low concentrations, it has been shown to eliminate the effects of ethylene on abscission and wilting of many ornamental crops such as carnation and rose *(Serek* et al 1995, *Sisler* et al 1996). There is limited information in the literature about the effect of 1-MCP on rose cut flowers but there are some date about potted roses. The treatment of 1-MCP led to extend the display life of potted roses *(Serek* et al 1994 & *Muller* et al 2000). The treatment of 1-MCP extended the vase life of different cut flowers *(Sisler & Serek* 2001, *Skog* et al 2001 & *Hassan & Gerzson* 2002).

Research work for improving quality and prolonging the vase life of rose cut flowers must be taken in consideration. The aim of this research was to study the postharvest quality of rose cut flowers under the treatments of 8-HQS and STS with or without sucrose and to make a comparison between them and 1-MCP in this respect in order to see is it a good alternative or not under the conditions of the experiment.

Materials and method

Plant material

Cut flowers used in the experiment were *Rosa hybrida* L. cv. Baroness. The flowers were obtained from a commercial grower in Hungary at commercial maturity (open bud stage). Flowers were brought to the laboratory of BKAE, Budapest as soon as possible. Lower leaves were removed and the flowering stems were trimmed to a uniform length of 45 cm.

Chemical treatments

HQS treatments

8-HQS was applied as a continuous treatment at concentrations of 200 and 400 ppm with or without sucrose of 50 g l^{-1}. The flowers were placed in glass vials containing 500 ml 8-HQS solution with and without sucrose of each concentration during the whole period of the experiment.

STS treatment

STS was prepared as described by *Gorin* et al (1985). Cut flowers were pulsed with STS for 6h at concentrations of 0.2, and 0.4 mM with or without sucrose at 50 g l^{-1}. After pulsing treatments, the flowers were put in glasses containing tap water till the end of experiment.

MCP treatment

1-MCP (EthylBloc) was obtained from AgroFresh Inc. Rohm and Haas company. The flowers, which were treated with EthylBloc, were put horizontally inside a 118x28x44cm box for each treatment. The box was sealed well with greenhouse plastic cover and the concentrations of 1-MCP were calculated as g m^{-3} (EthylBloc per cubic meters). Soon, the EthylBloc powder was weighed and placed in a test tube inside the box. Since a significant percentage of 1-MCP is released immediately after addition of hot water, the box was first sealed, and then, hot water was injected into the test tube (just enough to cover the powder for each treatment). The concentrations used were 0.3, 0.5 and 0.7 g m^{-3} for 6h. The treatment of 1-MCP was conducted at 15 °C for all treatments. After the treatments the flowers were aerated and then were placed into glass vials containing 500 ml tap water. The control flowers were put into glasses containing 500 ml tap water during the whole period of the experiment.

Vase life determination

The longevity of rose cut flowers was determined in a vase life evaluation room at natural daylight at 20 ± 1°C and 80–90% RH. Visual rating of flowers was evaluated on a scale from 1 to 4 when: 1 = entirely fresh flowers, 2 = initiation of wilting in 20% of petals and beginning of bent neck, 3 = wilting in 20–50% of petals and increase of the bent neck, 4 = wilting in 50–100% of petals. The longevity of rose cut flowers was defined as the number of days in vase life required for 50% of the flowers to reach stage 2 or more advanced stages.

Fresh weight measurements

Fresh weight determinations of the flowers were made just before the immersion of the flowers into the glasses of solutions and were repeated on the day when the vase life of the control flowers was terminated. The flowers were taken out of solutions for as short time as possible (20–30s). The fresh weight of each flower was expressed relative to the initial weight to represent the % of weight loss.

Chlorophyll determination

Chlorophyll content of leaves was extracted by acetone as previously described by *Dawood* (1993) from samples of cut leaf segments (0.5 g) taken on day 3 and on the day when the vase life of the control flowers was terminated. The samples were taken from the upper part of stems. The chlorophyll content was calculated as mg g^{-1}.

Analysis of results

Three replications of five flowers each were used per treatment in this experiment. Results were analyzed by using SPSS program Base 9, SPSS Inc., USA. The analysis of variance (ANOVA) as well as differences between means were checked by using Student-Newman-Keuls test (SNK)

at 0.05 level. This experiment was repeated at least twice and these data are of one of them.

List of abbreviations

8-HQS = 8-hydroxyquinoline sulfate
8-HQC = 8-hydroxyquinoline citrate
1-MCP = 1-methylcyclopropene
STS = Silver thiosulfate
chl. *a* = Chlorophyll *a*
chl. *b* = Chlorophyll *b*
RH = Relative Humidity

Results

Vase life

Effect of 8-HQS

All the treatments of 8-HQS significantly extended the vase life of rose cut flowers compared to the control *(Table 1)*. Adding sucrose to 8-HQS gave a longer vase life than the treatments of 8-HQS without sucrose. The longest vase life (11 days) was obtained by 400 ppm 8-HQS + 50 g l^{-1} sucrose compared to the untreated control (5.3 days).

Effect of STS

The data shown in *Table 1* prove that STS treatment increased the vase life of rose cut flowers. In addition, adding sugar to STS treatment improved the vase life of rose cut flowers. The best treatment was STS at 0.4 mM + 50 g l^{-1} sucrose which gave 12.3 days compared to 5.3 days for the untreated control *(Table 1)*.

Table 1 Effect of 8-HQS, STS and 1-MCP on the vase life and % loss of initial weight of rose cut flowers

Treatments	Vase life (Days)	% loss of initial weight
Control	5.33 a	24.05 a
8-HQS 200 ppm+50 g l^{-1} sucrose	8.33 bc	8.63 de
8-HQS 200 ppm	7.33 b	10.98 bc
8-HQS 400 ppm+50 g l^{-1} sucrose	11.00 e	6.75 ef
8-HQS 400 ppm	10.00 de	7.79 def
STS 0.2 mM+50 g l^{-1} sucrose	8.33 cd	9.91 cd
STS 0.2 mM	7.33 b	12.12 b
STS 0.4 mM+50 g l^{-1} sucrose	12.33 f	3.43 f
STS 0.4 mM	11.33 e	5.86 g
1-MCP 0.3 g m^{-3} 6h	9.00 cd	7.98 def
1-MCP 0.5 g m^{-3}6h	11.00 e	3.82 g
1-MCP 0.7 g m^{-3} 6h	10.00 de	8.79 de

Means followed by different letters differ significantly from each other according to SNK test at P = 0.05.

Effect of 1-MCP

As data in *Table 1* indicate, all levels of 1-MCP prolonged the vase life of rose cut flowers compared to the control. The treatment of 1-MCP at 0.5 g m^{-3} for 6h resulted in the best results in this concern which gave 11 days compared with 5.3 days for the untreated control *(Figure 1)*.

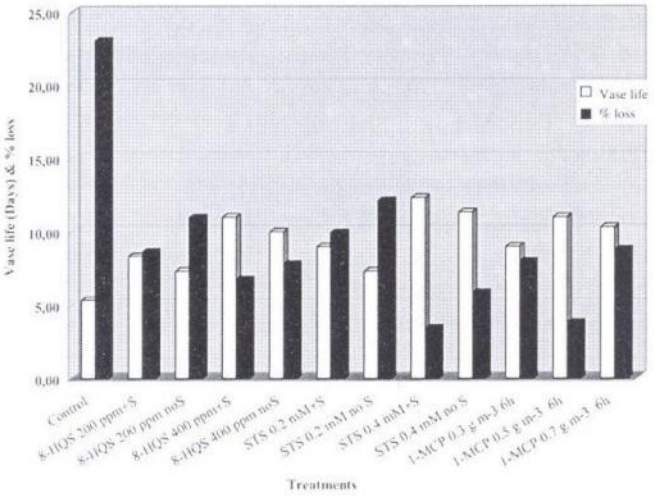

Figure 1 Effect of 8-HQS, STS and 1-MCP on the vase life and % loss of rose cut flowers

Percentage of weight loss of initial

Effect of 8-HQS

The results in *Table 1* show that 8-HQS treatment influenced the % of weight loss of rose cut flowers. All the treatments significantly minimized the % of weight loss compared with the control. Adding sucrose to all levels of 8-HQS had a positive effect in this respect. The minimum % of weight loss was obtained by 400 ppm 8-HQS + 50 g l^{-1} sucrose.

Effect of STS

All STS treatments lowered the % of weight loss compared to the untreated control. In addition, combining sugar with STS treatment gave lower values than STS treatment without sugar. The lowest % of weight loss was obtained by 0.4 mM STS + 50 g l^{-1} sucrose, which recorded 3.43% compared with 24.05% of the control *(Table 1 and Figure 1)*.

Effect of 1-MCP

The data shown in *Table 1* prove that 1-MCP treatments minimized the % of weight loss. The lowest value in this respect (3.82%) was obtained by the treatment of 1-MCP at 0.5 g m^{-3} for 6h comparing to the control which resulted in the maximum percentage of weight loss (24.05 %).

Chlorophyll content

A significant delay in chlorophyll loss (chl. *a* and chl. *b*) was monitored as a result of using different chemical treatments. All chemical treatments minimized the chlorophyll loss comparing with untreated control. The best treatment in this concern was STS 0.4 mM+50 g l^{-1} sucrose. Under this treatment the chlorophyll content of the leaves at the end of control was 3.36 and 1.3 mg g^{-1} comparing to 1.36 and 0.13 mg g^{-1} for the control for chlorophyll *a* and chlorophyll *b*, respectively *(Table 2* and *Figure 2)*.

Table 2 Effect of the best treatment of each chemical on the chlorophyll content (mg g^{-1} fresh weight) of leaves of rose cut flowers

Treatments	Day 3		End of control	
	chl.*a*	chl.*b*	chl.*a*	chl.*b*
Control	2.57a	0.72a	1.36a	0.13a
8-HQS 400 ppm+50 g l^{-1} sucrose	3.65b	1.22b	2.39b	0.84b
STS 0.4 mM+50 g l^{-1} sucrose	3.89c	1.40c	3.36c	1.30c
1-MCP 0.5 g m^{-3} 6h.	3.26d	1.18d	2.76d	0.83b

- Means followed by different letters differ significantly from each other according to SNK test at $P = 0.05$.
- Results were analyzed separately for each sampling day and statistical analysis is valid only within a column.

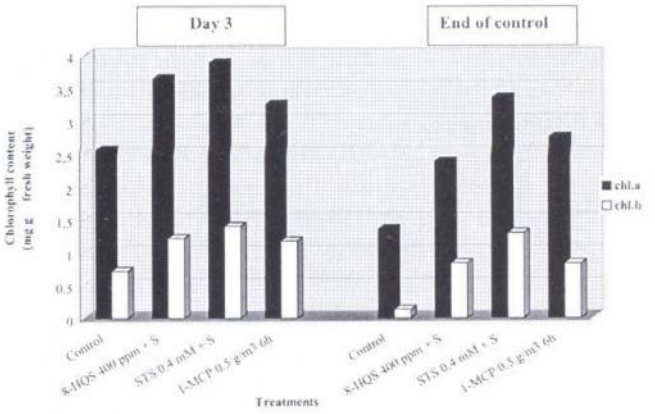

Figure 2 Effect of the best treatment of each chemicla on the chlorophyll content (mg g^{-1} fresh weight of leaves of rose cut flowers

Discussion

Extending the vase life of rose cut flowers by using 8-HQS may be due to the role of 8-HQS as anti-microbial agent which hence reduces stem plugging. In addition, these results could be explained through maintaining leaves turgid, by keeping fresh weight and chlorophyll losses by 8-HQS to a minimum. These results are in agreement with the finding of *Bhattacharjee* (1994), *Ichimura* et al (1999) & *Kim* et al (2000) on rose cut flowers.

STS is a very potent inhibitor of ethylene action in plant tissues. It also has some antimicrobial activity inside the plant tissues *(Nowak & Rudnicki* 1990). And hence, the vase life was extended. Also, under the STS treatment the percentage of weight loss and chlorophyll degradation was minimized and consequently, the vase life was extended. *Bhattacharjee & De* (1998), *Chikkasubbanna & Yogitha* (2002) and *Tiwari* et al (2002 b) obtained similar results on rose cut flowers.

Concerning the role of sucrose whether with 8-HQS or STS, is well known that supplying sugar increases the longevity of many cut flowers. While sucrose can act as a source of nutrition for tissues approaching carbohydrate starvation, it may also act as an osmotically active molecule thereby having a role in flower opening and subsequent water relations *(Kuiper* et al 1995). Similar findings were obtained by *Erin* et al (2002) who found that vase solutions containing sugar can improve the vase life of many cut flower crops.

Increasing the vase life of rose cut flowers by using 1-MCP could be attributed to the role of 1-MCP as an inhibitor of ethylene biosynthesis as well as ethylene binding and consequently preventing the undesirable postharvest effects of ethylene as reported by *Serek & Reid* (1993), *Cross* (1996). Keeping the leaves in a good state by lowering the percent of weight loss and retarding the chlorophyll degradation may increase the vase life. In the same trend, *Celikel & Reid* (2002) reported that even in the absence of exogenous ethylene, the life of stock flowers was significantly increased by inhibiting ethylene action using pretreatment with 1-MCP. *Serek* et al (1994) & *Muller* et al (2000) obtained similar results on potted roses. Also, *Hassan & Gerzson* (2002) found that the treatment of 1-MCP at 0.5 g m^{-3} for 6h increased the vase life and also minimized the % loss of initial weight of carnation cut flowers. One can also see that the effect of 1-MCP is not as long-lasting as those of STS. The flowers become sensitive to ethylene again after four to seven days at room temperature, but at cool temperature the anti-ethylene effects of 1-MCP last much longer. This is different from STS, which remains in the plant tissue and continues to be active over a long period *(Reid* et al 1999). The best treatment of each chemical compared to the control is shown in *Figure 3*.

Conclusion

All chemicals used improved the postharvest quality of rose cut flowers and based on our results it could be concluded that 8-HQS + sucrose was beneficial in reducing stem plugging and prolonging the vase life. Although the STS + sucrose and 1-MCP treatments extended the vase life of rose cut flowers, 1-MCP treatment does not have the heavy metal implications of STS treatment, and there should be no waste disposal problem. Since the material is a gas its use would obviate the need for placing flowers in additional treatment solutions, which is labor intensive. In addition, the use of STS, a possible environment pollutant, has been banned in several countries and 1–MCP is an effective and safe alternative to STS (*Cross* 1996). It could be concluded that 1-MCP is an effective blocker of ethylene perception in

Figure 3 The best treatment of each chemical compared to the control. Control flowers were placed in tap water and the photo was taken on the 6th day after starting the experiment

the rose cut flowers. Furthermore, its non-toxic character makes the material an excellent replacement for the environmentally unsafe silver ion. It should be noted that these results are valid for ethylene-free atmosphere and would be different when flowers were exposed to ethylene. So, the next step will be the treatment with external ethylene.

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