Effect of cold storage duration, harvesting stage and post harvest treatments on vase life of *Solidago canadensis* cv. "Tara" cut stems.

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ABSTRACT

Postharvest treatments and dry cold storage periods can delay senescence and improve vase life of Solidago canadensis cv. "Tara" cut stems at different harvest stages. This investigation was carried out during 2010 and 2011 seasons on *Solidago canadensis* cv. "Tara" cut stems in Plant Production Department, faculty of agriculture Saba Basha, aiming to study the effect of pulsing cut stems with five concentrations of gibberellic acid (GA_3) at zero, 0.25, 0.50, 0.75, 1.00 mM, and five concentrations of silver thiosulphate (STS) at zero, 1.00, 1.50, 2.00, 2.50 mM, before dry cold storage at seven periods (control-1,2,3,4,5,6 weeks) at two harvest stage of florets opening H1 30% and H2 10%.Results revealed that GA_3 and STS at 1.00 and 2.00 mM., respectively, achieved the best results for vase life. Besides, the cold storage period up to 6 weeks followed by possible days of vase life were achieved by using GA_3 (1.00 mM) and STS (2.00 mM) for the two harvest stage. Number of days from starting the vase life to full opening of the flowers and number of days after full opening of the flowers to fading increased by increasing the concentrations of pulsing solutions and decreased by increasing the dry storage durations.

Key words: *Solidago canadensis*, cut flowers, postharvest, preservation, harvest stage, cold storage, vase life, silver thiosulphate, gibberellic acid.

INTRODUCTION

Solidago canadensis have been introduced into Europe in the 17th century (Schmid and Weiner, 1993). This taxon presently ranges from Italy to southern Scandinavia and from Ireland to Russia; the species has also been introduced to Asia and Australia (Weber, 2000). In Europe, *S. canadensis* "Tara" now accounts for nearly 100 % of the Dutch imports of all Solidago cultivars since it seemed more robust than most other cultivars and now lies the sixth in the import ranking which is excellent for a one variety, one colour flower (Partwee, 2000). Cut flowers have significantly been one of the most important sources of national income in many countries. Including Egypt *Solidago canadensis*, L or goldenrod is now a mainstream cut flower, produced in the fields and the greenhouses as well, wherever cut flowers are grown. Florists and designers incorporate them in mixed bouquets and arrangements. Plants exhibit ease of culture, high yield, and excellent vase life. The crop looked much easier and highly

profitable for the Egyptian growers under open-field conditions (Armitage and Laushman, 2003).

Silver thiosulphate (STS), is thought to be a chemical that suppress ethylene action. The effectiveness of Ag+ in reducing ethylene action declines as the ethylene concentration is increased and delay flowers senescence. Pulsing *Solidago canadensis* cut stems with an aqueous solution of STS for 19 h, delayed leaf yellowing in cut spikes during vase life, and also inhibited flower senescence (Hadas-Philosoph *et al.*,1997). The treatment with STS by exposing the flower bases to 0.4 mM for 6 h increased the vase life of leaves as well as the inflorescence of cut *Solidago canadensis* spikes compared to the control (Hassan *et al.*, 2003). Gibberellic acid (GA_3) is a growth regulator that has been used as post harvest treatment for cut flowers, it also may retards the senescence of leaf and floral organs (Serek and Andersen, 1995 and Beata and Marek, 2004). Gibberellic acid retard early leaf yellowing in flowering shoots of *Solidago canadensis* cv. Yellow Submarine while preserving overall quality, GA_3 considerably delayed leaf yellowing in cut spikes during vase life, and inhibited flower senescence (Hadas-Philosoph *et al.*, 1997).

Harvest stage may affect the post harvest quality, Brahmankar *et al.*, (2005) studied the effects of different harvesting stages of golden rod (*Solidago canadensis*), i.e. unopened stage (H_1) with fully mature buds, 25% opened stage (H_2) and 50% opened stage (H_3) and found that, harvesting at less advanced stages (both unopened and 25% opened stages) recorded higher panicle weight, delayed senescence and enhanced vase life along with good quality maintenance. The unopened stage and 25% opened stage exhibited excellent flower quality with excellent flower colour maintenance, turgidity and freshness.

With respect to the effect of storage durations on the post-harvest quality, Koyama *et al.* (1995) reported that with a view to supplying high quality cut carnations flowers in summer, flowers were preconditioned with STS and 10% sucrose and then stored at 1 °C for 12 weeks. They found that the vase life of cv. "Nora" and cv. "Coral" flowers was extended after the 12 weeks of cold storage by STS treatment.

The aims of the present study were to:

1- Determine the effectiveness of some chemical materials as preservation treatment added before or during storage period to reduce flower senescence and increasing vase life during long term storage, and
2- Study the effect of dry storage period on Solidago flowers.

MATERIALS AND METHODS

Two separated experiments were carried out; the first with GA_3 and the second with STS.

1. cut flowers materials

The cut flowers used for this investigation were *Solidago canadensis* cultivar "Tara" obtained from a well known commercial nursery at Cairo.

Cut flowers were cut in uniform size and shape at two harvest stages (VBN, 1999 and Brahmankar *et al.*, 2005):

1 – Harvest stage 1 where only 30 % of florets are opened.

2 – Harvest stage 2 where only 10 % of florets are opened.

1.1. cut flowers preparation

Cut flowers were cut in early morning, wrapped using polyethylene, and then quickly moved to the laboratory under dry condition. Flower length was 65 cm long.

Flowering stems were trimmed before pulsing treatments to a uniform length of 50 cm (Khimani *et al.*, 2005) then placed in glass containers which contained the pulsing solution in tap water. As soon as possible, lower leaves were removed at the end of the third part of stems.

2. Chemicals used in the two experiments

2.1. Pulsing solution treatment before storage

2.1.1. Silver thiosulphate (STS)

Stock solution of STS was prepared as described by Reid *et.al.* (1980). Silver thiosulphate was prepared on the day of the experiment of stock solution of 4mM/ Silver nitrate ($AgNO_3$) (0.1M) and 16mM/ sodium thiosulphate ($Na_2S_3O_3.5H_2O$) (0.1M). Cut flowers were held to a depth of 3cm using tap water with concentrations of (1.00, 1.5, 2.00 and 2.50 mM) before storage for four hours.

2.1.2. Gibberellic acid (GA_3)

GA_3 was used with concentrations of (0.25, 0.50, 0.75 and 1.00 mM) in DI water before storage, by using (0.087, 0.173, 0.259 and 0.346 g/l) from the pure chemical to form the concentrations, respectively

2.2. Control

Control cut flowers were held in tap water at the same time of the other treatments.

3. Storage duration

Cut flowers were stored at 7 periods (0, 1, 2, 3, 4, 5 and 6 weeks) under dry conditions wrapped in Kraft paper and put in flower export carton boxes (100x40x30 cm).

3.1. Storage temperature

Storage temperature used was (2°C - 4°C) and relative humidity (90-95 %) as was recommended for Solidago and described by Nowak and Rudnicki (1990) and Hamza *et al.* (2008).

Temperature and relative humidity were recorded during the storage periods at the two seasons and in the laboratory, during the vase life period. The average temperature in the laboratory was from (17° to 22°C) and the relative humidity was from (40 to 80%) in the two seasons.

4. Holding solution

Flowering stems were trimmed before pulsing treatments to a uniform length of 50 cm then placed in glass containers which contained tap water to calculate the vase life and the tested parameters.

5. Experimental layout and statistical analysis

The experimental design was a split-split plot design containing 3 replications (Steel and Torrie, 1980). The harvest stage (H) was considered as the main factor, while the concentrations (C) of chemicals were the sub factor, on the other hand, the storage durations (S) were the sub-sub factor. The total number of treatments were then 70 (2 harvest stage × 5 concentrations × 7 storage duration). Each plot contained 3 replicates.

The first experiment started at 19/12/2010. Six cut flowers per plot were used for each treatment in the replicate. Three replicate were used, each replicate contained 70 treatments. The plot contained six plants for each treatment in the replicate. The total number of flowers was 1260 flowers. On the other hand, the second experiment started at 19/11/2011.

6. The collected data

1. Flower duration [vase life (days)]: was determined as the numbers of days from starting the vase life after cold storage to the fading stage.
2. Full opening stage (days): The number of days taken from the starting of the vase life to the full opening stage
3. Fading stage (days): the number of days from the full opening stage to the fading stage.

RESULTS AND DISCUSSION

1. Experiment (1) effect of GA_3

Means and the least significant differences test for the effect of harvest stage (H), GA_3 concentrations (C), storage durations (S) and their interactions on the total vase life, full opening and fading durations in the first and second seasons are given in Table1.

1.1. Effect of harvest stage

Data in Table 1 showed that the harvest stage had a significant effect on vase life in the two seasons. The second harvest stage resulted in the greatest vase life (13.22 and 15.46 days, for the first and second seasons; respectively) while the shortest vase life were obtained by the first harvest stage (9.73 and 12.14 days, for the first and second seasons; respectively). Full opening and fading durations significantly increased in the second harvest stage resulted in the greatest value (6.67-6.55 and 8.19-7.27 days, for the first and second seasons; respectively).

1.2. Effect of concentrations

Data in Table 1 cleared that the vase life was increased by increasing concentrations in both seasons. The highest concentration of

GA_3 resulted in the longest vase life (14.05 and 16.52 days, for the first and second seasons; respectively).The full opening and fading durations significantly increased by increasing the GA_3 concentration resulted in the maximum value (7.00-7.05 and 8.38-8.14 days, for the first and second seasons; respectively).

1.3. Effect of storage durations

Results in Table 1 showed that vase life was decreased by increasing storage durations in both seasons. The zero storage durations (control) resulted in the longest vase life (18.18 and 19.40 days, for the first and second season; respectively).While the longer-term storage durations (week six) resulted in the shortest vase life (4.03 and 6.38 days, for the first and second seasons respectively). The full opening and fading durations significantly decreased by increasing the storage durations resulted in the shortest duration at week six (2.15-1.88 and 3.42-2.97 days, for the first and second seasons; respectively).

1.4. Effect of interactions

Data in Table 1 showed that there were significant and highly significant interactions between the harvest stage (H), GA_3 concentrations (C) and storage durations (S) on vase life, full opening and fading durations in the two seasons.

From the previously mentioned results, it might be concluded that all the harvest stages used gave a clear effect on vase life especially H2. The increase in storage duration resulted in the shortest vase life. Moreover, as expected, the higher concentration of GA_3 gave the longest vase life; this is because gibberellic acid have been proven to extend the vase-life and delayed leaf senescence as reported by Patil and Dhaduk (2010) and Tiwari *et al.* (2010).The decreasing of vase life may be due to the respiration process during the dry cold storage of flowers. Respiration leads to higher rates of carbohydrate consumption and food depletion which was reflected on the number of days of vase life as found by Finger *et al.* (2003) and Verma *et al.* (2006).

Table 1: The effect of harvest stage, GA_3 concentrations, storage durations and their interactions on the full opening vase life, fading vase life and total vase life of *Solidago canadensis* cv. "Tara" flowering stems in the first and second seasons

Treatments	Full opening (days)		Fading (days)		Total vase life (days)	
	2010	2011	2010	2011	2010	2011
	Harvest stage (H %)					
H 1 (30%)	4.03	5.45	5.71	6.74	9.73	12.14
H 2 (10%)	6.67	8.19	6.55	7.27	13.22	15.46
L.S.D (0.05)	0.42	0.39	0.35	0.39	0.39	0.42
	Concentrations (C mM)					
C1	3.77	5.27	4.10	4.67	7.87	9.94
C2	4.50	6.23	5.83	6.74	10.33	12.96
C3	5.35	6.58	6.62	7.73	11.96	14.31
C4	6.11	7.50	7.07	7.88	13.18	15.38
C5	7.00	8.38	7.05	8.14	14.05	16.52
L.S.D (0.05)	0.36	0.34	0.13	0.34	0.34	0.36
	Storage durations (S week)					
S0	10.45	11.28	7.73	8.12	18.18	19.40
S1	7.78	9.40	8.78	8.87	16.57	18.27
S2	6.12	8.18	8.23	8.88	14.35	17.07
S3	4.48	6.47	7.87	8.30	12.35	14.77
S4	3.58	4.80	5.30	7.28	8.88	12.08
S5	2.88	4.00	3.13	4.65	6.02	8.65
S6	2.15	3.42	1.88	2.97	4.03	6.38
L.S.D (0.05)	0.41	0.34	0.21	0.34	0.34	0.41
	Interactions					
H X C	*	*	**	**	*	**
H X S	**	**	**	**	**	**
C X S	**	**	**	**	**	**
H X C X S	**	**	**	**	**	**

H: harvest stage, C: concentrations and S: storage durations.
**, * Highly significant at 0.01 and significant at 0.05 level of probability respectively. L.S.D least significant difference at 0.05 level of probability.

2. Experiment (2) effect of STS

Means and the least significant differences test for the effect of harvest stage (H), STS concentrations (C), storage durations (S) and their interactions on the total vase life, full opening and fading durations in the first and second seasons are given in Table 2.

2.1. Effect of harvest stage

Data in Table 2 showed that the harvest stage had a significant effect on vase life in the two seasons. The second harvest stage resulted in the greatest vase life (12.93 and 13.57 days, for the first and second seasons; respectively) while the shortest vase life were obtained by the first harvest stage (8.57 and 10.33 days, for the first and second seasons; respectively). Full opening and fading durations significantly increased in the second harvest stage resulted in the greatest value (6.21-6.71 and 7.04-6.54 days, for the first and second seasons; respectively).

2.2. Effect of concentrations

Data in Table 2 showed that the vase life was increased by increasing concentrations in both seasons and then decreased. The 2.00 mM concentration of STS resulted in the longest vase life (13.56 and 14.63 days, for the first and second seasons; respectively).The full opening and fading durations significantly increased by increasing the STS concentration to 2.00 mM and resulted in the maximum value (6.21-6.85 and 7.38-7.26 days, for the first and second seasons; respectively).

2.3. Effect of storage durations

Results in Table 2 showed that vase life was decreased by increasing storage durations in both seasons. The zero storage durations (control) resulted in the longest vase life (16.95 and 17.28 days, for the first and second season; respectively).While in the longer-term storage durations (week six) resulted in the shortest vase life (4.43 and 5.53 days, for the first and second seasons; respectively). The full opening and fading durations significantly decreased by increasing the storage durations resulted in the shortest duration at week six (2.08-1.85 and 2.57-2.96 days, for the first and second seasons; respectively).

2.4. Effect of interactions

Data showed that there were highly significant interactions between the harvest stage (H), STS concentrations (C) and storage durations (S) on vase life, full opening and fading durations in the two seasons (Table 2).

From the previously mentioned results, it might be concluded that all the harvest stage used gave a clear effect on vase life especially H2. The increase in storage duration resulted in the shortest vase life. The 2.00 mM concentration of STS gave the longest vase life; this is because the effectiveness of Ag+ in reducing ethylene action declines as the ethylene concentration is increased and delay flowers senescence as reported by

Hadas-Philosoph *et al.* (1997), Hassan *et al.* (2003) and Finger *et al.* (2008). The decreasing of vase life may be due to the respiration process during the dry cold storage of flowers. Respiration leads to higher rates of carbohydrate consumption and food depletion which was reflected on the number of days of vase life as found by Koyama *et al.* (1995) and Pompodakis *et al.* (2005).

Table 2: The effect of harvest stage, STS concentrations, storage durations and their interactions on the full opening vase life, fading vase life and total vase life of *Solidago canadensis* cv. "Tara" flowering stems in the first and second seasons

Treatments	Full opening (days)		Fading(days)		Total vase life (days)	
	2010	2011	2010	2011	2010	2011
	Harvest stage (H %)					
H 1 (30%)	3.36	4.85	5.22	5.48	8.57	10.33
H 2 (10%)	6.21	7.04	6.71	6.54	12.93	13.57
L.S.D (0.05)	0.35	0.39	0.95	0.60	1.31	0.99
	Concentrations (C mM)					
C1	3.18	4.58	3.40	3.44	7.08	8.02
C2	4.38	5.30	4.93	5.60	9.81	10.90
C3	4.95	6.17	5.81	6.47	11.26	12.64
C4	6.21	7.38	6.85	7.26	13.56	14.63
C5	5.20	6.32	6.37	7.27	12.07	13.60
L.S.D (0.05)	0.16	0.11	0.23	0.21	0.33	0.24
	Storage durations (S week)					
S0	9.52	9.82	6.93	7.47	16.95	17.28
S1	6.68	9.43	8.03	6.83	15.21	16.27
S2	5.05	6.54	8.07	7.74	13.62	14.28
S3	4.25	5.54	6.32	6.77	11.07	12.32
S4	3.33	4.22	3.82	5.55	7.65	9.77
S5	2.58	3.53	3.28	4.73	6.37	8.27
S6	2.08	2.57	1.85	2.96	4.43	5.53
L.S.D (0.05)	0.38	0.31	0.29	0.28	0.42	0.37
	Interactions					
H X C	**	**	**	**	**	**
H X S	**	**	**	**	**	**
C X S	**	**	**	**	**	**
H X C X S	**	**	**	**	**	**

H: harvest stage, C: concentrations and S: storage durations.
** Highly significant at 0.01 level of probability.
L.S.D least significant difference at 0.05 level of probability.

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الملخص العربى

تأثير فترات التخزين المبرد و طور الحصاد و معاملات ما بعد الحصاد على طول عمر الافرع الزهرية للسوليداجو صنف "تارا"

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١ – قسم بحوث الحدائق النباتية معهد بحوث البساتين مركز البحوث الزراعية٢ – قسم الانتاج النباتى كلية الزراعة سابا باشا جامعة الإسكندرية٣ – قسم الزهور و نباتات الزينة و تنسيق الحدائق كلية الزراعة جامعة الإسكندرية .

أجري هذا البحث في قسم الإنتاج النباتي، كلية الزراعة سابا باشا، جامعة الإسكندرية خلال موسمين ٢٠١٠ و ٢٠١١ لدراسة تأثير فترات التخزين المبرد و طور الحصاد و معاملات ما بعد الحصاد على طول عمر الأفرع الزهرية للسوليداجو صنف "تارا" و ذلك لإطالة عمر أزهار السوليداجو و تحسين جودتها. حيث تمت معاملة الأفرع الزهرية بمحاليل الحفظ المكونة من محلول حامض الجبريليك فى خمسة تركيزات و هى (صفر – ٠.٢٥ – ٠.٥٠ – ٠.٧٥ – ١.٠٠ مليمول) و محلول ثيوسلفات الفضة فى خمسة تركيزات و هى(صفر– ١.٠٠ – ١.٥٠ – ٢.٠٠ – ٢.٥٠ مليمول) و ذلك قبل التخزين الجاف المبرد للأزهار لفترات مختلفة و هى (صفر – ١ – ٢ – ٣ – ٤ – ٥ – ٦ اسبوع). حيث تمت هذة المعاملات على الازهار فى طورين مختلفين للحصاد و درجة النضج (طور الحصاد الأول و كانت نسبة تفتح الزهيرات ٣٠ % و طور الحصاد الثانى و كانت نسبة تفتح الزهيرات ١٠ %).و أظهرت النتائج المتحصل عليها أن إستخدام حامض الجبريليك و ثيوسلفات الفضة بتركيزات ١.٠٠ و ٢.٠٠ مليمول على الترتيب أعطى أعلى النتائج فى عمر الأزهار فى كل من طور الحصاد الأول و الثانى لكلا الموسمين و أن زيادة تركيز حامض الجبريليك أدت الى زيادة عمر الأزهار. و كانت هناك فروق معنوية بين طورين الحصاد بالنسبة لعمر الأزهار فى كلا الموسمين. و بصفة عامة أدت الزيادة فى فترة التخزين الى نقص شديد و تدريجى فى عمر الأزهار و أدى استخدام محاليل الحفظ الى تقليل التدهور السريع فى عمر الأزهار بعد الخروج من التخزين و أثناء بقائها فى الفازة.