

Optimizing Plant Density, Planting Depth and Postharvest Preservatives for *Lilium longifolium*

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A study was conducted to standardize production and postharvest handling of lily (*Lilium longifolium* L. cv. Mero Star). In production trial, three plant densities viz. 10, 20 and 30 cm between plants in 60 cm spaced rows and two planting depths viz. 7.5 and 15 cm were compared. Increased plant growth, yield and quality was recorded when plants were grown at a close spacing of 10 cm with 15 cm planting depth. In postharvest experiment, holding preservative solutions revealed significant superiority of cobalt chloride @ 5×10^{-4} M with longer vase life (9.0 Days), higher relative fresh weight (98.0%) and higher vase solution uptake rate (0.25 g g^{-1} IFW). However, for pulsing solutions, longer vase life (8.0 days) and higher relative fresh weight (93.0%) was recorded with 500 mg L^{-1} 8-hydroquinoline sulphate (8-HQS) while higher vase solution uptake rate (0.28 g g^{-1} IFW) for 200 mg L^{-1} 8-HQS. For lily production, higher plant density with deeper bulb planting proved better and pulsing with 8-HQS followed by placement in cobalt chloride solution improved postharvest performance and extended longevity rather than sucrose. Moreover, lily did not like sucrose during postharvest handling. These results would help growers and stakeholders to increase lily yield and improve flower quality and longevity.

Abstract

Keywords: Cut flowers, Depth, Holding, Lily, Plant spacing, Pulsing, Vase life.

INTRODUCTION

The lily (*Lilium longifolium* L.), a member of family Liliaceae, is one of the most fascinating bulbous flowering plant grown all over the world for its use as cut flower and potted plant. Lilies are native of the northern hemisphere up to south Canada and Siberia and their southern limit is Florida and India. Majority of lily cultivars are either hybrids or have developed through selection. At present, maximum cultivation of lilies is in Netherlands (3,699 ha) followed by France (438 ha) and Chile (240 ha) with total area of 5,172 ha in the world (Anonymous, 2009).

Plants require proper space to grow and to take other available essentials like water, air and light. Plants have to get these from the limited space in which they grow. Therefore, they are more vulnerable to deprivation of essentials, if they are not provided enough living space (Anonymous, 2011). Correct planting depth influences the available space for development of plant and, therefore, bulbs, corms and seeds should be planted according to their requirement. Additionally, the planting depth influences time to emergence and subsequently the flowering time and total crop duration. Hence, planting at a uniform depth is necessary for a uniform crop time (Padhye and Cameron, 2007).

Vase-life, a yardstick for evaluation of postharvest quality, is an important attribute for improving flower characteristics (Yamada *et al.*, 2003). For many years, floral preservatives have been acidified and biocides are added to inhibit bacterial proliferation. Use of preservatives is strongly recommended to extend vase life of cut flowers which is true at all stages of distribution. Preservatives are required as some are used as biocides and others contain carbohydrates which maintain the freshness and increase the vase life. These preservatives often double the vase life as well as improve general keeping qualities (Nowak and Rudnicki, 1990).

Short postharvest life is one of the most important problems of cut flowers (Kader, 2003). Addition of chemical preservatives to the holding solution is recommended to extend the vase life. Different concentration of sucrose viz. 0, 20, 40, 60, 80, 100 and 120 g L⁻¹ combined with 200 mg L⁻¹ 8-HQS were used as pulse for 10 h and observed that pulsing with less than 80 g L⁻¹ sucrose increased vase life by 4 days; more than 80 g L⁻¹ extended the vase life for 6-7 days, while 120 g L⁻¹ sucrose increased 9-10 days vase life of cut roses (Liao *et al.*, 2000). Sucrose combined with 8-HQS were tested on six lisianthus cultivars, which revealed that application of 200 mg L⁻¹ 8-HQS and 200 g L⁻¹ sucrose as pulse extended the vase life and promoted floret opening in all cultivars (Ichimura and Korenaga, 1998). Vase life and floret opening in cut snapdragon (*Antirrhinum majus* cv. Yellow Butterfly) have also been reported to be improved with 50 g L⁻¹ sucrose in combination of 200 mg L⁻¹ 8-HQS (Ichimura and Hisamatsu, 1999). Higher carbohydrate levels in vase solution also improve petal color, bud opening and extend the flower longevity of lisianthus up to 8 days (Soo Cho *et al.*, 2001). Therefore, the optimizing techniques of extending vase life of cut flowers will be of great importance to the growers and stake-holders (Nermeen *et al.*, 2010).

As lily cultivation is gaining popularity in Pakistan on account of its beautiful colors and longer vase life, higher market demand has been noticed in local markets during recent years. To fulfill this demand, lily is being imported which is quite expensive, therefore, the growers have started growing their own on small scale. However, very limited information is available for its successful cultivation and postharvest handling in the country. Keeping in view this situation, this study was conducted to optimize the planting density, depth and postharvest preservatives for extending vase life. The specific objectives of the study were to evaluate the performance of *Lilium longifolium* L. cv. Mero Star at different plant densities, planting depths and to study the effect of holding and pulsing preservatives for extending vase life.

MATERIALS AND METHODS

A study was conducted at Institute of Horticultural Sciences, University of Agriculture, Faisalabad, during 2009-2010 for evaluation of lily (*Lilium longifolium* L. cv. Mero Star) to determine its suitability for growing as cut flower in Punjab (Pakistan). Soil was thoroughly tilled and blocks were laid out according to the RCBD with factorial arrangements.

Expt. 1: Effect of plant densities and planting depths on liliium production.

Oriental liliium cv. Mero Star bulbs were placed in laboratory at $25 \pm 2^\circ\text{C}$ for 48 h before planting. After layout, bulbs were planted during 3th week of October, 2009 at two planting depths viz. 7.5 and 15 cm and three plant densities viz. 10, 20 and 30 cm between plants in 60 cm spaced rows. There were six treatments replicated thrice. Treatments included 10, 20 and 30 cm spacing at 7.5 and 15 cm planting depth. Five bulbs were planted in each row and each treatment had two rows planted at ridges. Other cultural practices like weeding, plant protection measures, nutrition, earthing up, staking, etc. were similar for all the treatments during entire study period.

Expt. 2: Effect of pulsing and holding solutions on vase life of liliium.

2.1. Plant Material. Cut stems of liliium were harvested, when one flower bud was open on the stem, from field plantings at Institute of Horticultural Sciences, University of Agriculture, Faisalabad. Cut stems were transferred to laboratory within 1 h of harvest. Harvests were conducted between 0700 – 0900 h with clean sharp secateurs, placed into buckets of clean tap water and shifted.

2.2. Treatments and Experimental Design. In pulsing trial, stem ends were dipped in 10 and 20% sucrose and 100, 200 and 500 mg L⁻¹ 8- HQS for 24 h after which individual stems were shifted in glass jars containing 400 ml of distilled water. The control stems were placed in distilled water during pulsing period.

In holding trial, stems were directly placed in glass jars containing 400 ml of distilled water (control), 1, 2, 3, 4% sucrose solution and cobalt chloride at 5×10^{-4} M containing 200 mgL⁻¹ 8-HQS each. In both experiments, five replicates were used in each treatment.

2.3. Data Collection. Data were collected on relative fresh weight (RFW) using following formula:

$$\text{Relative fresh wt. (\%)} = (\text{FW}_t / \text{FW}_{t=0}) \times 100$$

Where, FW_t is weight of stem (g) at $t = \text{day } 0, 1, 2, 3, \dots$

$\text{FW}_{t=0}$ is the fresh weight of same stem (g) at $t = \text{day } 0$ (Ahmad *et al.*, 2011).

Vase solution uptake rate (g g⁻¹ initial fresh weight (IFW)) = $(S_{t-1} - S_t) / \text{IFW}$ of stem

Where,

S_t is the wt. of vase solution (g) at $t = \text{day } 1, 2, 3, \dots$

S_{t-1} is wt. of vase solution (g) on previous day

Initial fresh weight is the fresh weight on day 0 (Ahmad *et al.*, 2011).

Vase life was recorded in days and stems were considered dead when more than 50% petals were wilted or faded.

Data were analyzed statistically according to Fisher's analysis of variance technique and treatment means were compared using Tukey's test at 5% level of probability (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

Greater sprouting (88.3%) was recorded when plants were spaced at 10 cm between plants with 15 cm depth while plants spaced at 20 and 30 cm had less sprouting (76.6% and 83.3%, respectively; data not presented). It may be due to the proper planting procedures or moisture and temperature availability which helped in higher sprouting of the bulbs. Increasing planting depth and density produced taller plants (Table 1). These results are in accordance with the findings of Sharma and Talukdar (2002) who reported wider spacing (45×20 and 60×25 cm) better than closer spacing for gladiolus corm sprouting. Plants were taller (38.6 cm) when bulbs were planted deep because of better soil temperature for growth and soil holding around the bulbs which helped in maximum nutrients uptake from the soil. These results are in line with the findings of Singh and Sangama (2001) who reported larger plant height with deeper planting and closer spacing of gladiolus. Results revealed that at higher planting density and planting depth, the number of leaves per plant were greater (28.7). This may be due to the early emergence of the plants from soil or due to the less internodal distance which increased the number of leaves. Plants closely spaced (10 cm) with deeper planting had larger leaf area (15.6 and 16.7 cm², respectively; Table 1). Leaf area was

greater when plants were closely spaced and deeply planting which might be due to more soil anchorage as well as more nutrients available from wider area around the bulbs. Plant foliage had higher chlorophyll contents when grown at higher density (48.2 SPAD) and deeper planting (49.3 SPAD) than shallow planting (Table 1). Close planting developed competition among plants which caused growth towards light which increased photosynthesis in plants and thereby leaf chlorophyll contents.

Analysis revealed that at wider plant spacing, higher number of flowering buds were recorded (3.3) while planting depth had no effect on flowering buds as shown in Table 1. These findings are in contrast to the findings of Mishra *et al.*, (2002) who recorded higher number of flowering buds at higher density. This may be due to more light availability and less nutrient competition among plants. Planting density and depth had no effect on stem diameter and averaged 0.76 cm for all planting depths and densities (Table 2). Higher fresh weight of a stem was recorded at deep planting (64.2 g) and higher plant density (60.4 g; Table 2). Larger plant population increased competition between plants which increased photosynthetic rate and thereby assimilation of more carbohydrates. Dry weight of stem was also higher at higher planting density (8.6 g) and deeper plantings (8.9 g) as shown in Table 2. This may be due to competition between plants which resulted in higher nutrient uptake and higher photosynthetic assimilation rates.

For postharvest handling of liliium, in pulsing trial, longer vase life (8.0 days) was recorded when stems were pulsed with 500 mg L⁻¹ 8-HQS for 24 h while in holding trial, cobalt chloride at 5 x 10⁻⁴M had longer vase life of 9.0 days (Table 3). Interestingly, in both experiments, liliium did not like sucrose and had shorter vase life than control. In holding experiment, with increase in sucrose concentration, vase life gradually reduced. Results revealed that stems have sufficient stored carbohydrates and do not like additional ones; however, addition of a biocide to kill microbes in vase solution as well as to lower the pH of solution proved beneficial and extended vase life. In holding solutions, stems placed in cobalt chloride maintained their relative fresh weight (RFW) and had higher RFW at end of vase period (Fig. 1). While, RFW of stems placed in 4 and 3% sucrose containing treatments started to decrease from day 1 and was minimum at end of vase life. For uptake rate, cobalt chloride followed by distilled water (control) had higher uptake rate than those sucrose containing treatments which decreased sharply till day 2 and was minimum at end of vase life (Fig. 2). Reduction in relative fresh weight of stems with sucrose solutions may be due to the blockage of the stem vessels due to bacterial populations in the solutions on account of sugars present in vase solution. The stems with cobalt chloride and distilled water maintained relative fresh weight for first 2 days of vase life period. Reduction in vase solution uptake rate by the stems placed in sucrose treatments may also be due to stem end blockage by microbes. These findings are in accordance with the findings of Williamson *et al.*, (2002) and Ahmad (2009) who reported that microbes can secrete toxic compounds like pectins which can reduce the postharvest life of cut stem by senescence or by blockage of the stem end and excessive sugars in vase solution may also increase bacterial proliferation ultimately causing stem end blockage and death of stems.

In pulsing solutions, stems placed in 500 mg L⁻¹ 8-HQS followed by 200 mg L⁻¹ 8-HQS had higher relative fresh weight at end of vase life (Fig. 3). While those pulsed with 10 and 20% sucrose had rapid reduction in RFW and had minimum fresh weight at end of vase life. Results revealed that sucrose concentrations proved toxic for the liliium stems and should be avoided in commercial handling. Regarding uptake rate, initially 500 mg L⁻¹ 8-HQS had higher uptake rate which decreased than 200 mg L⁻¹ 8-HQS towards the end of vase period (Fig. 4). Toxic effects of higher sucrose concentrations blocked stem ends and inhibited water uptake which ultimately lead to stems senescence. Results have suggested that 8-HQS pulsing is better as it helps control microbial growth in the solution, while sucrose increased bacterial population which caused stem end blockage and death of stems.

In summary, plants with closer spacing (10 cm between plants) with 15 cm deep planting produced good quality and higher yield. For postharvest handling, cobalt chloride proved best holding solution while 500 mg L⁻¹ 8-HQS pulsing for 24 h helped better to extend vase life and maintain higher relative fresh weight while vase solution uptake rate was higher with 200 mg L⁻¹ 8-HQS. However, use of sucrose did not prove effective and should be avoided during commercial handling of liliium stems.

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Tables

Table 1. Plant height, leaf area, leaf chlorophyll contents and number of flowering buds per plant of *Lilium longifolium* L. cv. Mero Star as influenced by various plant densities and depth.

Treatments	Plant height (cm)	Leaf area (cm ²)	Leaf chlorophyll contents (SPAD)	Number of flower buds per plant
Planting depth				
7.5 cm	32.2b	12.1b	45.3 ^b	3.1 ^a
15 cm	38.6a	16.7a	49.3 ^a	3.1 ^a
Plant spacing				
10 cm	38.5	15.6	48.2	2.9
20 cm	33.2	13.5	47.2	3.1
30 cm	34.5	14.1	46.5	3.3
Significance				
Plant depth (D)	*	**	*	*
Plant spacing (S)	ns	ns	ns	ns
D×S	ns	ns	ns	ns

** Significant at $p \leq 0.01$.

* Significant at $p \leq 0.05$.

ns Non-significant at $p \leq 0.05$.

Table 2. Stem diameter, fresh weight of stem and dry weight of stem of *Lilium longifolium* L. cv. Mero Star as influenced by various plant densities and depth.

Treatments	Stem diameter (cm)	Fresh weight of stem (g)	Dry weight of stem (g)
Planting depth			
7.5 cm	0.76	50.5 ^b	6.9 ^b
15 cm	0.76	64.2 ^a	8.9 ^a
Plant spacing			
10 cm	0.76	60.4	8.6
20 cm	0.76	53.4	7.4
30 cm	0.76	58.1	7.8
Significance			
Plant depth (D)	*	*	*
Plant spacing (S)	ns	ns	ns
D×S	ns	ns	ns

* Significant at $p \leq 0.05$.

ns Non-significant at $p \leq 0.05$.

Table 3. Vase life of *Lilium longifolium* L. cv. Mero Star as influenced by various holding and pulsing preservative solutions.

Holding solution		Pulsing solution	
Treatments	Vase life (days)	Treatments	Vase life (days)
Distilled water (control)	7.0 b	Distilled water (control)	7.0 ab
1% sucrose	5.0 b	10% sucrose	1.0 c
2% sucrose	5.0 b	20% sucrose	1.0 c
3% sucrose	3.0 c	100 mg L ⁻¹ 8-HQS	5.0 b
4% sucrose	2.0 c	200 mg L ⁻¹ 8-HQS	6.0 ab
Cobalt Chloride (5×10 ⁻⁴ M)	9.0 a	500 mg L ⁻¹ 8-HQS	8.0 a

Means sharing same letter in a column are statistically similar at $p \leq 0.05$.

Figures

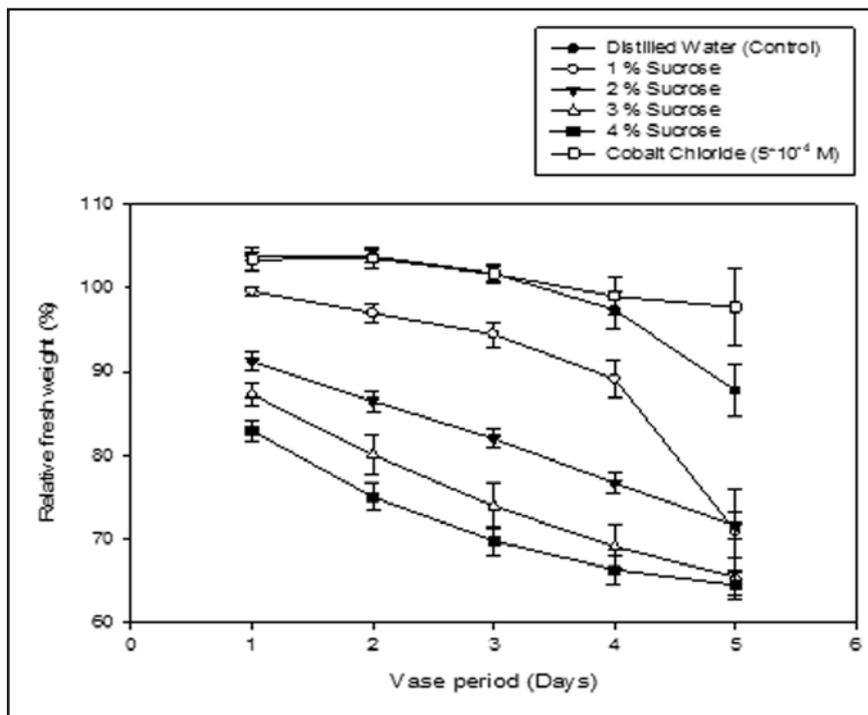


Fig. 1. Relative fresh weight of *Lilium longifolium* L. cv. Mero Star as influenced by different holding solutions. All treatments had 200 mg L⁻¹ 8-HQS as biocide.

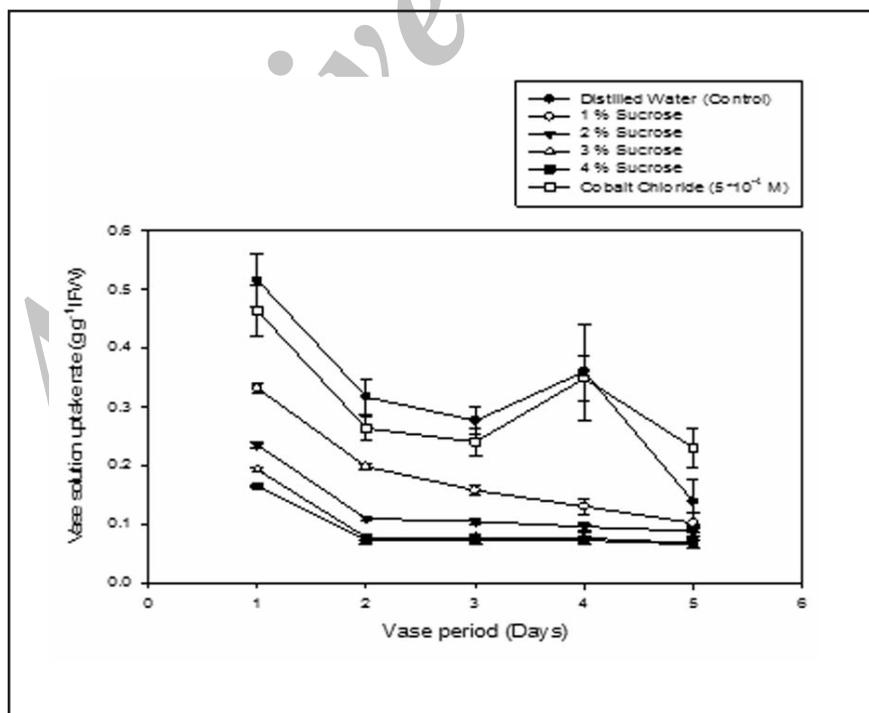


Fig. 2. Vase solution uptake of *Lilium longifolium* L. cv. Mero Star as influenced by different holding solutions. All treatments had 200 mg L⁻¹ 8-HQS as biocide.

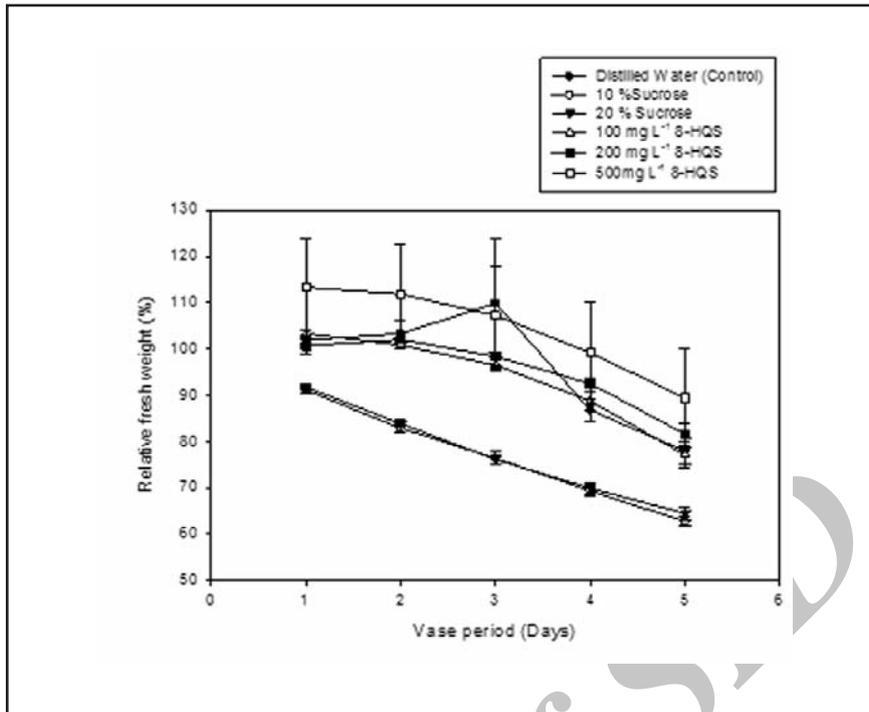


Fig. 3. Relative fresh weight of *Lilium longifolium* L. cv. Mero Star as influenced by different pulsing solutions.

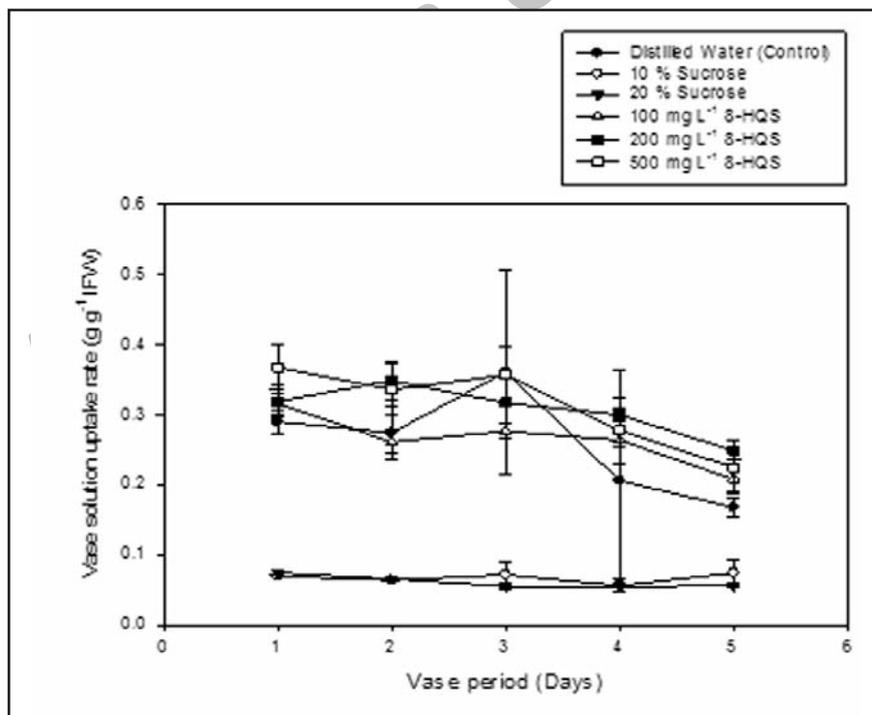


Fig. 4. Vase solution uptake of *Lilium longifolium* L. cv. Mero Star as influenced by different pulsing solutions.