International Journal of Agricultural Research

ISSN 1816-4897

Academic Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 5 (1): 1-10, 2010
ISSN 1816-4897

Effect of 1-MCP Fumigation on Vase Life and Other Postharvest Qualities of Siam Tulip (*Curcuma aeruqinosa* Roxb.) cv. Laddawan

P. Chutichudet, B. Chutichudet and K. Boontiang
Department of Agricultural Technology, Faculty of Technology,
Mahasarakham University, Mahasarakham 44000, Thailand

Abstract: The siam tulip is a relatively new exported cut flower that has become widely recognized for its attractive colorful pink bract. The main problem limiting this lovely flower's value is its poor vase life after cutting. The objective of this study was to extend siam tulip's shelf life by using a substance against ethylene action, 1-Methylcyclopropene (1-MCP). The experiment was arranged in a factorial completely randomized design, composed of two factors: 1-MCP concentration at four levels (0, 300, 600 or 900 ppb) and a period of fumigation at two levels (4 or 8 h) in a hermetically sealed plastic bucket (50 L) at 25°C. The results showed that flowers treated with 300 ppb 1-MCP for 8 h had maximal water uptake, preserved the highest anthocyanin content and the least occurrence of bract browning during postharvest life. No marked differences in weight loss of flowering stalk was observed.

Key words: 1-MCP, vase life, postharvest quality, siam tulip, bract browning, anthocyanin content

INTRODUCTION

Siam tulip (*Curcuma aeruqinosa* Roxb.) is an ornamental plant specie in the family of Zingiberaceae and a relative newcomer to the world of cut flowers and ornamental plants (Top Tropicals Plant Catalog, 2009). Nowadays, the added value of siam tulip cut flowers is increasing due to their strikingly beautiful brilliant pink inflorescence that makes it a very appealing cut flower, potted plant or landscape addition (Phipps, 2009). Thai Horticulture (2009) reported that the siam tulip originated in Thailand. It has been classed as a tropical native tender perennial and has become a popular ornamental plant that grows well in warm and wet climates. Thus, the predominant production is located in Thailand. Nowadays, the Laddawan siam tulip is a F1 hybrid, a cross between *Curcuma alismatifolia* and *Curcuma cordata*. It is a popular variety for cut flowers that has high commercial demand (Tropical Nurseries, 2009). The end of vase life of this flower is partially determined by a browning appearance on their bracts (Bunya-Atichart *et al*., 2004). This disorder causes the flower to senescence and limits the length of postharvest life. Such changes have a major negative impact upon its salable value at market. Generally, the senescence of flower after cutting has been attributed mainly to ethylene. The presence of ethylene leads to flower senescence, shortening of life and loss of bright color (Jiang, 2000). A practical method to decrease this disorder is a great importance. Recently, an ethylene action inhibitor, the

Corresponding Author: Dr. Benjawan Chutichudet, Department of Agricultural Technology, Faculty of Technology, Mahasarakham University, Mahasarakham 44000, Thailand

compound 1-methylcyclopropene (1-MCP), has been reported to prolong the display life in various cut flowers (Honghem *et al*., 2007). This compound is considered as non-toxic for human and the environment (Blankenship and Dole, 2003; Serek *et al*., 2006). Furthermore, 1-MCP is currently being considered for future use in applications to commercial cut flowers (Feng *et al*., 2000). At present, limited information have apparently been reported on the postharvest physiology of siam tulip. Thus, there is still a need for more information about 1-MCP application on post harvest of the siam tulip flower. The experiment outlined in the present research aimed to investigate the effectiveness of exogenous 1-MCP as a postharvest tool for extending the vase life and maintaining the quality characteristics of siam tulip cv. Laddawan, in order to assess the potential of 1-MCP as a pretreatment to extend the flower longevity and improve the qualities of this flower.

MATERIALS AND METHODS

Siam tulip flowers (*Curcuma aeruqinosa* Roxb.) cv. Laddawan cut at the commercial stage were purchased from a commercial garden in Chiang Mai, in the North of Thailand. Each flower was wrapped with a foam sheath and packed carefully in fiberboard cartons then transported in an air-conditioned vehicle to Mahasarakham University. After they arrived at the laboratory, the flowers were selected again for uniformity in size, shape, initial bract color and freedom from external damage before being placed into chambers for fumigating with 1-MCP. Each flowering stem was recut with stainless steel scissors into 30 cm lengths. The experiment was carried out from June to August 2008 at the Division of Agricultural Technology, Faculty of Technology, Mahasarakham University, in the Northeast of Thailand. A Factorial Randomized Complete Block Design was arranged and composed of two factors: concentration of 1-MCP four levels (0, 300, 600 or 900 ppb) with two periods of fumigation time (4 or 8 h). While control flowers were sealed in identical chambers without added 1-MCP, different concentrations in combination with fumigation periods were used as treatments: 0 ppb 4 h, 300 ppb 4 h, 600 ppb 4 h, 900 ppb 4 h, 0 ppb 8 h, 300 ppb 8 h, 600 ppb 8 h and 900 ppb 8 h. Each treatment was carried out in ten replicates, one flower per replication. All treatments were taken in sealed 50 L plastic buckets of 50 L capacity containing distilled water and exposed to different concentrations of 1-MCP (0, 300, 600 or 900 ppb) with two periods of time (4 or 8 h) at 25°C. After the period of exposure, each flowering stem end was subsequently stood in 500 mL plastic bottle containing distilled water and stored in ambient temperature (27.5°C, 91% R.H.). The following determinations were recorded every other day for assessments of each flowering stalk weight loss as percentage. Water uptake by flowering stalk was measured as mL. Vase life (days) was considered terminated when 30% of the flowers on each stem wilted and lost color. Wilting was assessed as percentage by visual mean and scores were given ranging from 0 to 100%. Total anthocyanin content was determined according to the method of Ranganna (1997) that compared with absorbance value at wavelength of 535 nm by the use of spectrophotometer model V-325-XS, from China. Total anthocyanin content was expressed as mL per 100 g Fresh Weight (FW). Level of bract browning was assessed as percentage by visual mean and scores were given ranging from 0 to 100%. The collected data were statistically analyzed using the SPSS Computer Program, Version 6 (SPSS, 1999).

RESULTS

After exposure with different concentrations of 1-MCP (0, 300, 600 or 900 ppb) and various periods of time (4 or 8 h) and then kept in plastic bottle containing distilled water stored at ambient temperature, the results composed of:

Table 1: Weight loss of flowering stalk of siam tulip after fumigating with 1-MCP

	Weight loss (%) of flowering stalk at DAS						
Factors	2	4	6	8	10	12	14
Conc. (ppb)							
0	11.49	20.51	28.91	28.14	31.04	34.33	30.18
300	9.03	16.19	23.30	28.59	31.49	32.60	33.66
600	10.58	18.97	25.91	27.72	31.15	30.61	30.37
900	11.19	20.53	29.65	28.67	29.67	29.79	31.46
F-test	ns	ns	ns	ns	ns	ns	ns
CV (%)	9.46	10.93	13.32	18.15	15.32	14.26	13.93
LSD	0.6965	1.3173	2.0076	2.7659	2.8352	4.5490	3.7901
Fumigation time (h)							
4	10.08	18.24	26.37	27.64	31.15	29.42	29.13
8	11.07	19.86	27.51	29.02	30.78	34.33	33.32
F-test	ns	ns	ns	ns	ns	ns	ns
CV (%)	13.09	11.65	14.17	17.47	13.77	13.69	13.69
Conc. × fumigation time							
0 ppb 4 h	11.24	20.08	28.64	30.04	33.32	32.92	31.01
300 ppb 4 h	8.74	15.66	21.61	24.08	27.22	22.54	23.31
600 ppb 4 h	10.15	18.35	26.00	25.56	30.71	29.42	28.74
900 ppb 4 h	10.19	18.85	29.25	31.55	34.23	37.33	37.07
0 ppb 8 h	11.74	20.95	29.19	25.48	27.86	36.68	29.35
300 ppb 8 h	9.33	16.72	24.99	33.60	36.23	39.31	38.26
600 ppb 8 h	11.02	19.58	25.83	29.45	31.50	31.45	31.28
900 ppb 8 h	12.18	22.20	30.05	23.48	20.38	18.47	23.06
F-test	ns	ns	ns	ns	ns	ns	ns
CV (%)	17.92	13.33	14.06	17.25	13.85	13.26	13.11
LSD	0.9936	1.8874	2.9022	3.8873	3.9601	6.1016	5.2288

ns: Non significant

Weight Loss of Flowering Stalk

The results indicated that 1-MCP fumigation had no effect to the weight loss of flowering stalk of siam tulip during vase life (Table 1).

Water Uptake

During postharvest life, the results began to show significant differences in water uptake by flowering stem of siam tulip since, the sixth day. Both treating with 1-MCP at 600 ppb for 4 h and 300 ppb for 8 h stimulated the highest water uptake through flowering stem of 6.00 and 5.40 mL on 14 days after storage (DAS), respectively (Table 2).

Vase Life

The result from Table 3 showed that flowers-exposed to 1-MCP at 300 ppb regardless of exposure duration increased the siam tulip's vase life by 12.90 days. While the interaction of different concentrations and fumigation periods of 1-MCP had no significant effect on the vase life of siam tulip flowers.

Wilting Percentage

Siam tulip flower showed a sharp increase the wilting incidence after storage. The results showed that flower treated with 1-MCP at 300 or 600 ppb for 4 or 8 h appeared the least bract wilting, as measured by visual means at 8 DAS (Table 4).

Anthocyanin Content

The results from Table 5 showed that the concentrations of anthocyanin gradually decreased during storage. Siam tulip flowers started to show a highly significant difference

Table 2: Water uptake by flowering stalk of *Curcuma aeruginosa* Roxb. after fumigating with 1-MCP

	Water uptake (mL) at DAS						
Factors	2	4	6	8	10	12	14
Conc. (ppb)							
0	2.00	1.90	2.95	4.14a	3.62a	2.00	3.56
300	2.20	2.05	3.30	2.10b	2.00b	2.06	4.88
600	2.25	2.25	2.65	3.00ab	2.94ab	2.39	3.00
900	2.20	2.35	3.70	3.20ab	2.90ab	3.00	3.20
F-test	ns	ns	ns	*	*	ns	ns
CV (%)	4.11	3.44	4.86	6.76	5.36	3.23	6.71
LSD	0.1989	0.1643	0.3421	0.5067	0.3605	0.2365	0.8549
Fumigation time (h)							
4	2.25	2.18	3.53a	2.28b	2.20b	2.00	4.50
8	2.08	2.10	2.78b	3.60a	3.36a	2.44	3.35
F-test	ns	ns	*	*	*	ns	ns
CV (%)	3.07	3.49	4.81	6.75	5.25	3.31	6.74
Conc. × fumigation time							
0 ppb 4 h	2.30	2.10	2.70bc	2.29bc	2.43bcd	1.50c	4.25ab
300 ppb 4 h	2.30	2.10	3.70ab	2.30bc	2.00d	1.86bc	4.00ab
600 ppb 4 h	2.10	2.10	3.20abc	2.43bc	2.38cd	2.20abc	6.00a
900 ppb 4 h	2.30	2.40	4.50a	2.00bc	2.10d	3.00a	3.33ab
0 ppb 8 h	1.70	1.70	3.20abc	6.00a	5.00a	2.60ab	3.00ab
300 ppb 8 h	2.10	2.00	2.90bc	1.90c	2.00d	2.20abc	5.40a
600 ppb 8 h	2.40	2.40	2.10c	3.40bc	3.40bc	2.50ab	1.33b
900 ppb 8 h	2.10	2.30	2.90bc	3.80b	3.70b	3.00a	3.00ab
F-test	ns	ns	**	**	**	*	*
CV (%)	4.13	3.47	4.65	6.07	4.76	3.07	5.89
LSD	0.2826	0.2348	0.4634	0.6560	0.4536	0.3232	1.0839

Letter(s) within columns indicate least significant differences (LSD) at *p = 0.05, **p= 0.01. ns: Non significant

Table 3: Vase life of siam tulip flower after fumigating with 1-MCP

Factors	Vase life (days)
Conc. (ppb)	
0	10.20b
300	12.90a
600	11.95ab
900	10.30b
F-test	*
CV (%)	3.39
LSD	0.7704
Fumigation time (h)	
4	11.20
8	11.48
F-test	ns
CV (%)	3.65
Conc. × fumigation time	
0 ppb 4 h	10.00
300 ppb 4 h	12.20
600 ppb 4 h	12.00
900 ppb 4 h	10.60
0 ppb 8 h	10.40
300 ppb 8 h	13.60
600 ppb 8 h	11.90
900 ppb 8 h	10.00
F-test	ns
CV (%)	3.01
LSD	1.1116

Letter(s) within columns indicate least significant differences (LSD) at *p = 0.05. ns: Non significant

of anthocyanin content after 6 DAS. Flower-treated with 1-MCP at 300 ppb for 8 h retained the maximal anthocyanin content of 32.95 mL per 100 g FW on 12 DAS. Thus, 1-MCP treatment at 300 ppb for 8 h had a positive effect on anthocyanin pigment in flower bract.

Table 4: Wilting percentage of siam tulip flower after fumigating with 1- MCP

	Wilting percentage (%) at DAS				
Factors	2	4	6	8	10
Conc. (ppb)					
0	2.80	11.25a	14.85	17.92a	14.92
300	1.38	3.90b	6.00	11.30b	13.75
600	2.35	7.50ab	8.15	10.72b	14.00
900	2.10	9.05a	11.98	17.29a	16.93
F-test	ns	*	ns	**	ns
CV (%)	9.28	8.97	10.57	1.86	6.56
LSD	0.4476	1.5889	2.4206	0.6432	1.75
Fumigation time (h)					
4	1.73	7.73	9.30	13.56	16.58a
8	2.59	8.13	11.19	13.97	12.77b
F-test	ns	ns	ns	ns	*
CV (%)	9.26	9.49	10.92	3.01	4.70
Conc. × fumigation time					
0 ppb 4 h	1.90	11.00	11.80	15.57b	16.67
300 ppb 4 h	1.50	5.60	7.40	10.80c	16.00
600 ppb 4 h	2.20	7.00	8.30	10.50c	13.13
900 ppb 4 h	1.30	7.30	9.70	17.78b	20.22
0 ppb 8 h	3.70	11.50	17.90	20.67a	13.17
300 ppb 8 h	1.25	2.20	4.60	11.80c	11.50
600 ppb 8 h	2.50	8.00	8.00	10.90c	14.70
900 ppb 8 h	2.90	10.80	14.25	16.40b	11.00
F-test	ns	ns	ns	**	ns
CV (%)	9.06	9.06	10.66	1.67	4.44
LSD	0.6177	2.2706	3.4515	0.8320	2.3942

Letter(s) within columns indicate least significant differences (LSD) at *p = 0.05, **p = 0.01. ns: Non significant

Table 5: Anthocyanin content in bract of siam tulip after storage

	Anthocyanin content (mL per 100 g FW) at DAS					
Factors	2	4	6	8	10	12
Conc. (ppb)						
0	40.90	41.34a	37.08	34.81	29.00	23.07
300	40.13	41.51a	32.19	32.49	28.12	25.09
600	40.48	35.42ab	35.63	33.43	27.52	22.89
900	39.57	29.79b	30.99	29.46	25.69	21.93
F-test	ns	**	ns	ns	ns	ns
CV (%)	2.67	2.45	5.36	2.02	2.19	2.03
LSD	3.0986	2.6130	1.9471	1.9005	1.7401	1.3626
Fumigation time (h)						
4	38.60	37.74	33.00	29.64b	24.17b	20.30b
8	41.94	36.29	34.94	35.46a	31.00a	26.19a
F-test	ns	ns	ns	**	**	**
CV (%)	2.58	2.73	2.06	1.86	1.78	1.59
Conc. × fumigation time						
0 ppb 4 h	44.47	46.19a	42.50a	35.51bc	30.53b	24.25c
300 ppb 4 h	33.75	43.17ab	23.73c	24.40d	19.60e	17.23h
600 ppb 4 h	38.93	35.57bc	39.17a	35.55bc	24.07cd	18.73g
900 ppb 4 h	37.23	26.03c	26.61c	23.09d	22.46de	21.00f
0 ppb 8 h	37.33	36.49ab	31.65b	34.10bc	27.46bc	21.89e
300 ppb 8 h	46.51	39.86ab	40.65a	40.57a	36.63a	32.95a
600 ppb 8 h	42.04	35.28bc	32.09b	31.32c	30.96b	27.05b
900 ppb 8 h	41.90	33.55bc	35.37b	35.83b	28.92b	22.87d
F-test	ns	*	**	**	**	**
CV (%)	2.59	2.39	3.41	1.65	1.93	1.29
LSD	4.2495	3.6053	1.3053	1.5485	1.3434	0.1228

Letter(s) within columns indicate least significant differences (LSD) at *p = 0.05, **p = 0.01. ns: Non significant

Table 6: Level of browning appearance of siam tulip's bract after fumigating with 1-MCP

	Browning appearance (%) at DAS				
Factors	2	4	6	8	10
Conc. (ppb)					
0	3.70	14.30a	12.85	15.31a	23.50a
300	2.63	7.50c	8.43	9.95b	14.30b
600	4.60	10.45bc	8.78	10.67b	17.28b
900	2.43	11.35ab	12.68	15.64a	23.50a
F-test	ns	**	ns	**	**
CV (%)	8.22	5.55	5.29	2.74	2.74
LSD	0.6138	1.3516	1.5019	0.8577	1.3175
Fumigation time (h)					
4	2.69	11.35	11.23	13.44a	19.91
8	3.99	10.45	10.14	11.36b	17.77
F-test	*	ns	ns	*	ns
CV (%)	8.31	5.91	5.49	3.31	3.40
Conc. × fumigation time					
0 ppb 4 h	3.05bc	13.20ab	11.90ab	15.43ab	24.17a
300 ppb 4 h	3.35bc	9.80bc	12.80ab	13.70bc	16.40cd
600 ppb 4 h	2.80bc	11.00ab	9.80ab	10.13d	16.88cd
900 ppb 4 h	1.55c	11.40ab	10.40ab	14.56b	23.67a
0 ppb 8 h	4.35ab	15.40a	13.80a	15.17ab	22.83ab
300 ppb 8 h	1.90c	5.20c	4.05c	6.20e	12.20d
600 ppb 8 h	6.40a	9.90bc	7.75bc	11.10cd	17.60bc
900 ppb 8 h	3.30bc	11.30ab	14.95a	17.60a	23.20a
F-test	**	*	**	**	**
CV (%)	7.68	5.56	5.94	2.11	2.75
LSD	0.8109	1.9151	2.0080	0.9474	1.8946

Letter(s) within columns indicate least significant differences (LSD) at *p = 0.05, **p = 0.01. ns: Non significant

Level of Browning Appearance

The degree of bract browning on the flowers rapidly increased during storage. At longer storage times, the occurrence of bract discoloration proceeded. Bract browning appearance of all treatments showed significantly different levels while recording the data at two daily intervals. The results from Table 6 indicated that treating with 1-MCP at 300 ppb for 8 h resulted in the least browning percentage of 12.20% on 10 DAS. Therefore, it is possible to apply 1-MCP for control the bract browning in siam tulip flower.

DISCUSSION

To test the effect of 1-MCP on postharvest life and other postharvest characteristics of siam tulip flowers, Laddawan were treated with various concentrations of 1-MCP in combination with fumigation periods for 4 or 8 h. The results revealed that during storage, the weight loss of the siam tulip flower steadily declined throughout their vase life and were quite invariable among the treatments. A similar finding in a previous reported by Porat *et al.* (1999) found that 1-MCP did not affect weight loss in oranges, while Wu *et al.* (2009) reported that the treatment with 0.5 $\mu l\ L^{-1}$ 1-MCP significantly delayed weight loss of Chinese chive scapes flowers. The opposite result was confirmed by Chutichudet *et al.* (2010), who cited that patumma flowers treated with different concentrations of 1-MCP for 4 or 8 h affected to lower the weight more than that of untreated flowers. This was probably due to the fact that siam tulip flower was cut at a young stage and considered as a perishable product and susceptible to readily loosing a lot of water through transpiration immediately after cutting (Nakano *et al.*, 2003). This caused the deleterious results and led to show the similar fresh weight of flowering stem between 1-MCP treated and untreated flowers (Ben-Yehoshua and Cameron, 1989).

The results of water uptake by flowering stalk showed that treatment with 1-MCP at 300 ppb for 8 h and 1-MCP at 600 ppb for 4 h remarkably increased water uptake through flowering stem more than in the control flowers. This indicated that a positive water balance in these flowering stems could be improved by 1-MCP application after cutting. However, there is a few published data reported in the role of 1-MCP related to postharvest physiological characteristics of the siam tulip flowers. While Chutichudet *et al.* (2010) found that 1-MCP fumigating had no effect on the water uptake of Patumma flowering stalk during vase life.

For the vase life of siam tulip flower, the results showed that the interaction of different exposure by 1-MCP at 0, 300, 600 or 900 ppb for 4 or 8 h had no effect on extending the flower longevity. This result is consistent with the findings of Chutichudet *et al.* (2010), who showed 1-MCP had no effect on the vase life of Patumma. The lack of these responses may have been due to plant tissues varying greatly in their ability to respond to the 1-MCP substance (Blankenship and Dole, 2003). In addition, another reason may be due to the efficacy of 1-MCP. It may have a transient ability to bind to ethylene receptors of the plant tissue in which their effects for blocking the ethylene produced at the later storage is not permanently attached, or it binds to other receptors (Sisler and Serek, 1997). This is in agreement with the previous data of Blankenship and Dole (2003), who found that the concentration of 1-MCP gas in fumigated plant material declined with time. Thus, after storage, the 1-MCP effect was almost completely lost. These caused to fail for blocking ethylene action in some species of cut flowers (Kim *et al*., 2007) such as several Australian native cut flowers (Macnish *et al*., 2000) because the diffusion of 1-MCP out of plant material after applying is rapid. Harima *et al.* (2003) also found that the length of the protection period by 1-MCP varies with plant species and tissues. These does not corresponded to the results of Able *et al.* (2002) and Yuan *et al.* (2010), who reported that 1-MCP treatment markedly increased the shelf life of broccoli (*Brassica oleracea* var. *italica*) florets and *Mokara* Jairak Gold (Honghem *et al*., 2007). However, at present there is limited research that has determined the effectiveness of 1-MCP to postharvest longevity in cut siam tulip. Additional experiments are needed to further investigate the effects of 1-MCP related to postharvest physiological characteristics of siam tulip flower.

The results on wilting showed that no obvious differences in wilting occurrence between flowers of 1-MCP-treated and control treatment during vase life. A possible explanation for these effects of 1-MCP may be that bract wilting resulted from the failure of the cut stem to replace water lost mainly through transpiration (Bunya-Atichart *et al*., 2004). These brought about a hastening to eventually senescence of flower as the longer storage period evolved. A related observation that 1-MCP affected to delay the flower wilting as the result of promoting the more water uptake by flowering stem was observed particular at 8 DAS. While some researchers found the 1-MCP had no effect to delay the wilting of some flower, such as Patumma (Chutichudet *et al*., 2010) and Oriental hybrid lilies (Çelikel *et al*., 2002). However, these are not in line with the results of Celikel and Reid (2002), who found that 1-MCP could prevent the rapid wilting of carnation Sandra, alstroemeria (*Alstroemeria*), snapdragon, larkspur (*Consolida ambigua*), sweet william (*Dianthus barbatus*), stock (*Matthiola incana*) and penstemon Firebird (Serek *et al*., 1995a).

The results of anthocyanin content showed that anthocyanin content in the bract of flower declined continually until the end of the storage period, with those flowers treated with 300 ppb of 1-MCP had a greatest amount of anthocyanin (32.95 mL per 100 g FW). This result was also found to be true in Patumma flowers (Chutichudet *et al*., 2010). These may be due to the effects of 1-MCP depend on the plant species (Serek *et al*., 1995b). Generally,

anthocyanin is considered in a group of plant flavonoids, which is often degraded after harvest, accompanied by flower browning (Underhill and Critchley, 1994). In some cases, anthocyanin degradations occur due to changes in the vacuoles that decrease the stability of the pigments and cause the chemical degradation of the anthocyanins, which result to senescence process (Oren-Shamir, 2009). Hershkovitz *et al.* (2005) cited that pretreatment with 1-MCP could reduce the damage of membrane in fresh product, which is an important factor involved in retaining bract discoloration. These results indicated that 1-MCP application had potential for commercial use to maintain the flower quality in term of pink color. The biochemical background of these effects, however, is still largely unknown, so properties of the 1-MCP involved in anthocyanin degradation require detailed characterization.

For browning incidence, the results showed that 1-MCP application at 300 ppb for 8 h dramatically affected to decrease the browning appearance. The flower-treated with 1-MCP at this treatment also exhibited significantly the highest water uptake and the maximal anthocyanin content during vase life. Generally, bract browning is a senescence symptom accompanied by decreasing the water uptake and degrading the anthocyanin in flower (Oren-Shamir, 2009). Able *et al.* (2002) found that 1-MCP treatment had an important role to decrease the color change in florets of broccoli. In addition, Tian *et al.* (2005) also found that water loss leads to change in anthocyanin pigment molecules, ultimately yielding brown pigments. Thus, the more water uptake by flowering stem, the higher anthocyanin level and the less browning of bract were observed which is consistent with the findings of Jiang *et al.* (2002). From the results, it may be possible to confirm the positive effect of 1-MCP treatments on alleviating the browning appearance. However, the specific mechanism of 1-MCP in reducing the browning incidence is still scarcely known. A better understanding of the mechanisms involved in improving the siam tulip's qualities should be further investigated on the effects of 1-MCP at 300 ppb in conjunction with longer application period for extending the flower longevity and maintaining the postharvest characteristics.

In conclusion, it was found that siam tulip flowering stems responded positively to 1-MCP application at 300 ppb for 8 h by exhibiting to promote the quality characteristics of the highest water uptake, the best retention of anthocyanin content and the lowest browning appearance. However, the application of 1-MCP had no effect to the percentage of weight loss of siam tulip during vase life. Thus, 1-MCP at 300 ppb for 8 h has potential to slow the loss qualities of siam tulip during storage under ambient storage compared to the untreated control.

ACKNOWLEDGMENTS

This study was funded by the Mahasarakham University under project No. 5201087/2552. The authors wish to express their sincere thanks to the Financial Office for financial assistance and Mr. Paul Dulfer for his kindness to improve this manuscript. We appreciate the support of Dr. Sucharit Suanphairoch, who kindly provided the 1-MCP.

REFERENCES

Able, A.J., L.S. Wong, A. Prasad and T.J. O'Hare, 2002. 1-MCP is more effective on a floral brassica (*Brassica oleracea* var. *italica* L.) than a leafy brassica (*Brassica rapa* var. *chinensis*). Postharvest Biol. Technol., 26: 147-155.

Ben-Yehoshua, S. and A.C. Cameron, 1989. Exchange Determination of Water Vapor, Carbon Dioxide, Oxygen, Ethylene and other Gases of Fruits and Vegetables. In: Modern Methods of Plant Analysis, New Series, Gases in Plant and Microbial Cells, Linskens, H.F. and J.F. Jackson (Eds.). Vol. 9. Springer-Verlag, Berlin, ISBN: 3-540-18821-5, pp: 177-193.

Blankenship, S.M. and J.M. Dole, 2003. 1-Methylcyclopropene: A review. Postharvest Biol. Technol., 28: 1-25.

Bunya-Atichart, K., S. Ketsa and W.G.V. Doorn, 2004. Postharvest physiology of *Curcuma alismatifolia* flowers. Postharvest Biol. Technol., 34: 219-226.

Celikel, F.G. and M.S. Reid, 2002. Postharvest handling of stock (*Matthiola incana*). HortSci., 37: 144-147.

Çelikel, F.G., L.L. Dodge and M.S. Reid, 2002. Efficacy of 1-MCP (1-methylcyclopropene) and Promalin for extending the post-harvest life of Oriental lilies (*Lilium* X*Mona Lisa* and *Stargazer*). Sci. Hort., 93: 149-155.

Chutichudet, P., B. Chutichudet and K. Boontiang, 2010. Effect of 1-MCP on vase life and other postharvest qualities of Patumma (*Curcuma alismatifolia*) cv. Chiang Mai Pink. Trends Hortic. Res. (In Press).

Feng, X., A. Apelbaum, E.C. Sisler and R. Goren, 2000. Control of ethylene responses in avocado fruit with 1-methylcyclopropene. Postharvest Biol. Technol., 20: 143-150.

Harima, S., R. Nakano, S. Yamauchi, Y. Kitano, Y. Yamamoto, A. Inaba and Y. Kubo, 2003. Extending shelf-life of astringent persimmon (*Diospyros kaki* Thunb.) fruit by 1-MCP. Postharvest Biol. Technol., 29: 319-324.

Hershkovitz, V., S.I. Saguy and E. Pesis, 2005. Postharvest application of 1-MCP to improve the quality of various avocado cultivars. Postharvest Biol. Technol., 37: 252-264.

Honghem, S., V. Bunyakitjinda, A. Uthairatanakij and K. Obsuwan, 2007. Effect of 1-MCP on displayed life of orchid hybrid mokara jairak gold inflorescence. Agric. Sci. J., 38: 70-73.

Jiang, Y.M., 2000. Role of anthocyanins, polyphenol oxidase and phenols in lychee pericarp browning. J. Sci. Food Agric., 80: 305-310.

Jiang, W.B., Q. Sheng, X.J. Zhou, M.J. Zhang and X.J. Liu, 2002. Regulation of detached coriander leaf senescence by 1-methylcyclopropene and ethylene. Postharvest Biol. Technol., 26: 339-345.

Kim, H.J., R. Craig and K.M. Brown, 2007. Ethylene resistance of regal pelargonium is complemented but not replaced by 1-MCP. Postharvest Biol. Technol., 45: 66-72.

Macnish, A.J., D.H. Simons, D.C. Joyce, J.D. Faragher and P.J. Hofman, 2000. Response of native Australian cut flowers to treatment with 1-methylcyclopropane and ethylene. HortSci., 35: 254-255.

Nakano, R., E. Ogura, Y. Kubo and A. Inaba, 2003. Ethylene biosynthesis in detached young persimmon fruit is initiated in calyx and modulated by water loss from the fruit. Plant Physiol., 131: 276-286.

Oren-Shamir, M., 2009. Does anthocyanin degradation play a significant role in determining pigment concentration in plants? Plant Sci., 177: 310-316.

Phipps, N., 2009. Information about Curcuma flower. http://www.plantingflowerbulbs.com/curcuma-flower.htm.

Porat, R., B. Weiss, L. Cohen, A. Daus, R. Goren and S. Droby, 1999. Effects of ethylene and 1-methylcyclopropene on the postharvest qualities of Shamouti oranges. Postharvest Biol. Technol., 15: 155-163.

Ranganna, S., 1997. Plant Pigments. In: Manual of Analysis of Fruit and Vegetable Products. Ranganna, S. (Ed.). TaTa McGraw-Hill Publishing Co., Ltd., New Delhi.

SPSS, 1999. Base 9.0 for Windows Users Guide. SPSS Inc., USA.

Serek, M., E.C. Sisler and M.S. Reid, 1995a. Effects of 1-MCP on the vase life and ethylene response of cut flowers. Plant Growth Regul., 16: 93-97.

Serek, M., G. Tamari, E.C. Sisler and A. Borochov, 1995b. Inhibition of ethylene-induced cellular senescence symptoms by 1-methylcyclo propene a new inhibitor of ethylene action. Physiol. Plant., 94: 229-232.

Serek, M., E.J. Woltering, E.C. Sisler, S. Frello and S. Sriskandarajah, 2006. Controlling ethylene responses in flowers at the receptor level. Biotechnol. Adv., 24: 368-381.

Sisler, E.C. and M. Serek, 1997. Inhibitors of ethylene responses in plants at the receptor level: Recent developments. Physiol. Plant, 100: 577-582.

Thai Horticulture, 2009. Flowers and ornamental plants. http://www.doae.go.th/library/html/thaihort/curcuma.htm.

Tian, S.P., B.Q. Li and Y. Xu, 2005. Effects of O_2 and CO_2 concentrations on physiology and quality of litchi fruit in storage. Food Chem., 91: 659-663.

Top Tropicals Plant Catalog, 2009. *Curcuma* sp. http://toptropicals.com/catalog/uid/CURCUMA_sp.htm.

Tropical Nurseries, 2009. Curcuma laddawan. http://www.tropicalnurseries.com/cur_la.html.

Underhill, S. and C. Critchley, 1994. Anthocyanin decolorization and its role in lychee pericarp browning. Aust. J. Exp. Agric., 34: 115-122.

Wu, C., X. Du, L. Wang, W. Wang, Q. Zhou and X. Tian, 2009. Effect of 1-methylcyclopropene on postharvest quality of Chinese chive scapes. Postharvest Biol. Technol., 51: 431-433.

Yuan, G., B. Sun, J. Yuan and Q. Wang, 2010. Effect of 1-methylcyclopropene on shelf life, visual quality, antioxidant enzymes and health-promoting compounds in broccoli florets. Food Chem., 118: 774-781.