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Postharvest Quality, Vase Life and Photosynthetic Yield (Chlorophyll Fluorescence) of Bougainvillea Flower by Applying Ethanol

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Abstract: The experiment was carried out to investigate the effect of different concentrations of ethanol (ET) on vase life and delay senescence of bougainvillea flower. The treatments were water control, 2%, 4%, 8%, 10%, 20%, 30%, 40%, 50% and 70% ET. Dry weight was higher in lower concentration of ethanol and lower in higher concentration. Flower longevity was 2 days more in 8% and 10% ethanol than water control and other concentrations of ethanol. Petal wilting and senescence were occurred 2 days later in 8% and 10% ET than in water control. Percent petal's color changed was later in water 8% and 10% than in control, 2%, 4%, 20%, 30%, 40%, 50% and 70% ET. Chlorophyll fluorescence intensity (photosynthetic yield) followed by time (ms) at different ethanol concentrations was higher in 4, 8 and 10% ET than in water control and other concentrations. Fo (lower fluorescence) was lower in 8 and 10% ET than in water and other concentrations. However, Fm and Fv [(higher fluorescence and relative variable fluorescence (Fm – Fo)] were higher in 4, 8 and 10% ET than in other ET concentrations. Fv/Fm (quantum yield or photosynthetic yield) was higher in 8 and 10% ET than in other ET concentrations. The result showed flower vase life was significantly affected by ethanol concentrations and longevity was higher in 8% and 10% ethanol than in water control and other concentrations.

Key words: bougainvillea flower, longevity, senescence, fluorescence, Fm/Fv

INTRODUCTION

Bougainvilleas are popular ornamental plants and used as official flowers in most areas with warm climates, including Australia, India, Malaysia, the Mediterranean region, Mexico, South Africa, Taiwan, and the United States in Arizona, California, Florida, Hawaii, and southern Texas. Bougainvillea is used to decorate fences and arbors with explosions of color in the house corridor, office and play ground. A bougainvillea tree can make guarding the entry or framing a window. Bougainvillea is a great vine for large containers to decorate hot patios and plazas. Bougainvillea is also used to create beautiful flowering bonsai specimens. Bougainvillea flower are dropped having a short vase life. Cameron *et al* (1981) reported that bougainvillea bracteoles were attractive at the end of 6-day observation period and dropped 32.2% treated with STS (0.5 oz/Gallon) while, 100% was dropped in control tree.

In normal senescing, cut carnation flowers show irreversible wilting of the petals. (Nichols, 1968; Cook and Van Staden (1983 and 1986). Pun *et al* (1999) reported that ethanol (4 and 6%) increased the vase life of' carnation flowers and cultivars showed variable response to ethanol treatment with regards to vase life increment. They also mentioned that treatment with 4% ethanol inhibited ethylene production as well as sensitivity to ethylene and responsive to ethanol. Longevity of vase life was an important factor in consumer preference and considerable research has been carried out on the causes of carnation senescence (Reidetal. 1980; Reid *et al.* 1983; Cook *et al.* 1985; Menguc & Usta 1994). Senescence of cut flowers was induced by several factors, e.g., water stress (Sankat & Mujaffar 1994), carbohydrate depletion (Ketsa 1989), micro-organisms (Witte & Van Doom 1991), and ethylene effects (Wu *et al.* 1991). Ethanol has been found to be effective in increasing the vase life of carnation flowers by inhibiting ethylene biosynthesis (Heins & Blakely 1980; Wu *et al.* 1992) as well as its action (Wu et al. 1992). The concentration of ethanol effective in increasing vase life of carnation flowers ranges from 2% to 8% (Heins & Blakely 1980; Wu *et al.* 1992). This variation in response could be due to differences in cultivar sensitivity to ethylene (Serrano *et al.* 1991; Mayak & Triosh 1993) or differences in age of the flowers used (Wu *et al.* 1992) or 5 (Heins 1980).

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Podd and Staden (2004) stated that ethanol, when applied as low concentration holding solutions both extend the vase life of cut carnation flowers. They also mentioned that low concentration of either ethanol or acetaldehyde apparently decreased the formation of ethylene by inhibiting the action of ACC synthase.

Treatment of cut carnation flowers with low concentrations of ethanol increases their vase life significantly (Heins 1980; Wu *et al.* 1992; Podd and Staden 1998). Podd and Staden (2004) stated that carnation flower senescense was delayed by ethanol.

Literatures are not yet available on this research project. That is why our interest has grown to develop vase life of bougainvillea flower. The aims of this project are to develop Bougainvillea flower quality (color development, longevity, expansions and delay senescence) newly by applying different ethanol concentrations and to improve the use of ornamental plant in the social and occasional functions.

MATERIALS AND METHODS

***Site*:**
The experimental site was University of Malaya campus, Kuala Lumpur, Malaysia.

Plant Material:

Four-year-old Bougainvillea trees were used in this experiment for collecting flower samples. Bougainvillea flowers (purple) were collected from nursery, University of Malaya campus. The tree was 1.2 m of height and canopy length was 2.0 m. The tree consisted of 6 branches. Flowers were harvested from each branch randomly. Weeding, irrigation and pesticide were done as needed.

Flower Harvesting and Measurement:

Flower was harvested on 18th January, 2007. Flowers were weighed initially immediately after harvest and used for setting treatments.

Treatment Setting:

Treatments were set following completely blocked design. Each treatment was repeated by 4 replications. Total 40 flowers of 7 branches were collected for 10 treatments. The treatments were water control, 2% ethanol (ET), 4% ET, 8% ET, 10% ET, 20% ET, 30% ET, 40% ET, 50% ET and 70% ET. Flower stems (petiole) were placed individually in an opening solution containing different concentrations of ethanol immediately after cutting and were placed at 28 ^{0}C of room temperature.

Vase Life, Petal Wilting, Petal Discoloration (Color Changed) and Senescence Evaluation:

Vase life was observed by counting day. Flower status was observed everyday. Petal wilting was investigated. Percent petal wilting was calculated by observing the total petal area divided by wilted petal area multiplying by100. Color changing (petal discolor) was determined by visual observation. After wilting phase, petal senescence was evaluated by observing petal abscission symptom.

Fresh and Dry Weight Measurement:

Fresh weight was measured immediately after harvest on 18th January, 2007. Dry weight was measured after all flowers were abscised.

Chlorophyll Content Measurement:

Chlorophyll content was measured by Chlorophyll meter SPAD-502, Minolta Co. Japan which represented by SPAD value. The petal was inserted into the meter and measured SPAD value 5 times from different spot of a single petal.

Chlorophyll Fluorescence Yield Measurement:

Chlorophyll fluorescence yield were measured by Hansatech Plant Efficiency Analyser. Petal was attached to the leafclip and kept for 30 minutes to maintain dark adaptation. Afterward, the leafclip was oriented with the side containing shutter plate. When light shine was applied on to the petal, the fluorescence signal was continued for 3 second and observed fluorescence yield or photosynthetic yield. It was represented by Fo, Fm, Fv and Fv/Fm (Photosynthetic yield). Where, Fo = Lower fluorescence, Fm = Higher fluorescence, Fv = Relative variable fluorescence (Fm - Fo). Temperature = 28 ^{0}C. Time range = 10µs-3 sec.

Petal drop (abscission) measurement:

Flowers were forced with air using fan. The flowers were kept in front of the table fan for 5 min. The petal was dropped by air force and petal drop percent was calculated.

Design of Experiment:

The experimental design was Randomized completely block design (RCBD). There were 4 replications and a total of 40 flowers used in the experiment. Mean seperations were done by Duncan`s multiple range test (DMRT).

RESULTS AND DISCUSSIONS

Wilting occurrence was shown on 6 DAT in water control, while it was shown in 8 DAT for 8 and 10% ET treated flower (Fig. 1). The wilting was started from 1 DAT for 70% ET, 2 DAT for 50 and 40 % ET, 3 DAT for 30 % ET, 4 DAT for 20 % ET, 6 DAT for 4, 2 % ET and water (control), 8 DAT for 8 and 10 % ET treated trees (Fig 1). In case of water control 100% wilting was done in 8 DAT, while it was found in 10 DAT for 8 and 10% ET treated flower. Percent petal senescence was earlier in water control, 2, 4% ET than in 8 and 10% ET (Fig. 2). The petal senescence range was 2-12 days in different concentrations of ethanol.

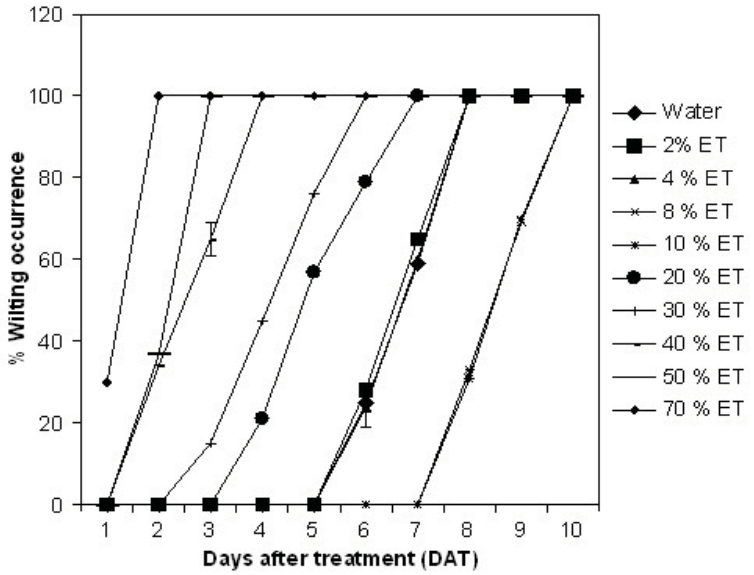

Fig. 1: Wilting occurrence followed by days after treatment at different ethanol concentrations. Bars represent SE (n=4).

The senescence order was 70< 50 < 30 < 20 <water control<8 and 10%. Percent petal discoloration was earlier in water, 2, 4 20, 30, 40, 50 and 70% ET than in 8 and 10% ET respectively (Fig. 3). The similar increasing trend (day) was found in case of all ET treated flowers. Petal discoloration was started in 4 DAT for water control and completed (100%) in 12 DAT. However, it was started in 6 DAT and completed (100%) in 12 DAT for 8 and 10% ET treated flowers.

Chlorophyll fluorescence intensity (yield) followed by time (ms) was different at different ethanol concentrations (Fig. 4). Chlorophyll fluorescence intensity was found fluctuated trend in case of all treatments. Fluorescence was higher in 8 and 10% ET than in other treatments. Fo = Lower fluorescence, Fm = Higher fluorescence, Fp = Intermediate fluorescence were higher in 8 and 10% ET than in other concentrations followed by time ranging from 0.01 – 1 ms. Fm and Fv = Relative variable fluorescence (Fm - Fo) were higher in water control, 2, 4, 8 and 10% ET than in other treatments followed by time ranging from 2 ms – 3 sec. (Fig. 5). Among these treatments, Fm and Fv were higher in 8 and 10% ET than in water control, 2 and 4% ET. . Optimum quantum yield [(Photosynthetic yield (Fv/Fm)] was higher in 8 and 10% ET than in other concentrations (Fig. 6).

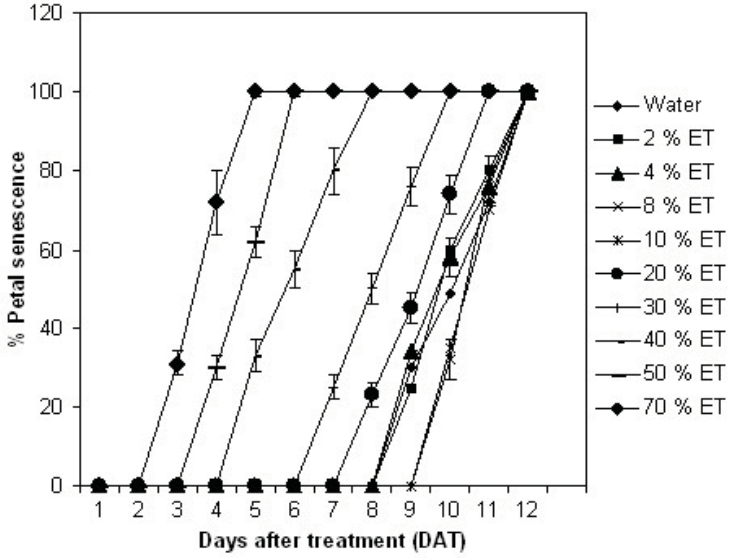

Fig. 2: Petal senescence followed by days after treatment at different ethanol concentrations. Bars represent SE (n=4).

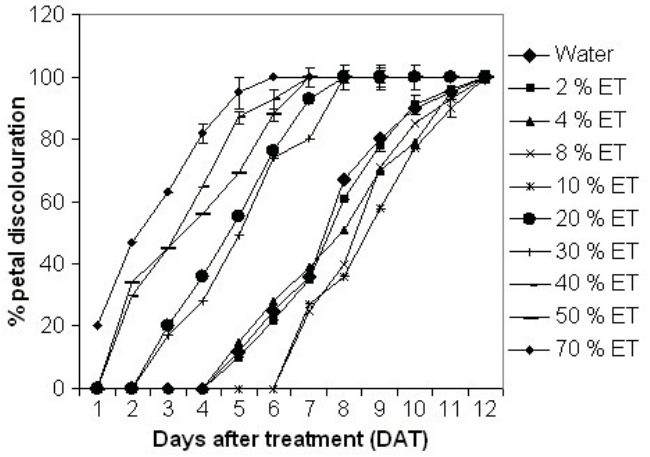

Fig. 3: Petal discolouration followed by days after treatment at different ethanol concentrations. Bars represent SE (n=4).

Vase life was 2 days more in 8 and 10% ET than in water control, 2 and 4% ET treated flowers (Table 1). The vase life was gradually decreasing as 7, 5, 3, 2, 1 and <1 day following the order of 8and 10>water control, 2 and 4 > 20 > 30 > 40 and 50> 70% ET. Fresh weight (before wilting) was measured and there was not significantly difference among all treatments (Table1). Dry weight was measured after abscission. Dry weight significantly reduced in case of all treatment but more significantly reduced at 30, 40, 50 and 70% ET treated flower. Fresh and dry weight ratio was lower at higher at 2, 4, 8 and 10% ET than water control, 20, 30, 40, 50 and 70% ET (Table 1). Petal was shed 33% at 8 and 10% ET, 66% at water control, 2, 4, 20 and 30% ET and 100% at 40, 50 and 70% ET.

Initially chlorophyll (carotine) content (SPAD value) was higher at water control 8, 10, 50, 70 than 2, 4 20, 30 and 40% ET. However, finally it was higher in 8 and 10% ET other than all treatments. Fig. 7 shows the different flower structures and color changing after treatment application at different stages.

Table 1: Postharvest parameters of Bougainvilla sp. flower as affected by different concentrations of ethanol.

Treatments	Fresh weight (g) (Initial)	Dry weight (g) after senescence (Final) g	Ratio (FW/DW)	Vase life (longevity) [Day]	Petal (abscission) shedding (%)	Chlorophyll (carotene) content (SPAD value)	
						Initial	Final
Water	0.66±0.10a	0.359±0.05b	1.83±0.20a	5.1±0.31c	66±5.7b	3.8±0.5a	0.4±0.02b
2 % Ethanol	0.72±0.11a	0.447±0.06c	1.61±0.11a	5.3±0.35c	66± 5.7b	3.7±0.4a	0.4±0.02b
4 % Ethanol	0.56±0.09a	0.311±0.05b	1.80±0.13a	5.2±0.34c	66±5.7b	3.6±0.4a	0.3±0.01a
8 % Ethanol	0.65±0.08a	0.374±0.06c	1.73±0.12a	7.2±0.45d	33±3.3a	3.8±0.3a	0.6±0.03b
10 % Ethanol	0.61±0.12a	0.403±0.05c	1.51±0.15a	7.3±0.38d	33±3.3a	3.8±0.3a	0.7±0.03b
20 % Ethanol	0.52±0.07a	0.315±0.04b	1.65±0.16a	3.0±0.27b	66± 00b	3.6±0.4a	0.3 ±0.01a
30 % Ethanol	0.70±0.11a	0.300±0.04b	2.33±0.23b	2.0±0.25b	66± 00b	3.7±0.5a	0.2±0.01a
40 % Ethanol	0.68±0.10a	0.191±0.03a	3.56±0.28c	1.1±0.12a	100±00c	3.5±0.4a	0.2±0.01a
50 % Ethanol	0.53±0.08a	0.126±0.03a	4.20±0.37c	1.0±0.05a	100±00c	3.8±0.5a	0.1±0. 005a
70 % Ethanol	0.62±0.09a	0.087±0.02a	7.12±0.51d	<1.0±0.05a	100±00c	3.8±0.5a	0.1±0.005a

Mean±SE (n =4). FW: Fresh weight, DW: Dry weight, Means followed by the common letters in column are not significantly different at the 5% level by Duncan`s multiple range test (DMRT).

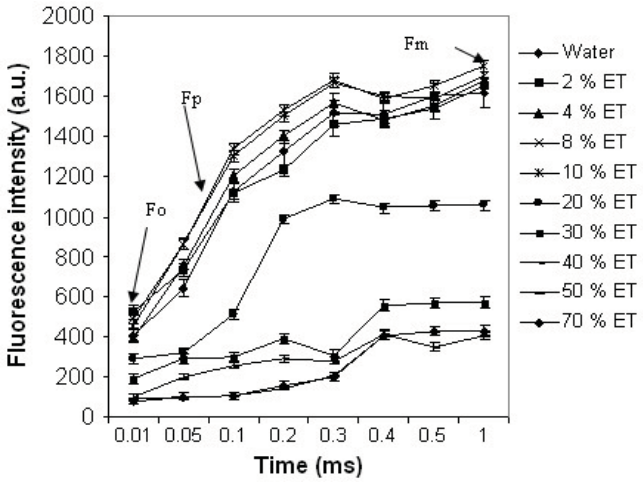

Fig. 4: Chlorophyll fluorescence intensity (yield) followed by time (ms) at different ethanol concentrations. Fo = Lower fluorescence, Fm = Higher fluorescence, Fp = Intermediate fluorescence. Temperature = 28 0C. Bars represent SE (n=4).

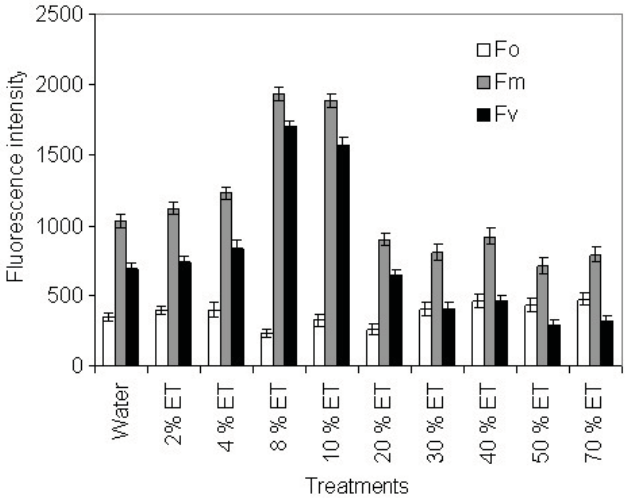

Fig. 5: Chlorophyll (carotene) fluorescence (yield) followed by days after treatment at different ethanol concentrations. Fo = Lower fluorescence, Fm = Higher fluorescence, Fv = Relative variable fluorescence (Fm - Fo). Temperature = 28 0C. Bars represent SE (n=4). Time range: 2ms-3 sec.

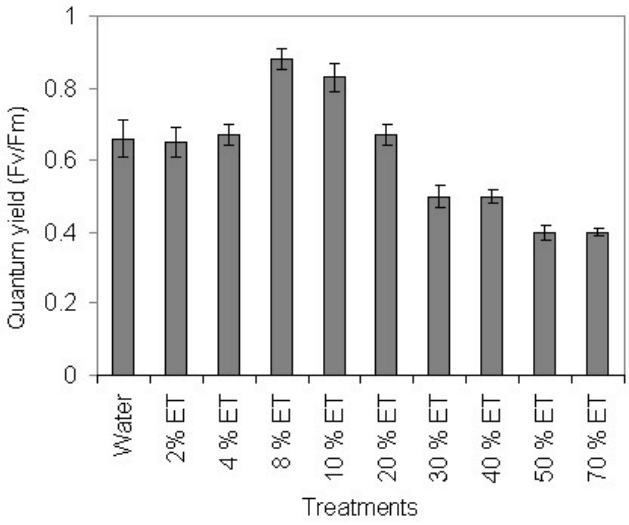

Fig. 6: Photosynthetic yield (Optimum quantum yield, Fv/Fm) followed by days after treatment at different ethanol concentrations. Fo = Lower fluorescence, Fm = Higher fluorescence, Fv = Relative variable fluorescence (Fm - Fo). Temperature = 28 0C. Bars represent SE (n=4).

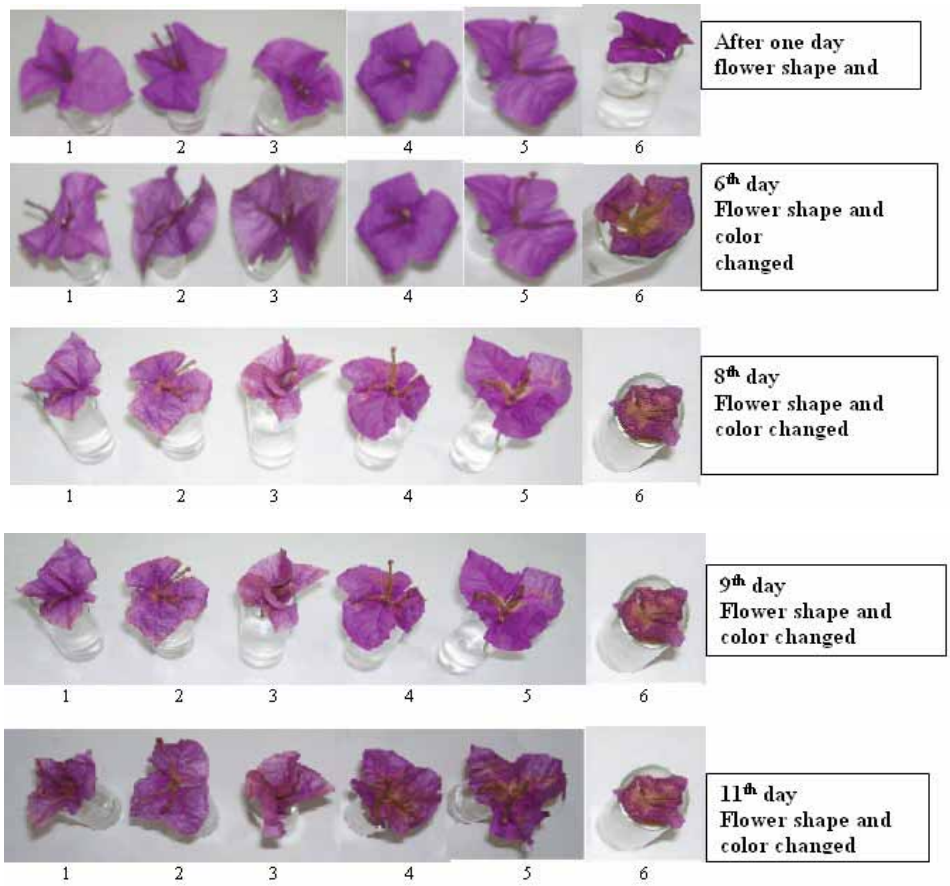

Fig. 7: Photo shows the petal and perianth wilting and abscission (shape and color) after treatment.1: Water control, 2: 2%ethanol, 3: 4% ethanol, 4: 8% ethanol, 5: 10% ethanol, 6: 70% ethanol

The results show that ethanol is effective as ethylene inhibiting component in bougainvillea flower. It was found that the more effective was 8 and 10% ethanol. Results indicate that sensitivity to ethylene develops several days after flower opening such that ethanol only has a limited ability to delay vase life as well as petal abscission. It was reported that ethylene was the major coordinator of senescence in many flowers (Nickols, 1968). Podd and Staden (2004) stated that ethanol, when applied as low concentration holding solutions both extend the vase life of cut carnation flowers. They also mentioned that low concentration of ethanol apparently decreased the formation of ethylene by inhibiting the action of ACC synthase.

Ethanol has been found to be effective in increasing. The vase life of carnation flowers has been increased using ethanol by inhibiting ethylene biosynthesis (Heins & Blakely 1980; Wu *et al.* 1992) as well as its action (Wu *et al.* 1992).

In our results, we found more effective in case of 8 and 10% ET. Similar results to us were found by some researchers. The concentration of ethanol was effective in increasing vase life of carnation flowers ranges from 2% (Heins & Blakely 1980) to 8% (Wu *et al.* 1992) for the different cultivars. This variation in response could be due to differences in cultivar sensitivity to ethylene (Serrano *et al.* 1991; Mayak & Triosh 1993). Treatment of cut carnation flowers with low concentrations of ethanol increased their vase life significantly (Heins 1980; Wu *et al.* 1992; Podd and Staden 1998). Quantum yield (Fv/Fm) was higher in 8 and 10% ET than in other concentrations. It is meant the stress or effect of 8 and 10% ET is less on bougainvillea flower. That is why it is effective for flower longevity.

Conclusion:

This study has shown that it is possible to extend vase life of bougainvillea sp.using 8% and 10% ethanol by causing delay senescence. Low concentration of ethanol decreased the formation of ethylene by inhibiting the action of ACC synthase as a result over all flowers (wilting, abscission, scar and color changing) were affected physiologically.

Though literatures were found regarding concentrations of ethanol (2-8%) were effective in extending vase life of cut carnation flowers. However, in this experiment our result is highlighted the similar effect in bougainvillea flower.

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