Effects of Anti-Ethylene Treatments on Quality and Longevity of Cut Leaves of *Caryota urens* and *Miscanthus sinensis* 'Variegatus'

W.D.K.N. FERNANDO and W.M.E.P. WICKRAMASINGHE.

Department of Horticulture and Landscape Gardening, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), Sri Lanka.

ABSTRACT

Cut foliage being viable and actively metabolizing parts of plants is subject to rapid ageing process. In order to meet the requirements of cut foliage export market, a reliable and economical solution is required to minimize the rate of aging. It is necessary to prolong the longevity while maintaining important quality parameters. Specific anti-ethylene compounds are widely used to slow down the ageing process of floricultural products. In the present study, some anti-ethylene compounds were used to maintain the quality and to extend the longevity of *Caryota urens* and *Miscanthus sinensis* 'Variegatus' cut leaves. Distilled Water and anti-ethylene treatments such as $2mgl^{-1}$ potassium permanganate ($KMnO_4$), $4mgl^{-1}$ $KMnO_4$, 2% ethanol, 4% ethanol, $1000mgl^{-1}$ Silver nitrate ($AgNO_3$) and Silver thiosulphate (STS) were used as treatments.

The best overall leaf quality and highest longevity was recorded in cut leaves of *Caryota urens* when the cut surface was immersed in a solution of $2mgl^{-1}$ $KMnO_4$ continuously. A considerable improvement in maintaining overall leaf quality and enhancing longevity was recorded by the continuous dip of $4mgl^{-1}$ $KMnO_4$ and 40 minutes dip of STS while the cut leaves dipped in $2mgl^{-1}$ $KMnO_4$ for 1 hour, $2mgl^{-1}$ $KMnO_4$ for 6 hours, STS for 20 minutes and STS for 1hour did not show any significant impact. Cut leaves treated with $4mgl^{-1}$ $KMnO_4$ for 1 hour showed the lowest performance. Overall quality and longevity of *Miscanthus sinensis* 'Variegatus' were not improved significantly by the treatments given in this experiment compared to the control. It provides some evidence to state that, *M. sinensis.* is a less ethylene sensitive species having a higher potential to use it as cut leaves. However, dipping cut leaves in $2mgl^{-1}$ $KMnO_4$ continuously could be selected as a feasible treatment to maintain the overall quality with extended longevity of *Caryota urens* and *Miscanthus sinensis* 'Variegatus' along with its cost effectiveness.

KEYWORDS: Anti-ethylene treatments, *Caryota urens*, Ethanol, Longevity, *Miscanthus sinensis* 'Variegatus', $KMnO_4$, $AgNO_3$, STS, Vase-life

INTRODUCTION

The floriculture industry is a relatively new venture in Sri Lanka. It mainly consists of flowers and foliage mostly grown in the Western, Northwestern and Central Provinces. Sri Lanka has one of the world richest collections of flora with excellent climatic condition and favorable geographical position for its extensive exploitation. The commercial exportation began in 1979/1980 with the establishment of a few exports oriented ornamental plant nurseries. Flowers, flowering plants, foliage plants and cut foliage are the major products which are produced and exported to variety of markets in Europe, Far-East and the Middle East (Mubarak, 2002).

Cut leaves are one of the most important foliage plant products exemplifies higher level of postharvest losses mainly due to its perishable nature. Cut leaves are metabolically active and they encompass all metabolic processes under restricted supply of water and food materials resulting quick senescence. The key to the longest vase life (postharvest longevity) of cut flowers is the provision of sufficient sugars/carbohydrates and water by the maintenance of optimum preharvest, harvesting and postharvest conditions while minimizing stress (Perry, 2002). One of the major reasons behind the short shelf life and poor quality of cut leaves under optimum conditions is ethylene accumulation which enhances the senescence (Blessington, 2004). It is estimated that 30-40 percent of cut flower and plant inventory die prematurely due to the direct impacts of ethylene induced disorders. Typical wilting of petals, drying out buds, yellowing flowers and leaves and premature flower opening are some of the major symptoms of ethylene damage in cut flowers. Ethylene induces abscission of the leaves and petals and distorts the plant by causing malformed leaves and flowers (Bledsoe *et al.*, 2005). Extended postharvest life of cut foliage would increase its use, availability and potential of long distance transportation. Although studies on lengthening of vase life of cut flowers are abundant (Yapa *et al.*, 2000), only few studies have been carried out on cut leaves which have a huge export potential. Hormonal and chemical preharvest treatments and postharvest treatments such as cold storage and chemical treatments have a significant influence on postharvest quality, maturing and storability of cut leaves. However it requires an effective and low cost method to maintain the quality and increase the longevity of cut leaves.

The purpose of this study was to examine the benefits of some anti-ethylene treatments to lengthen the longevity and preserving the quality of two demanded cut foliage viz. *Caryota urens* and *Miscanthus sinensis* 'Variegatus' in order to acquire the maximum utility.

MATERIALS AND METHODS

This study was carried out at the Horticulture Laboratory of the Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura. The temperature and relative humidity during the experiment were recorded.

Healthy, uniform export quality cut leaves of *Caryota urens*, *Miscanthus sinensis* 'Variegatus' (Green) and *Miscanthus sinensis* 'Variegatus'(White)

were selected under the supervision of the Quality Controller of Asian Cuttings (Pvt.) Ltd. at Katana. Cut ends of collected leaves were immersed in water during transportation. Cut leaves were brought to the laboratory within 45 minutes and kept at rest for 1 hour. The leaves were cleaned using distilled water to remove debris and re-cut under water in order to get the same petiole length. Stock solutions of the chemicals required for different treatments were prepared using distilled water in advance. Silver thiosulphate (STS) and ethanol were prepared just before the commencement of the experiment. Disinfected and dried empty jam jars were used to treat the cut leaves with different solutions. All the containers were covered with black sheets from the beginning of the experiment. The experiment was repeated twice in two different periods.

The leaves dipped in distilled water as the control (T1), in $2mgl^{-1}$ $KMnO_4$ solution for 1 hour and transferred into distilled water (T2), continuously in $2mgl^{-1}$ $KMnO_4$ (T3), in $2mgl^{-1}$ $KMnO_4$ solution for 6 hours and transferred into distilled water (T4), in $4mgl^{-1}$ $KMnO_4$ solution for 1 hour and transferred into distilled water (T5), continuously in $4mgl^{-1}$ $KMnO_4$ solution (T6), in 2% (v/v) ethanol solution for 10 minutes and transferred into distilled water (T7), in 4% (v/v) ethanol solution for 10 minutes and transferred into distilled water (T8), in $1000mgl^{-1}$ $AgNO_3$ solution for 10 minutes and transferred into distilled water (T9), in silver thiosulfate (STS) solution, which was prepared by dissolving 0.1358g $AgNO_3$ and 0.924g $Na_2S_2O_3$ XH_2O into 500ml distilled water separately and pouring $AgNO_3$ slowly into $Na_2S_2O_3$ XH_2O solution while stirring (Yapa *et al.*, 2000), for 20 minutes and transferred into distilled water (T10), in the STS solution for 20 minutes and transferred into distilled water (T11) and in the STS solution for 1 hour and transferred into distilled water (T12) as treatments.

Distilled water in containers was replaced in 3 day intervals. Treatments were arranged in a complete randomized design with five replicates per treatment. Five leaves were kept in a container having 200ml of solution as a replicate. The quality of the cut leaves were evaluated daily by a panel of four members. Parameters used to evaluate the quality of C. *urens* cut leaves were leaf colour, degree of glossiness, petiole conditions and over all appearance of leaves and *M. sinensis'* Variegatus' cut leaves were leaf colour, degree of glossiness and overall appearance of leaves.

The self determined making scheme used to asses the leaf quality and longevity of *C. urens* included original colour /green (4), light green (3), slightly yellowing (2), moderately yellowing (1) and server yellowing (0) for leaf colour; high glossiness – fresh (3), slight loss of glossiness (2), severe loss of glossiness (1) and wilted (0) for degree of glossiness; good stability and strength in petiole (4), slightly bending (3), moderate bending (2), severely bending (1) and all rot (0) for petiole condition and very good (3), moderately good (2), slightly good (1) and poor (0) for over all appearance of laves. The self determined marking scheme used to asses the leaf quality and longevity of *M. sinensis* included original colour /green (4), light green (3), slightly yellowing (2), moderately yellowing (1) and server yellowing (0) for leaf colour; high glossiness (3), slightly loss of glossiness (2), severe loss of glossiness (1) and wilted (0) for degree of glossiness and very good (3), moderately good (2), slightly good (1) and poor (0) for over all appearance of laves.

During the experimental period petiole condition of *C. urens* was not changed; even leaves were wilted. Hence, quality and longevity assessments of *C. urens* petiole condition were not considered. Time taken (days) to reduce the original colour of *C. urens* and *M. sinensis* 'Variegatus' cut leaves was accessed by using RHS (Royal Horticultural Society) colour chart (Anon, 2001). Longevity was estimated by the time taken (days) to reduce the percentage number of leaves of the grade of very good over all leaf appearance from the initial percentage of 100 to 60. The total visual quality was estimated by the time taken (days) to reduce mean aggregate value of the three quality parameters (leaf colour, degree of glossiness and over all appearance of leaves) from initial figure of 10 to 7 for *C. urens* and *M. sinensis*.

Vase life of cut leaves of *C. urens* and *M. sinensis* according to the colour of leaf was determined by the number of day taken to reduce points given by the evaluators from 4 to 3. The vase life according to the glossiness of leaf was determined by the number of days taken to reduce points from 3 to 2. Over all appearance of the leaf was determined as the number of days taken to reduce points from 3 to 2. The data were statistically analyzed by means of categorical data analytic techniques using Statistical Analysis System (SAS, 1991).

RESULTS

The average temperature and relative humidity during the experiment were 34°C and 66.37% respectively. Since the environmental conditions of two experimental periods were not significantly different, the data of two trials were averaged and used for the analysis. Early browning of petiole of *C. urens* and base of the *M. sinensis* cut surfaces was observed after two days of treatment when the cut leaves were treated with $1000mgl^{-1}$ $AgNO_3$.

Longevity assessment

The highest longevity (16 days) of *C. urens* cut leaves were observed in T3, T6 and T11 while the lowest longevity (7 days) was recorded when the leaves were treated with $4mgl^{-1}$ $KMnO_4$ for 1 hour (T5). The second highest longevity (15 days) was recorded in T2, T10 and T12 while the second lowest longevity (9 days) was recorded in T7 where 2% ethanol was used for 10 minutes (Figure 1a).

The highest longevity (18 days) of *M. sinensis* cut leaves were recorded in T3, T6 and T11 while lowest longevity (14 days) was observed in T7 where 2% ethanol was used for 10 minutes and T9 where $1000mgl^{-1}$ $AgNO_3$ was used for 10 minuets. The second highest longevity (17 days) was recorded in T1, T10 and T12 while the second lowest longevity

(15 days) was recorded in T8 where 4% ethanol was used for 10 minutes and T5 where the $KMnO_4$ used for 1 hour. However, there is no significant difference in the longevity of cut leaves of *M. sinensis* under the given treatments (Figure 1b).

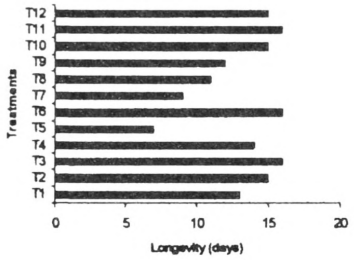

Figure 1a. Longevity of *C. urens*

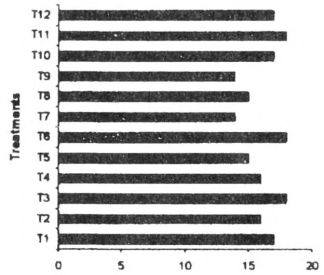

Figure 1b. Longevity of *M. sinensis*.

[Note: T1-control – distilled water, T2-2mgl^{-1} $KMnO_4$ dip for 1 hr, T3- 2mgl^{-1} $KMnO_4$ continuous dip, T4 - 2mgl^{-1} $KMnO_4$ dip for 6 hrs, T5 - 4mgl^{-1} $KMnO_4$ dip for 1 hr, T6 - 4mgl^{-1} $KMnO_4$ continuous dip, T7 – 2% ethanol for 10 min, T8 – 4% ethanol for 10 min, T9 – 1000mgl^{-1} $AgNO_3$ dip for 10 min, T10 – STS dip for 20 min, T11 – STS dip for 40 min and T12 – STS dip for 1 hr.]

Total visual quality

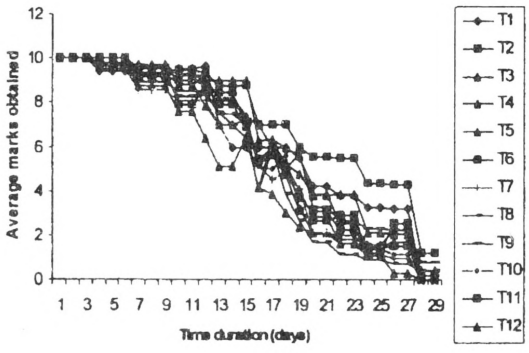

Figure 2a. Change of total visual quality of cut leaves of *C. urens* treated by different anti-ethylene compounds as expressed by the average marks given by the evaluators.

[Note: T1-control – distilled water, T2-2mgl^{-1} $KMnO_4$ dip for 1 hr, T3- 2mgl^{-1} $KMnO_4$ continuous dip, T4 - 2mgl^{-1} $KMnO_4$ dip for 6 hrs T5 - 4mgl^{-1} $KMnO_4$ dip for 1 hr, T6 - 4mgl^{-1} $KMnO_4$ continuous, T7 – 2% ethanol for 10 min, T8 – 4% ethanol for 10 min, T9 – 1000mgl^{-1} $AgNO_3$ dip for 10 min, T10 – STS dip for 20 min, T11 – STS dip for 40 min and T12 – STS dip for 1 hr.]

The total visual quality of the cut leaves treated with the various anti ethylene treatments were determined qualitatively and average marks obtained by each species for different treatments are given in Figure 2a and Figure 2b. The results clearly showed that the total visual quality of cut leaves treated with different anti-ethylene had been diminished during the period of study. Though there was no significant difference in total visual quality of cut leaves among the treatments until 6 days, it was significantly different after 13 days. Cut leaves of *C. urens* treated with T5, T9 and T8 were found to be ineffective enhancing the total visual quality compared to the control. A severe reduction of total visual quality was observed in T5 after 11 days of the treatment.

M. sinensis cut leaves did not show significant difference in total visual quality according to the treatment until 16 days though the difference was significant after 19 days. The cut leaves of treated with T7, T8 and T9 were found to be ineffective in enhancing the total visual quality compared to the control while all other treatments were effective until rejection. Cut leaves treated with T7, T8 and T9 showed severe reduction of total visual quality 16 days after the treatment compared to the control (T1). There was no significant difference in total visual quality in other treatments compared to the control (Figure 2b).

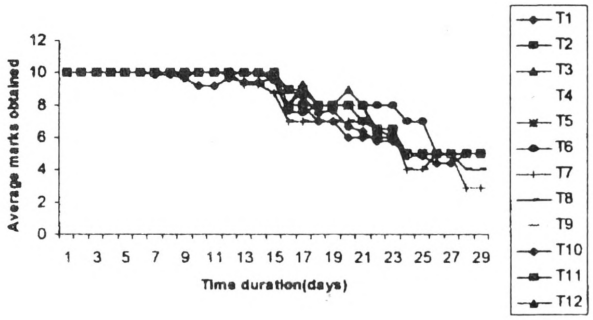

Figure 2b. Change of total visual quality of cut leaves of *M. sinensis* treated by different anti-ethylene compounds as expressed by the average marks given by the evaluators.

[Note: T1-control – distilled water, T2-2mgl^{-1} $KMnO_4$ dip for 1 hr, T3- 2mgl^{-1} $KMnO_4$ continuous dip, T4 - 2mgl^{-1} $KMnO_4$ dip for 6 hrs, T5 - 4mgl^{-1} $KMnO_4$ dip for 1 hr, T6 - 4mgl^{-1} $KMnO_4$ continuous dip, T7 – 2% ethanol for 10 min, T8 – 4% ethanol for 10 min, T9 – 1000mgl^{-1} $AgNO_3$ dip for 10 min, T10 – STS dip for 20 min, T11 – STS dip for 40 min and T12 – STS dip for 1 hr.]

Leaf colour assessment

Initial colour of the *C. urens* cut leaves was 136 B in Fan 3 of yellow green group according to the RHS colour chart. After several days it was changed to 136 C in Fan 3 of yellow green group. Time taken to change the colour varied according to the treatment. First change was observed (10 days) in T5 and T7 while other treatments were found to be effective in maintaining leaf colour for a longer period compared to the control. The longest time (20 days) taken to change the colour was observed in T3 where 2mgl^{-1} $KMnO_4$ was treated continuously. Among the STS treatments, T11 where STS was used for 40 minutes showed 17 days to change the original colour of *C. urens* according to the RHS colour chart (Figure 3a).

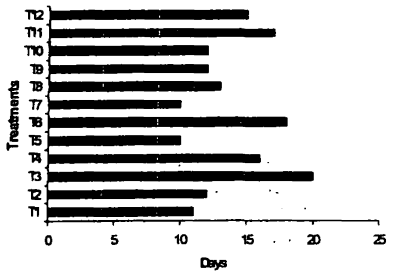

Figure 3a.Time taken to (days) change the colour of *C. urens* according to the RHS colour chart

[Note:T1-control – distilled water, T2-2mgl^{-1} $KMnO_4$ dip for 1 hr, T3- 2mgl^{-1} $KMnO_4$ continuous dip, T4 - 2mgl^{-1} $KMnO_4$ dip for 6 hrs, T5 - 4mgl^{-1} $KMnO_4$ dip for 1 hr, T6 - 4mgl^{-1} $KMnO_4$ continuous dip, T7 – 2% ethanol for 10 min, T8 – 4% ethanol for 10 min, T9 – 1000mgl^{-1} $AgNO_3$ dip for 10 min, T10 – STS dip for 20 min, T11 – STS dip for 40 min and T12 – STS dip for 1 hr.]

The initial colour of *M. sinensis* 'Varigatus' (Green) cut leaves was 136 B in Fan 3 of yellow green group and the initial colour of *Miscanthus sinensis* 'Varigatus' (White) cut leaves was 157 C in Fan 4 of green white group according to the RHS colour chart. After several days it was changed to 136 C in Fan 3 of yellow green group and 157 D in Fan 4 of green white group respectively. First colour change was observed after 13 days (for green colour) and 14 days (for white colour) in T7 while other treatments were able to maintain leaf colour effectively for a significantly higher period compared to the control. The longest time taken to change the colour was observed in T3 (22 days) where 2mgl^{-1} $KMnO_4$ was used continuously. Among the STS treatments, T11 where STS was used for 40 minutes showed 16 days (for green colour) and 21 days (for white colour) to change the original colour of *M. sinensis* (Figure 3b and Figure 3c).

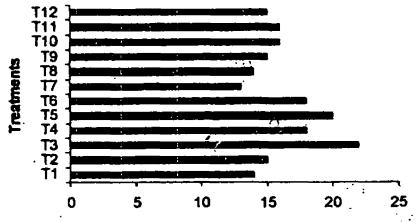

Figure 3b. Time taken to (days) change the colour of *M. sinensis* (Green colour) according to the RHS colour chart.

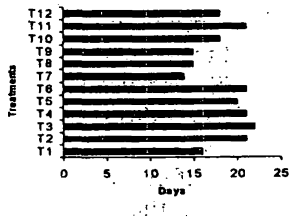

Figure 3c. Time taken to (days) change the colour of *M. sinensis* (White colour) according to the RHS colour chart

[Note:T1-control – distilled water, T2-2mgl^{-1} $KMnO_4$ dip for 1 hr, T3- 2mgl^{-1} $KMnO_4$ continuous dip, T4 - 2mgl^{-1} $KMnO_4$ dip for 6 hrs, T5 - 4mgl^{-1} $KMnO_4$ dip for 1 hr, T6 - 4mgl^{-1} $KMnO_4$ continuous dip, T7 – 2% ethanol for 10 min, T8 – 4% ethanol for 10 min, T9 – 1000mgl^{-1} $AgNO_3$ dip for 10 min, T10 – STS dip for 20 min, T11 – STS dip for 40 min and T12 – STS dip for 1 hr]

Vase- Life

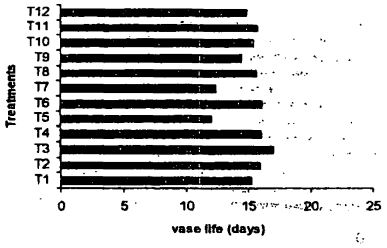

Figure 4a. Vase-life of *C. urens* cut leaves according to the leaf colour under different anti-ethylene treatments.

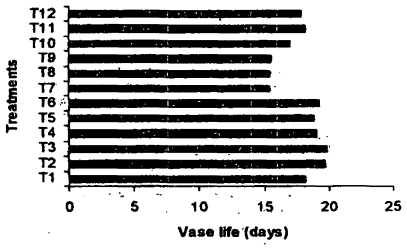

Figure 4b. Vase-life of *M. sinensis* cut leaves according to the leaf colour under different anti-ethylene treatments.

[Note:T1-control – distilled water, T2-2mgl^{-1} $KMnO_4$ dip for 1 hr, T3- 2mgl^{-1} $KMnO_4$ continuous dip, T4 - 2mgl^{-1} $KMnO_4$ dip for 6 hr, T5 - 4mgl^{-1} $KMnO_4$ dip for 1 hr, T6 - 4mgl^{-1} $KMnO_4$ continues dip, T7 – 2% ethanol for 10 min, T8 – 4% ethanol for 10 min, T9 – 1000mgl^{-1} $AgNO_3$ dip for 10 min, T10 – STS dip for 20 min, T11 – STS dip for 40 min and T12 – STS dip for 1 hr.]

Vase-life of *C. urens* in relation to the leaf colour is shown in Figure 4a. The lowest vase-life (12.10 days) was observed in T5 which was significantly ($p=0.0006$) lower than all other treatments including the control while second lowest vase life (12.40days) was recorded in T7 which was significantly ($p=0.0097$) lower compared to the control (T1) (15.20 days).

The highest and the second highest vase-lives in relation to the leaf colour, which were not significantly different ($p>0.05$), were recorded in T3 (16.90 days) and T6 (16.12 days) respectively and were significantly higher ($p>0.05$) than that of control (T1) (15.20 days). Among the STS treatments, T11 where STS was used for 40 minutes showed highest vase life (15.76 days) which was not significantly different ($p>0.05$) from the vase-life of the control.

The vase-life of *M. sinensis* cut leaves according to the leaf colour was not improved significantly ($p>0.05$) by the anti-ethylene treatments given in this experiment compared to 18.20 day vase-life of the control (Figure 4b). Longest vase life was

observed in T3 (19.80 days) and T2 (19.72 days) while T7 (15.40 days), T8 (15.44 days) and T9 (15.56 days) recorded comparatively lower vase-lives. Among the STS treatments T11 where STS was used for 40 minutes showed highest (18.12 days) vase life (Figure 4b).

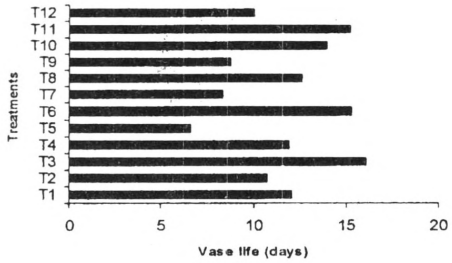

Figure 5a. Vase –life of *C. urens* cut leaves according to the degree of glossiness under different anti-ethylene treatments.

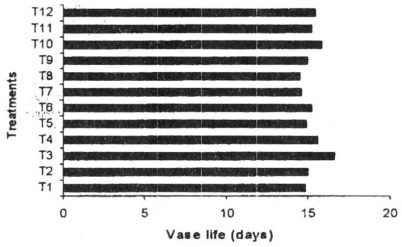

Figure 5b. Vase –life of *M. sinensis* cut leaves according to the degree of glossiness under different anti-ethylene treatments.

[Note:T1-control – distilled water, T2-2mgl^{-1} $KMnO_4$ dip for 1 hr, T3- 2mgl^{-1} $KMnO_4$ continuous dip, T4 - 2mgl^{-1} $KMnO_4$ dip for 6 hrs, T5 - 4mgl^{-1} $KMnO_4$ dip for 1 hr, T6 - 4mgl^{-1} $KMnO_4$ continuous dip, T7 – 2% ethanol for 10 min, T8 – 4% ethanol for 10 min, T9 – 1000mgl^{-1} $AgNO_3$ dip for 10 min, T10 – STS dip for 20 min, T11 – STS dip for 40 min, T12 – STS dip for 1 hr.]

The highest vase-life of cut leaves of *C. urens* according to the degree of glossiness was recorded in T3 (16.08 days) and was significantly (p=0.0001) higher than that of the control (12.04 days). T11 and T6 preserved the glossiness for 15.28 days and 15.20 days respectively while T5 (6.60 days) showed significantly (p=0.0001) poor performance in maintaining leaf glossiness compared to the control. Among the STS treatments, T11 where STS was used for 10 minutes showed highest vase-life in relation to the degree of leaf glossiness (Figure 5a).

The vase-life of *M. sinensis* cut leaves according to the degree of glossiness was not improved significantly by the anti-ethylene treatments used in this experiment compared to the control (14.08 days). The longest (16.60 days) vase life was observed in T3 while the lowest (14.60 days) was recorded in T7 (Figure 5b). Among the STS treatments, T11 where STS was used for 40 minutes showed (15.08 days) the highest vase-life according to the degree of leaf glossiness.

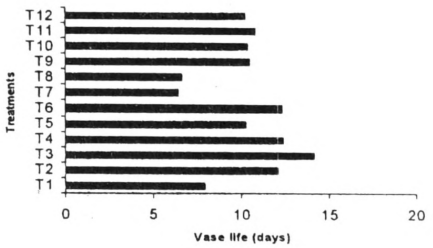

Figure 6a. Vase-life of *C. urens* according to the overall appearance of the leaves under different anti- ethylene treatments.

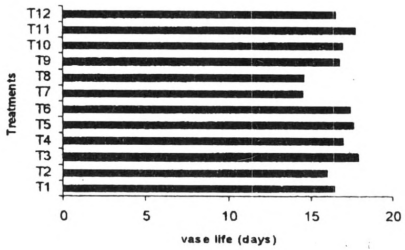

Figure 6b. Vase- life of *M. sinensis* according to the overall appearance of the leaves under different anti- ethylene treatments.

[Note:T1-control – distilled water, T2-2mgl^{-1} $KMnO_4$ dip for 1 hr, T3- 2mgl^{-1} $KMnO_4$ continuous dip, T4 - 2mgl^{-1} $KMnO_4$ dip for 6 hrs, T5 - 4mgl^{-1} $KMnO_4$ dip for 1 hr, T6 - 4mgl^{-1} $KMnO_4$ continuous dip, T7 – 2% ethanol for 10 min, T8 – 4% ethanol for 10 min, T9 – 1000mgl^{-1} $AgNO_3$ dip for 10 min, T10 – STS dip for 20 min, T11 – STS dip for 40 min and T12 – STS dip for 1 hr.]

Vase-life of *C. urens* determined by the overall appearance of cut leaves changed significantly (p<0.0001) due to the treatments as shown in figure 6a. T3 recorded a significantly (p<0.0001) higher vase-life of 14.16 days compared to T1 where the vase-life was 7.90 days. T3 cloud be selected as the best treatment in order to maintain the overall appearance of *C. urens* cut leaves with a minimum rate of deterioration. T7 and T8 did not improve the vase-life (6.40 days and 6.60 days respectively) significantly (p>0.05) compared to the control (7.90 days). T5 where 2mgl^{-1} $KMnO_4$ was used for 1 hour showed significant improvement in (p=0.0001) vase life (10.25 days) compared to control. Among the STS treatments, T11 where STS was used for 40 minutes showed highest vase life (10.84 days) in relation to the overall appearance of *C. urens* cut leaves (Figure 6a).

Similar to the other leaf characters, the vase life of *M. sinensis* determined by the overall appearance was not improved significantly (p>0.05) by the anti-ethylene treatments given in this experiment compared to the control (16.40 days). However, longer vase-lives

of 17.90 days, 17.76 days and 17.40 days were recorded in T3, T11 and T6 respectively while the lower vase-lives were observed in T7 (14.52 days) and T8 (14.60 days). Among the STS treatments, T11 where STS was used for 40 minutes showed the highest (17.76 days) vase life according to the overall appearance of *M. sinensis* cut leaves (Figure 6b).

DISCUSSION

The purpose of selecting export quality cut leaves for this experiment using a quality control expert was in order to minimize the differences among the leaves. The leaves were kept at rest for 1 hour in the laboratory to overcome the transport stress. Most of the foliage plants prefer 30^{0}C temperature and 50-80% relative humidity (Anon, 2005). There is no stress under optimum environmental conditions to stimulate the production of ethylene gas (Wickramasinghe *et al.*, 2004). However, it was impossible to provide optimum environmental conditions throughout the experiment. Therefore, measurements obtained in this experiment may not be the maximum level which would be recorded under optimum conditions. Cut leaves free from mechanical damages and pest and disease attacks were selected to minimize the increasing production of ethylene gas which accelerates senescence and yellowing of leaves and shortens the vase life of cut leaves.

Ethanol did not give any significant impact on preserving the quality of cut leaves due to its high evaporative nature. Silver nitrate caused browning in *C. urens* petiole and base of the *M. sinessis* cut leaves. Browning of wounded parts trims down the demand for cut leaves. It was reported that silver nitrate could preserve certain types of floricultural products (cut flowers). However, the function of the silver nitrate in that is not fully understood. In some cases, silver nitrate seems to function strictly as a germicide than in reducing ethylene impacts or in improving water uptake (Wilkins, 1999).

Removal of ethylene could be done by using the ability of $KMnO_4$ to oxidize ethylene into carbondioxide and water. Hence, $KMnO_4$ is quite effective in reducing ethylene levels. The addition of $KMnO_4$ further retards senescence by maintaining ethylene at a low level for a long period (Wills *et al.*, 1998). According to this study 2mgl^{-1}$KMnO_4$ continuous dip (T3) could be selected as the most effective anti-ethylene treatments to enhance the longevity and vase-life and to preserve total visual quality and original colour for a longer period in *C. urens*. However, 4mgl^{-1} $KMnO_4$ 1 hr dip (T5) gave lowest performance compare to control (T1). T5 was higher concentration for a shorter period which impeded the uptake through the petiole (Kumar and Kazuo, 2003). T4 where 2mgl^{-1} $KMnO_4$ was used for 6 hours showed better performance compare to the control, while the second highest performance was observed in T6 where higher concentration of $KMnO_4$ (4mgl^{-1}) was used for a longer period (continuously) to facilitates more absorption of the chemical through the petiole.

Third highest performance among the STS treatments was observed when *C. urens* cut leaves were dipped in STS solution for 40 min (T11). Its activity as an antidote which interferes with the action and synthesis of ethylene by the leaf itself may be the reason behind higher performance. It also contains antibacterial agents which prevents bacterial build up in the stems (Mary, 1988). In the experiment, the $AgNO_3$ and $Na_2S_2O_3$ solutions were immediately added together and treated as STS since it is photo degradable compound. STS long term dip did not give better performance compare to T11. It may be due to toxic effects.

Other than the anti-ethylene compound sucrose also shows some impact on the bio synthesis of ethylene. According to the Kumar and Kazuo (2003), the beneficial effect of sugars on the prolongation of the flower vase life in several species has been attributed to the suppression of ethylene biosynthesis or sensitivity to ethylene.

In terms of cost-effectiveness, $KMnO_4$ which is cheaper than STS could be selected as the economically feasible treatment among the anti-ethylene compounds test in this experiment.

Longevity, vase-life and total visual quality of *M. sinensis* did not improve significantly by any of the treatments used in this experiment compared to control (T1). Therefore, *M. sinensis* can be considered as a species with poor ethylene sensitivity. However, T3, T6 and T11 can be used to increase longevity, vase-file and total visual quality compared to the other treatments used in this experiment.

CONCLUSIONS

A continuous dip in 2mgl^{-1} $KMnO_4$, a continuous dip in 4mgl^{-1} $KMnO_4$ and a 40 minute dip in STS have the ability to increase the longevity and vase-life of *C. urens* cut leaves while maintaining total visual quality at a higher level. One hour dip in 4mgl^{-1} $KMnO_4$ solution and a dip in ethanol solution have a less capacity in improving longevity and vase-life of *C. urens* cut leaves compared to continuous dip in 2mgl^{-1} $KMnO_4$, continuous dip in 4mgl^{-1} $KMnO_4$ and 40 minutes dip in STS treatments. Considering the cost effectiveness 2mgl^{-1} $KMnO_4$ continuous dip can be selected as the best anti-ethylene treatment to improve the postharvest performance of *C. urens* cut leaves.

M. sinensis did not show a considerable level of response to the anti-ethylene treatments given in this experiment. It may be due to the poor sensitivity of *M. sinensis* to the ethylene gas. However, 2mgl^{-1} $KMnO_4$ continuous dip, 4mgl^{-1} $KMnO_4$ continuous dip and STS 40 minutes dip have the capacity to increase the longevity, vase-life and total visual quality of *M. sinensis* cut leaves to a certain level.

Further studies should be undertaken to find out the effect of sucrose substrate with $KMnO_4$ for the improvement of postharvest life of cut leaves.

ACKNOWLEDGEMENTS

Authors wish to acknowledge Professor S .J. B. A. Jayasekera, Dean, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka for his encouragement in the successful completion of this study. Authors also wish to offer their sincere thanks to Dr. B. Ranaweera, Head of the Department, Dr. D. B. Kelaniyangoda, Senior Lecturer, Mr. K. Yakandawala, Lecturer and Mrs. R .H. M. K. Rathnayake, Lecturer, Department of Horticulture and Landscape Gardening for their guidance. Special thanks are extended to Director and all the staff members of Asian Cuttings (Pvt.) (Ltd), Katana for providing required export quality cut leaves. The assistant given by the Mr. K .H. M .I. Karunarathne, Computer Services Unit at Makandura in statistical analysis is also greatly acknowledged. The help given by Mr. R .M. A. Padmasiri, Technical Officer and all the staff members of the Department of Horticulture and Landscape Gardening is greatly appreciated.

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