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Effect of 1-methylcyclopropene on postharvest physiology and quality of cut rose flowers

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Abstract

A lab experiment was conducted on a Hybrid Tea rose variety "First Red" to study the effect of 1-Methyl Cyclo Propene on post harvest quality of cut rose flowers. Pretreatment of flower stem with 1-Methyl Cyclo Propene was carried out in airtight chamber. The experiment was laid with 0.18 % of 1-MCP / m^3 for 6 hours and 0.18 % of 1-MCP / $2m^3$ for 6 hours along with control. The treatment 0.18 % of 1-MCP / m^3 for 6 hours recorded the lowest mean values for physiological loss in weight (11.43 per cent), loss of membrane integrity (31.63 per cent), transpirational loss of water (5.23 g $stalk^{-1}$) and peroxidase activity (0.031 units g^{-1} of fresh weight) during the entire vase life period while the control recorded the highest mean values for physiological loss in weight (25.36 per cent), loss of membrane integrity (53.82 per cent), transpirational loss of water (8.44 g $stalk^{-1}$) and peroxidase activity (0.057 units g^{-1} of fresh weight). Besides, the cut rose flowers treated with 0.18 % of 1-MCP/ m^3 for 6 hours had highest relative water content of 78.16 per cent and water uptake of 6.80 g $stalk^{-1}$. Flowers exposed to 0.18 % of 1-MCP/ m^3 for 6 hours maintained higher mean values for appearance (score 4 – very good) and stem strength (82.40 ^{o} angle) during the entire course of study. The cut rose flowers exposed to 0.18 % of 1-MCP/ m^3 for 6 hours had significantly enhanced the vase life and recorded the longest vase life of 4.3 days whereas the control recorded the shortest vase life of 2.6 days.

Key words: 1-methylcyclopropene, vase life, cut roses

Introduction

Rose is one of the best known and most popular of all garden flowers throughout the world and is one of the natures beautiful and attractive creations, universally known as the "Queen of flowers". It is a symbol of love, adoration, innocence and other virtues. Rose ranks first among the cut flowers trade in domestic and international markets. However, the diminishing keeping quality of cut roses badly affects both the growers as well the traders. Lower status of carbohydrates, proteins and fats in the floral tissue, poor handling and marketing methods badly impair the physiology and biochemistry of flower petals leading to reduced vase life of cut flowers. The extension of vase life of cut flower and improved post harvest development practices has now become commercial and economically important practice based on scientific principles (Bhattacharjee, 1994).

Quality and display life of ornamentals are often reduced by the effects of ethylene present in the particular environment at physiological active concentration (Halevy and Mayak, 1979). The recently developed cyclo propenes have been shown to have potential for preventing the deleterious effect of ethylene in plants (Sisler and Serek, 2001).

The anti ethylene effects of these compounds is associated with molecular strain whereby their excessive structural strain permits a very tight bonding to electron donor compounds such as low valency metals that act to relieve the strain, in the receptor. They compete with ethylene before they bind and remain bound to receptor for a long time thus preventing ethylene from binding (Sisler and Serek, 2001).

A new tool, 1-methylcyclopropene (1-MCP), has been added to the list of options for extending the shelf life and quality of plant products especially cut flowers. The objective of the present investigation was to study the effect of 1-MCP treatment on the postharvest quality of rose cut flower cv. "First Red"

Materials and methods

The research work was carried out on a Hybrid Tea rose variety "First Red' at the Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The crop for post harvest study was raised by following the prescribed cultural practices. The commercial formulation of 1-MCP in the name of celfresh (0.18 % of 1-MCP) at different concentrations were used for the study. The experiment was laid out in completely randomized design with five replications. The different treatments include

C_0: Control

C_1: 0.18 % of 1-MCP / m^3 for 6 hours

C_2: 0.18 % of 1-MCP / $2m^3$ for 6 hours

The treatment with 0.18 % of 1-MCP / m^3 for 6 hours (C_1) and 0.18 % of 1-MCP / $2m^3$ for 6 hours (C_2) were imposed after flower harvest. Pretreatment of flower stem was carried out in airtight chamber. The flowers were kept in bucket containing distilled water. The 0.18 % 1-MCP in the form of tablets was dissolved in small beaker and required concentration was achieved and then the chamber was sealed air tight immediately. Duration of the treatment was 6 hours. Untreated (C_0) flowers served as control. On alternate days flower samples were taken out from each treatment and evaluated for different post harvest parameters. The observations recorded were appearance, stem strength (^{o} angle), freshness (%), physiological loss in weight (%), relative water content (%), water

uptake (g stalk^{-1}), membrane integrity (%), transpirational loss of water (g stalk^{-1}), peroxidase activity (units per gram of fresh weight) and vase life (days).

Appearance: Flower appearance was stated as excellent, very good, good, poor and very poor to 5, 4, 3, 2 and 1 sensory score for the flowers showing 0-5, 6-10, 11-25, 26-50 and > 51 % wilting or abscission or discoloration or bent neck, respectively.

Stem strength: Angle of bent neck of rose flowers were measured in degree with protractor by holding the base of the flower stem and bloom facing up.

Freshness: The number of flowers found fresh without senescence symptoms was recorded throughout the course of study and expressed in per cent.

Physiological loss in weight (PLW): The initial weight of the flower was taken and subsequent weights were taken in the following days. The PLW was arrived by using the following formula and expressed in percentage.

$$PLW = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

Relative water content (RWC): The relative water content of rose petals was estimated as per the method suggested by Venkatarayappa *et al.* (1980). Petals were punched uniformly and the fresh weight of punches (30 numbers) was taken. Then the punches were made to float in water for two hours, after which turgid weight of those punches was recorded after removing excess water by blotting them thoroughly. The dry weight was recorded after drying in an oven at 70°C. The relative water content of the petal was calculated using the following formula and expressed in percentage.

$$RWC = \frac{\text{Fresh weight – Dry weight}}{\text{Turgid Weight – Dry Weight}} \times 100$$

Water uptake (WU): The difference between consecutive measurements of the container and the vase solution (without flower) were recorded at every alternate day interval to measure the water uptake within that particular duration and presented as gram per flower (Venkatarayappa *et al.*, 1980).

Membrane integrity: The loss in membrane integrity was assessed with the aid of UV visual spectrometer as per the method suggested by Leopold (1981).

Transpirational loss of water (TLW): The difference between consecutive measurements of the container and the vase solutions (with flower) were recorded at every alternate day interval to measure the transpirational loss of water within that particular duration of vase period and presented as gram per flower (Venkatarayappa *et al.*, 1980).

Peroxidase activity (POD): Peroxidase activity was determined by adopting the procedure of Malik and Singh (1980). The enzyme activity was expressed as units per gram of fresh weight (1 unit = 1m mole/ minute).

Vase life: The vase life of cut flower was recorded as per the method suggested by Halevy and Mayak (1979).

Statistical analysis: The statistical analysis was done by adopting the standard procedures of Panse and Sukhatme (1985).

Results and discussion

Appearance: On day 1, flowers in all the treatments showed excellent appearance (score 5) and they were onpar with each other. On the day 3, C_1 (0.18 % of 1-MCP / m^3 for 6 hours) and C_2 (0.18 % of 1-MCP/ 2 m^3 for 6 hours) treatments showed very good appearance with the score of 4 and there was no significant difference among them. On day 5 and day 7, C_1 exerted superior performance over C_2 and control. The appearance was very poor (score 1) on day 7 in the control.

Stem strength (°angle): 1-MCP treatments differed significantly on stem strength of cut rose flowers. On day 1, the treatment C_1 recorded the highest stem strength (89.12 °angle) and was significantly differed from control and C_2. The stem strength decreased from day 1 to day 7 in all the treatments. During the entire vase life period the C_1 treatment showed superior effect on stem strength while the control recorded the lowest value for the same period. The lowest stem strength of 60.58 ^{0} angle was recorded in the control on day 7 of vase life period.

Freshness: The treatment C_1 recorded the highest freshness percentage of 98.76 on day 1 (Table 3). The freshness percentage decreased from day 1 to day 7 in all the treatments including C_1. On day 3, C_1 recorded the higher value for freshness percentage of flowers and significantly differed from both C_2 and C_0. The lowest freshness percentage of 44.21 was observed in the C_0 on day 7.

Physiological loss in weight: The physiological loss in weight increased from day 1 to day 7 and reached the maximum on day 7 in all the treatments (Table 4). The lowest physiological loss in weight was recorded in C_1 during the entire vase life period. The highest physiological loss in weight (32.16 per cent) was observed in control on day 7. This may be due to reduction in respiration rate and ethylene production by 1-methylcyclopropene. Because

Table 1. Effect of 1-MCP treatments on appearance of cut rose flowers

Treatments	Day 1	Day 3	Day 5	Day 7	Mean
C_0 (Control)	5	2	2	1	2.5
C_1 (0.18 % 1-MCP/ m^3 for 6 h)	5	4	4	3	4.0
C_2 (0.18 % 1-MCP/2m^3 for 6 h)	5	4	3	2	3.5
Mean	5.0	3.3	3.0	2.0	
SEd	0.09	0.06	0.05	0.03	
LSD (*P*=0.05)	0.20	0.13	0.12	0.08	

Score: 5 – Excellent; 4 – Very good; 3 – Good; 2 – Poor; 1 – Very poor

Table 2. Effect of 1-MCP treatments on stem strength (^{0} angle) of cut rose flowers

Treatments	Day 1	Day 3	Day 5	Day 7	Mean
C_0 (Control)	74.43	68.24	64.41	60.58	66.92
C_1 (0.18 % 1-MCP/ m^3 for 6 h)	89.12	84.53	80.37	75.56	82.40
C_2 (0.18 % 1-MCP/2m^3 for 6 h)	82.18	76.31	70.46	64.58	73.38
Mean	81.91	76.36	71.75	66.91	
SEd	1.514	1.413	1.328	1.239	
LSD (*P*=0.05)	3.299	3.079	2.894	2.700	

during vase life period the reserved food material of the flower is utilized for respiration, the petals starve for food material and undergo wilting and senescence which results in the loss in weight.

Relative water content: The relative water content increased from day 1 to day 3 and decreased from day 5 onwards to the end of the vase life period (Table 5). On day 1, the treatment C_1 exhibited highest relative water content of 76.51 per cent while the control showed only 60.81 per cent. During the entire course of study, the relative water content was maximum (85.88 per cent) on day 3 in the treatment C_1. During the entire period of study, the treatment C_1 recorded the exemplary performance over C_2 and C_0. On day 7, the treatment C_0 exhibited the lowest relative water content of 61.57 per cent. The results are in accordance with the findings of Serek *et al.* (1995) in alstroemeria, Jones *et al.* (2000) in pelargonium, Celikel *et al.* (2002) in lilium and Reid *et al.* (2002) in hibiscus.

Water uptake: There was a significant increase in water uptake in 1-MCP treatments over the control at different periods of vase life (Table 6). Among the treatments, C_1 recorded maximum water uptake (6.09 g stalk^{-1}) and the minimum water uptake was noticed in C_0 on day 1. On day 3, the water uptake recorded was highest in C_1. On day 5 and day 7 also, C_1 recorded the maximum water uptake over other treatments. The lowest water uptake of 1.57 g stalk^{-1} was recorded on day 7 in C_0.

Loss of membrane integrity: During the senescence of flowers, a sequence of events takes place, such as changes in membrane including micro viscosity and phase transition temperature of membrane lipids. As a consequence a sudden surge in ethylene production and loss of differential permeability are observed (Bhattacharjee, 1999 and Thomson *et al.*, 1982). In the present investigation the loss of membrane integrity was maximum in C_0 and minimum in C_1 during the whole vase life period (Table 7). The percentage of leachates increased from day 1 towards the end of vase life period and reached the maximum on day 7. On day 7, C_0 recorded maximum loss of membrane integrity of 72.01 per cent.

The reduced loss of membrane integrity in C_1 may be due to inhibition of ethylene activity by 1-methylcyclopropene. The affinity of 1-MCP for the receptor is approximately 10 times greater than that of ethylene. Compared to ethylene, 1-MCP is very active at much lower concentrations (Sisler *et al.*, 1996). 1-MCP also influenced ethylene biosynthesis in some species through feedback inhibition (Sisler and Serek, 1997). 1-methylcyclopropene treatment reduces damage to the cell organelles caused by ethylene as a result percentage of leachates was lowest in the treatment C_1.

Transpirational loss of water: The maximum transpirational loss of water was observed in C_0 and the minimum tranpirational loss of water in C_1 on day 1 (Table 8). The tranpirational loss of water increased from day 1 to day 5 and decreased towards the end of vase life period. The highest tranpirational loss of water stalk^{-1} (9.98 g) was observed on day 5 in C_0. During the entire vase life period, the treatment C_1 showed minimum values for tranpirational loss of water whereas the maximum values were obtained from C_0. This may be due to reduction in ethylene production, transpiration and respiration activities by 1-methylcyclopropene (Sisler and Serek, 2001).

Table 3. Effect of 1-MCP treatments on freshness (%) of cut rose flowers

Treatments	Day 1	Day 3	Day 5	Day 7	Mean
Control	83.42	70.45	59.09	44.21	64.29
0.18 % of 1-MCP/ m^3 for 6 h	98.76	91.53	82.56	71.69	86.14
0.18 % of 1-MCP/ 2m^3 for 6 h	90.13	82.59	70.13	61.51	76.09
Mean	90.77	81.52	70.59	59.14	
SEd	1.677	1.511	1.313	1.110	
LSD (*P*=0.05)	3.655	3.293	2.862	2.419	

Table 4. Effect of 1-MCP treatments on physiological loss in weight (%) of cut rose flowers

Treatments	Day 1	Day 3	Day 5	Day 7	Mean
C_0 (Control)	18.8	22.86	27.61	32.16	25.36
C_1 (0.18 % 1-MCP/ m^3 for 6 h)	5.97	8.35	12.68	18.70	11.43
C_2 (0.18 % 1-MCP/2m^3 for 6 h)	8.76	12.53	17.91	22.53	15.43
Mean	11.18	14.58	19.40	24.46	
SEd	0.229	0.291	0.375	0.463	
LSD (*P*=0.05)	0.500	0.634	0.818	1.008	

Table 5. Effect of 1-MCP treatments on relative water content (%) of cut rose flowers

Treatments	Day 1	Day 3	Day 5	Day 7	Mean
C_0 (Control)	60.81	68.43	64.56	61.57	63.84
C_1 (0.18 % 1-MCP/ m^3 for 6 h)	76.51	85.88	77.93	72.31	78.16
C_2 (0.18 % 1-MCP/2m^3 for 6 h)	70.35	80.43	71.31	68.56	72.66
Mean	69.22	78.25	71.28	67.48	
SEd	1.2820	1.4490	1.3179	1.2470	
LSD (*P*=0.05)	2.7932	3.1572	2.8716	2.7169	

Table 6. Effect of 1-MCP treatments on water uptake (g stalk^{-1}) of cut rose flowers

Treatments	Day 1	Day 3	Day 5	Day 7	Mean
C_0 (Control)	3.06	2.17	1.96	1.57	2.19
C_1 (0.18 % 1-MCP/ m^3 for 6 h)	6.09	8.21	7.56	5.32	6.80
C_2 (0.18 % 1-MCP/2m^3 for 6 h)	4.21	6.48	3.28	2.11	4.02
Mean	4.45	5.62	4.27	3.00	
SEd	0.085	0.113	0.090	0.063	
LSD (*P*=0.05)	0.185	0.247	0.196	0.137	

Table 7. Effect of 1-MCP treatments on loss of membrane integrity (% solute leakage) of cut rose flowers

Treatments	Day 1	Day 3	Day 5	Day 7	Mean
C_0 (Control)	36.25	47.60	59.41	72.01	53.82
C_1 (0.18 % 1-MCP/ m^3 for 6 h)	17.53	27.46	34.93	46.58	31.63
C_2 (0.18 % 1-MCP/2m^3 for 6 h)	21.12	29.58	40.56	52.31	35.89
Mean	24.97	34.88	44.97	56.97	
SEd	0.484	0.664	0.851	1.069	
LSD (*P*=0.05)	1.054	1.447	1.854	2.330	

Table 8. Effect of 1-MCP treatments on transpirational loss of water (g stalk^{-1}) of cut rose flowers

Treatments	Day 1	Day 3	Day 5	Day 7	Mean
C_0 (Control)	6.35	8.52	9.98	8.91	8.44
C_1 (0.18 % 1-MCP/ m^3 for 6 h)	3.23	4.46	7.21	6.02	5.23
C_2 (0.18 % 1-MCP/2m^3 for 6 h)	4.59	6.86	8.23	7.51	6.80
Mean	4.72	6.61	8.47	7.48	
SEd	0.090	0.125	0.157	0.139	
LSD (*P*=0.05)	0.196	0.274	0.343	0.304	

Peroxidase activity: Peroxidase enzyme activity in senescing petals are directly associated with respiration and increased levels of free radicals and peroxides (Leopold, 1981). The peroxidase activity was lowest (0.031 units per g of fresh weight) in the treatment C_1 and highest peroxidase activity of 0.057 units per g of fresh weight was recorded in C_0 (Table 9). Thus, the increased peroxidase enzyme activity in control flowers indicated the presence of higher stress in the control. This is in consonance with the earlier findings of Amariutei *et al.* (1995) in gerbera. The reduction in peroxidase activity in C_1 treatment may be due to reduction in respiration rate and increase in free radical scavenging activity of 1-methylcyclopropene (Borochov *et al.*, 1976).

Table 9. Effect of 1-MCP treatments on peroxidase activity (units g^{-1} of fresh weight of flowers) and vase life of cut rose flowers

Treatments	Peroxidase activity (units g^{-1} of fresh weight of flowers)	Vase life (days)
Control	0.057	2.6
0.18 % of 1-MCP/ m^3 for 6 h	0.031	4.3
0.18 % of 1-MCP/ 2m^3 for 6 h	0.048	3.8
Mean	0.045	3.56
SEd	0.0027	0.067
LSD (*P*=0.05)	0.0058	0.146

Vase life: The longest vase life (4.3 days) was recorded in the treatment C_1 and was followed by C_2 with the vase life of 3.8 days (Table 9). The shortest vase life was recorded by C_0 with only 2.6 days. The increased vase life may be due to substantial increase in relative water content and water uptake and reduced physiological loss in weight (Blankenship and Dole, 2003). 1-MCP competes with ethylene before it bind and remain bound to receptor for a long time thus preventing ethylene from binding (Sisler and Serek, 2001). As a result the ethylene production is lowered. Our results are in line with the findings of Serek *et al.* (1995) in alstroemeria, Jones *et al.* (2000) in pelargonium, Celikel *et al.* (2002) in lilium, Reid *et al.* (2002) in hibiscus and Amariutei *et al.* (1995) in gerbera.

The pre packing treatment of cut rose flowers with 1-MCP minimized the physiological loss in weight, loss of membrane integrity, transpirational loss of water and peroxidase activity and improved the appearance, stem strength, freshness, relative water content and water uptake as a result the vase life and quality of the cut rose flowers were improved.

The safety, toxicity and environmental profiles of 1-MCP in regard to humans, animals and the environment are extremely favorable. The compound is used at low rates, has a non-toxic mode of action and is chemically similar to that of naturally occurring substances. The rat inhalation LC_{50} is greater than 2.5 mg L. So, 1-MCP can be used as an important tool to reduce ethylene damage in flowers thus improving vase life and post harvest quality of cut flowers.

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