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INHIBITION OF THE GRAVITROPIC RESPONSE OF *MOLUCCELLA LAEVIS* L. CUT SPIKES BY CALCIUM CHELATORS (EDTA)

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ABSTRACT: ***The experimental trial was consummated throughout two successive seasons (2008 and 2009) at Ornamental Plants Research and Landscape Design Dep., Hort. Res. Inst, Giza. This study was conducted to investigate the combined effect of different pulsing solution (distilled water (D.W),D.W + benzyladenine (BA 25mg/l), D.W + calcium chelate EDTA (Ca^{+2}) (30 mM/l), D.W + Benziladinine (BA25mg/l) + calcium chelate EDTA (Ca^{+2})(30 mM/l), D.W + sucrose (suc 30g/l) + benzyladenine (BA 25mg/l) + 8-hydroxyquinoline citrate (8- HQC 250 mg/l) + calcium chelate EDTA (Ca^{+2}) (30 mM) + citric acid (ca 200 mg/l), d.W + sucrose (suc 30g/l) + 8-hydroxyquinoline citrate (8- HQC 250 mg/l) + calcium chelate EDTA (Ca^{+2}) (30 mM/l) + citric acid (ca 200 mg/l), storage position (vertical and horizontal position) and storage periods at 5°C for 3 and 7 days on quality of Moluccella laevis L. cut spikes.***

The obtained results emphasized that the spikes pulsed in the different solutions for 24 hr then stored in vertical position at 5°C for 3 and 7 days showed improved water uptake, increased in percentage of flower weight, decreased weight loss during storage periods (3 and 7 days), decreased curvature, increased vase life, decreased degradation of chlorophyll (a and b) and decreased caroteniods content as compared with control (D.W). This indicated that calcium chelators EDTA inhibited the gravitropic bending of moluccella cut flower stalks. Results obtained with various pulsing solutions indicated that calcium may play essential roles in gravitropism-related processes of cut flower stalks. Finally, it could be concluded that the best treatment was pulsing in the preservative solution D.W + sucrose (suc 30g/l) + benzyladenine (BA 25mg/l) + 8- hydroxyquinoline citrate (8- HQC 250 mg/l) + calcium chelater (Ca^{+2}) (30 mM/l) + citric acid (ca 200 mg/l) and then stored in a vertical position for 3 days at 5°C.

Key words: ***Moluccella, cut flowers, bending, curvature, calcium, vase life.***

INTRODUCTION

Moluccella is a genus of four species of annual and short – lived perennial plants native to northwestern India to the Mediterranean.Cut spikes of *Moluccella laevis* L. belong to family Labiatae or Lamiaceae. Common name of *Moluccella laevis* is bells of Ireland or shellflower.

Description of cut spikes: tiny flowers surrounded by clusters of bells (calyxes). Flowers are rarely seen, the calyx is considered the blossom. Color of flower is flowers- white, calyx-green.Bloom size is 16 to 24 inches in height.

Flowers are sensitive to geotropic bending (gravitropism) and must be transported in an upright position.

The major postharvest problem with some cut flowers is upward bending as a response to gravity, mainly during transport when flowers are held horizontally. Since gravitropic bending is a growth process, it occurs only in flower shoot regions capable of linear growth after harvest, mainly during the first 24 hours in the vase (Halevy and Mayak, 1981).

Gravitropism in shoots and roots of higher plants is the result of a symmetric growth. (Li *et al*., 1991, and Trewavas, 1992). The negative gravitropic response of grass seedlings coleoptiles is brought about by gravity, which induces redistribution of auxin towards the lower side of this gravireacting organ, this causes the growth a symmetry that leads to coleoptiles reorientation.

The role of calcium (Ca^{+2}) as a second messenger in mediating auxin redistribution and effects that lead to the gravitropic response has been suggested (Slocum and Roux, 1983); such a role was recently demonstrated by visualization of rapid changes in cytosolic calcium of oat coleoptiles that were directly correlated with the increase of gravity stimulated cell elongation (Gehring *et al*., 1990).

The gravitropic bending would be prevented without affecting cell elongation or other auxin dependent functions. This would enable a better strategy for postharvest handling of graviresponding cut flowers to be designed (Philosoph *et al*., 1996).

Calcium (Ca^{+2}) is an important element that is found in 3% of the earth's crust (Cmpbel 1983). It is essential to living organisms and to plant growth and development. Some of these benefits include stronger cell walls (Anghileri, 1982), increase postharvest life of flowering plants, and as well as disease resistance (Starkey and Pederson, 1997). Ca is a major component in the cell wall of most plants in the form of Ca pectate. It is a relatively immobile element, but can become more mobile as the plant ages (Anghileri, 1982). Plants that a deficient in Ca may have pale leaf margins and burned leaf edges among other symptoms (Schraer, 1970)

Calcium (Ca^{+2}) may increase postharvest longevity of cut flowers. Such increase may be due to the physiological events related to senescence, such as a decrease in water uptake, increase of water transpiration loss, decrease of fresh weight, stem bending or prevention of disease during propagation (Patel and Mankad, 2002).

Ca promoted flower opening, enhance initial fresh weight and delay its reduction rate. Ca treatment delay the decrease in petal membrane proteins

and phospholipids and slow down the rate of electrolyte leakage from petals. It also suppressed ethylene production (Torre *et al*.1999)

Extending the longevity of cut flowers is very important. Calcium has been found to increase postproduction longevity and bud opening in cut rose flowers. When Ca was applied as Ca $(NO_3)_2$, it lengthened vase life of cut rose flowers and promoted bud opening. Treatments were applied either alone or with 2% sucrose and 200 ppm of 8- hydroxyquinoline citrate, they were continuously or as a short term pulse (Michalczuk *et al*., 1989).

The abscission of leaves, flowers and fruits is presumed to be brought about through the weakening of the cell walls in the abscission zone; the functions of Ca in the plant have included the cementing of cell walls, and also roles in the structure of membranes, in the structure of chromosomes, and as activators of certain enzyme (Jones and Lunt, 1967).

Flowers abscission resulting from the pectins were degraded and the cellulose was partially broken down in cell separation. The Ca level in the abscission zone decreased and lost from the walls of cells in the abscission layer during abscission (StÖsser *et al*., 1969).

The economic success of ornamentals depends on the quality of pigmentation, and faded colours decreases product value (Shamir *et al*., 2003).

Many cut flowers can be stored in the dark for up to two weeks, but low or no light during long storage periods can induce leaf yellowing in some species, includind alstroemeria (*AIstroemeria* spp.), lilies (*Lilium* spp.), and chrysanthemum (Nowak and Rudnicki, 1990).

Pulse conditioning with benzyladenine was effective on prolonging vase life both in stored and non stored cut Hosta leaves relative to not treated with BA. (Wachowicz *et al*., 2007).

The objective of this study was to evaluate two storage position (vertical and horizontal), different pulsing solutions and two storage periods (3 and 7 days) to improve postharvest quality of *Moluccella laevis* L.and to maintain their upright during cold storage and transportation.

MATERIALS AND METHODS

The experimental trial research was carried out at the Ornamental Plant Research and Landscape Design Department, Horticultural Research Institute; Giza, Egypt throughout two successive seasons (2008 and 2009).

Freshly cut Moluccella spikes were obtained from local commercial growers. Flowers were harvested when flowers are ½ open and green (Fig ,1) in the early morning and transported vertically to the laboratory during 1 hr. Pre-cooling of flowers was performed by placing them in ice cold water for 3 hr. The pre-cooling is an important postharvest operation, which removes the field heat and greatly improves quality and enhances the vase life of cut spikes. The flowers were selected for uniformity in terms of development; the stems were trimmed to an equal length (80 cm).

Flower stems (288) were pulsed for 24 hr. in one of the following a preservative solution:

1- **Distilled water (D.W). (48 flowers) as a control.**
2- **D.W + benzyladenine (BA 25mg/l). (48 flowers).**
3- **D.W + calcium chelate EDTA (Ca^{+2}) (30 mM/l). (48 flowers).**
4- **D.W + benzyladenine (BA 25mg/l) + calcium chelate EDTA (Ca^{+2}) (30 mM/l). (48 flowers).**
5- **D.W + sucrose (suc 30g/l) + benzyladenine (BA 25mg/l) + 8-hydroxyquinoline citrate (8- HQC 250 mg/l) + calcium chelate EDTA (Ca^{+2}) (30 mM/l) + citric acid (ca 200 mg/l). (48 flowers).**
6- **D.W + sucrose (suc 30g/l) + 8- hydroxyquinoline citrate (8- HQC 250 mg/l) + calcium chelate EDTA (Ca^{+2}) (30 mM)+ citric acid (ca 200 mg/l). (48 flowers).**

After that the flower stems in all pulsing solution were divided into four groups: the first group (12 flowers) was wrapped in Kraft paper and packed vertically in cardboard boxes (33*33*125 cm) then, stored at 5° C for 3 days.

The second group (12 flowers) was wrapped in Kraft paper and packed vertically in cardboard boxes (33*33*125 cm) then, stored at 5° C for 7 days.

The third group (12 flowers) was wrapped in Kraft paper and packed horizontally in cardboard boxes (33*33*125 cm) then, stored at 5° C for 3 days.

Fig. (1): Flowers were harvested when flowers are ½ open and green.

The fourth group (12 flowers) was wrapped in Kraft paper and packed horizontally in cardboard boxes (33*33*125 cm) then, stored at 5° C for 7 days.

After the end of storage periods, flower boxes were kept at 10 °C for 3 hrs, as preconditioning treatment to avoid temperature stress of the normal atmosphere. Flowers were kept in vases containing distilled water under lab condition, i.e. 15- 20° C, 60-70% RH till end of the longevity of flowers.

Measurements:

1- **Weight loss percentage was recorded after the end of storage periods (3 and 7 days).**
2- **Flower vase life (days) was considered ended when green bell- like calyxes surround tiny fragrant white flowers began wilting.**
3- **Percentage of flowers abscission was estimated at the end of experiment.**
4- **Water uptake (cm^3) by the cut spikes was estimated by subtracting the amount of water at the end of experiment from the initial volume.**
5- **Flower fresh weight percentage increase.**
6- **Stem angle: in order to measure the stem angle, after the end of storage periods, the spikes were placed on a sheet of paper on which the outline of the stem had been drawn. The angle was then determined using a goniometer according to Botondi *et al*., (1998).**
7- **Chlorophyll and caroteniods contents (mg/100g f.w.) were determined in calyxes colorimetrically according to Saric *et al*. (1967) when the vase life of the flowers was terminated.**

This experiment was carried out in a complete randomized design factorial (CRD) with three factors, pulsing solution (factor A) was applied in 6 pulsing solutions, storage period (factor B) was applied in 2 levels (3 and 7 days) and storage position (factor C) was also applied in 2 levels (vertical and horizontal).

Statistical analysis:

All data were subjected to statistical analysis according to the procedure reported by Snedecor and Cochran (1982) and means were compared least significant difference (L.S.D) test at the 5% level of probability in the two seasons.

RESULTS AND DISCUSSION

Effect of pulsing solutions, storage position, storage periods and their interaction on *Moluccella laevis* L.cut spikes after dry cold storage at 5°C for 3 and 7 days:

1- Weight loss percentage:

Data in Table (1) show that Moluccella cut flowers pulsed in the different preservatives solutions gave the lowest percentage of weight loss during dry cold storage than those pulsed in distilled water (control) in both two seasons.

Moluccella cut spikes pulsed for 24 hr in solution containing suc (30g/l) + 8-HQC (250mg/l) + CA (200mg/l) + ca chelator (EDTA) (30mM/l) + BA (25mg/l) reduced the percentage of weight loss followed by solution containing suc (30g/l) + 8-HQC (250mg/l) + ca (200mg/l) + Ca chelator (EDTA) (30mM/l), as compared with other pulsing solutions.

Table 1

This is in harmony with that obtained by Khenizy *et al*., (2009) who stated that pulsed chrysanthemum cut flowers in a preservative solution containing sucrose (3%) + 8-HQC (250 mg/l) + silver nitrate (25 mg/l) + citric acid (150 mg/l) for 18 hr gave lower percentage of flower weight loss than those pulsed in the distilled water in both seasons vertical storage position of moluccella cut spikes reduced the weight loss percentage compared to the horizontal storage position. These results are in agreement with Halevy and Mayak (1981) who found that the major postharvest problem of cut flowers is their upward bending as a response to gravity, mainly during transport when flowers are held horizontally.

Data in Table (1) clearly indicate that dry storage period for 7 days exhibited more loss in weight than cut flowers stored for 3 days in both seasons. Similar results were found by Zaky (2008) who indicate that the percentage of Eucalyptus branches weight loss was gradually increased when dry cold storage period exceeded two weeks to reach its maximum loss at three weeks cold storage.

The results of interaction indicated that pulsing moluccella cut spikes for 24 hr in a solution containing suc ((30g/l)) + 8-HQC (250mg/l) + ca (200mg/l) + Ca^{+2} chelator (EDTA) (30mM/l) + BA (25mg/l), placed in a vertical position during storage and stored for 3 days was the best treatment compared with other treatments used in both seasons. These results coincided with the findings of El- Saka (1996) who found that weight loss percentage of Iris cut flowers was gradually increased by the extension of dry storage period. Also, Rekha *et al*., (2001) mentioned that sucrose + 8- HQC and sucrose + GA reduced the tranpirational loss of water of gladiolus spikes.

2- Flower vase life:

The results in Tables (2, 3) indicate that in comparison to the control (D.W), all pulsing solution treatments prolonged the vase life of moluccella cut spikes, in both seasons.

Pulsing basal ends of moluccella cut flowers in a solution containing suc (30g/l) + 8-HQC ((250mg/l)) + ca (200mg/l) + Ca^{+2} chelator (EDTA) (30mM/l) + BA (25mg/l), was the most effective treatment for increasing vase life as compared with other treatments.

In this regard, Anuradha *et al*., (2002) found that a holding solution containing benzyladenine in combination with sucrose and 8-hydroxyquiolin recorded the maximum total vase life of Anthurium cut flowers. Also,Setyadjit, *et al*., (2004) reported that exogenous treatments with cytokinins, such as 6- benzylaminopurine (BA), can delay senescence of some plant tissues., Mortazavi *et al*., (2007) mentioned that the cytokinin and calcium application decreased senescence percentage of *Rosa hybrid* L. cv. Illona. Singh and Kumar (2008) found that the pre- storage pulse treatment (300 ppm 8-HQ for 1 hr and 20% sucrose for 12 hr) enhanced thevase life of gladiolus cut flowers.

Table 2

Table 3

Regarding the effect of storage position, it can be concluded from Tables (2 and3) that storage in a vertical position of moluccella cut spikes gave the highest values of vase life (12.11 and 11.19 days) in the first and second seasons respectively than those stored in a horizontal position.

Similar results were obtained by Joiner *et al*., (1973) who found that snapdragon inflorescences show a rapid gravitropic response when placed horizontally, thereby causing a serious problem during their postharvest handling.

As shown in Tables (2 and 3) vase life of moluccella cut spikes was decreased by increasing dry storage period from 3 to 7 days in the two seasons.

These agreed with results obtained by Song *et al*., (1995) who found that as storage duration increased of cut flowers of *Delphinum elatum*, vase life was decreased. Also, El- Saka (1996) mentioned that a long period of dry storage can be harmful to the quality and vase life of Iris cut flowers.

The combination between pulsing solution of suc (30g/l) + 8-HQC ((250mg/l) l) + ca (200mg/) + Ca^{+2} chelator (EDTA) (30mM/l) + BA (25mg/l), storage position (vertical position) and storage period (3 days) increase the longevity of moluccella cut spikes (18.67 and17.67days in the first and second seasons, respectively) as compared with all tested treatments. These results are in agreement with those of El-Saka (1996) who reported that vase life of Iris cut flowers was highly significant decreased by extending dry storage period.

Also, Halevy (1995) found that manipulation of cytosolic Ca^{+2} level may become a novel means for controlling flower senescence and geotropic bending of flower.Singh and Kumar (2008) also found that post-harvest treatment of pre-storage pulsing of gladiolus cut flowers with 300 ppm 8-HQ for 1 hr + 20% sucrose for 12 hr, post storage treatment of 300 ppm 8-HQ+ 5% sucrose, led to a delay in flower senescence.

3- Floret abscission:

Data illustrated in Tables (4 and 5) show that placing basal stem ends of moluccella cut spikes in different pulsing solutions decreased floret abscission in the two seasons when compared with cut spikes treated with distilled water as a check. Pulsing solution containing suc (30g/l) + 8-HQC ((250mg/l)) + ca (200mg/l) + Ca^{+2} chelator (EDTA) (30mM/l) + BA (25mg/l) decreased the floret abscission more than other pulsing solutions. In this concern, Poovaiah and Leopold (1973) found an inhibition of abscission in bean petiole explants by the application of Ca^{+2}. Also, Khalil *et al*., (2006) found that the foliage of lentil plants sprayed twice at (70 and 80 days from sowing with kinetin solution of 10, 20 and 40 mg/l showed decreased the percentage of abscessed flowers.

Table 4

Table 5

Results in Tables (4 and 5) show that stored moluccella cut spikes in a vertical position decreased the floret abscission more than the spikes stored in a horizontal position, in both seasons.

The results presented in Tables (4 and 5) pointed out that the period of storage for 3 days for moluccella cut spikes decreased the floret abscission than spikes stored for 7 days, in both seasons.These results confirmed those obtained by Al- Saqri *et al*., (2003) who mentioned that abscission of undeveloped flower buds in *Hibiscus rosa- sinensis* increased with shipping duration.

The results of interaction in Tables (4 and 5) proved that moluccella cut spikes stored at a vertical position for 3 days and pulsed with either suc (30g/l) + 8-HQC (250mg/l) + ca (200mg/l) + Ca^{+2} chelator (EDTA) 30mM/l + BA (25mg/l) or suc (30g/l) + 8-HQC (250 mg/l) + ca (200mg/l) + Ca^{+2} chelator (EDTA) (30mM/l) show decreased floret abscission over the other treatments in both season.

4- Water uptake:

It is clear from data presented in Tables (6 and 7) that pulsing solution containing suc (30g/l) + 8-HQC (250mg/l) + ca (200mg/l) + Ca^{+2} chelator (EDTA) (30mM/l) + BA (25mg/l) was the most effective solution for increasing water uptake of moluccella cut spikes as compared with other pulsing solutions. This is in harmony with the obtained by Rekha *et al*., (2001) who mentioned that the preservatives solutions in combination with sucrose, sucrose +8-HQS and sucrose + GA_3 increased the water uptake of gladiolus spikes.

Data in Tables (6 and 7) clearly indicate that water uptake of moluccella cut spikes was decreased in spikes stored in a horizontal position compared to spikes stored in a vertical position, in both seasons. The same trend was also found in water uptake of moluccella cut spikes which decreased with increasing storage period from 3 to 7 days, in both seasons an indicated in Tables (6 and 7).

Similar results were obtained by Song *et al*., (1995) who found that as storage duration of cut flowers of *Delphinium elatum* increased, solution uptake was decreased.

The results of interaction stated that the highest water uptake of moluccella cut spikes was obtained by pulsing cut flowers in a solution containing suc (30g/l) + 8-HQC (250mg/l) + ca (200mg/l) + Ca^{+2} chelator (EDTA) (30mM/l) + BA (25mg/l) and stored for 3 days in a vertical position, than the other treatments in the two seasons.

Table 6

Table 7

5- Fresh weight percentage of cut spikes:

Data registered in Tables (8 and 9) show that treating moluccella cut flowers with solutions containing suc (30g/l) + 8-HQC (250mg/l) + ca (200mg/l) + Ca^{+2} chelator (EDTA) (30mM/l) + BA (25mg/l) and suc (30g/l) + 8-HQC (250mg/l) + ca (200mg/l) + Ca^{+2} chelator (EDTA) (30mM/l) show increased the fresh weight percentage compared with other treatments, in the two seasons.

In this regard, Reddy *et al*., (1997) stated that flower spikes of tuberose treated with 8- hydroxyquinoline sulfate (8-HQS) and 8-HQS + citric acid exhibited the highest fresh weight. Also,Rekha *et al*., (2001) indicated that sucrose + GA_3 increased fresh weight of gladiolus cut flowers.

Moluccella cut spikes treated with all pulsing solutions placed in a vertical position during dry storage increased the fresh weight percentage compared with cut flowers stored in a horizontal position, in both seasons (Tables 8 and 9)

Data in Tables (8 and 9) show that moluccella cut spikes stored for 3 days enhanced the fresh weight percentage more than the cut spikes stored for 7 days, in the two seasons.Similar results were found by Song *et al*., (1992) who stated that as the storage period of cut gladiolus spikes increased, fresh weight was markedly decrease. Also, El-Saka and Auda (1997) showed that four weeks storage were less efficienty than two weeks for fresh weight of *Hippeastrum vittatum.*

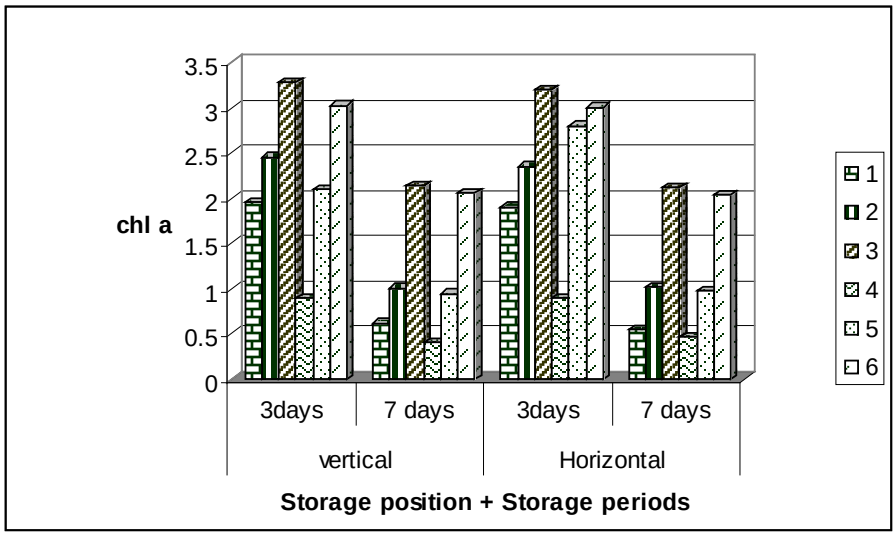
The results of interaction between pulsing solution x storage position x storage period showed that pulsing moluccella cut spikes in the solution containing suc (30g/l) + 8-HQC (250mg/l) + ca (200mg/l) + Ca^{+2} chelator (EDTA) (30mM/l) + BA (25mg/l) and placed in a vertical position for 3 days in dry storage resulted in highest increase in fresh weight percentage than other treatments, in both seasons.These findings are in agreement with those previously obtained by Song *et al*.,(1995) who mentioned that, as storage duration increased of *Delphinium elatum* pulsed with STS (0.4mM) + sucrose (7%) + GA_3 (100 ppm) + $Mncl_2$ (1 mM) for 2 hr, fresh weight was decreased.

6- Chlorophyll content:

Moluccella cut spikes treated with all pulsing solutions retarded the degradation of the leaf chlorophyll (a and b) contents compared to pulsing distilled water (control) in both seasons (Fig 2, 3, 4 and 5).

Table 8

Table 9



1- Distilled water (D.W)

2- Benzyladenine (BA25mg/l)

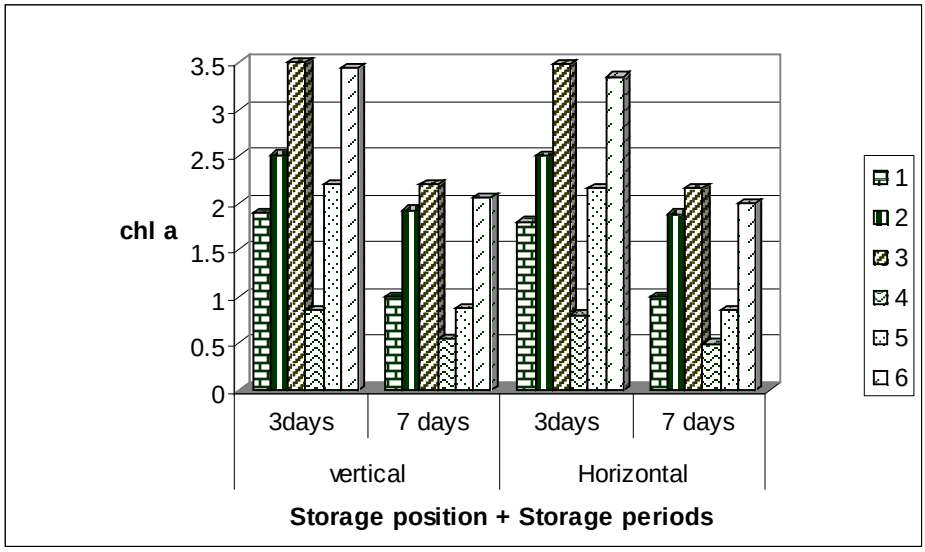
3- D.W + calcium chelater (Ca^{+}) (30 mM)

4- Benzyladenine (BA25mg/l) + calcium chelater (Ca^{+}) (30 mM/l)

5-Suc (30g/l) + BA(25mg/l) + 8-HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

6- Suc (30g/l) + 8- HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

Fig (2): Effect of pulsing solution, storage position and storage periods chlorophyll (a) content (mg/100g f.w.) of moluccella cut spikes during 2008.



1- Distilled water (D.W)

2- Benzyladenine (BA25mg/l)

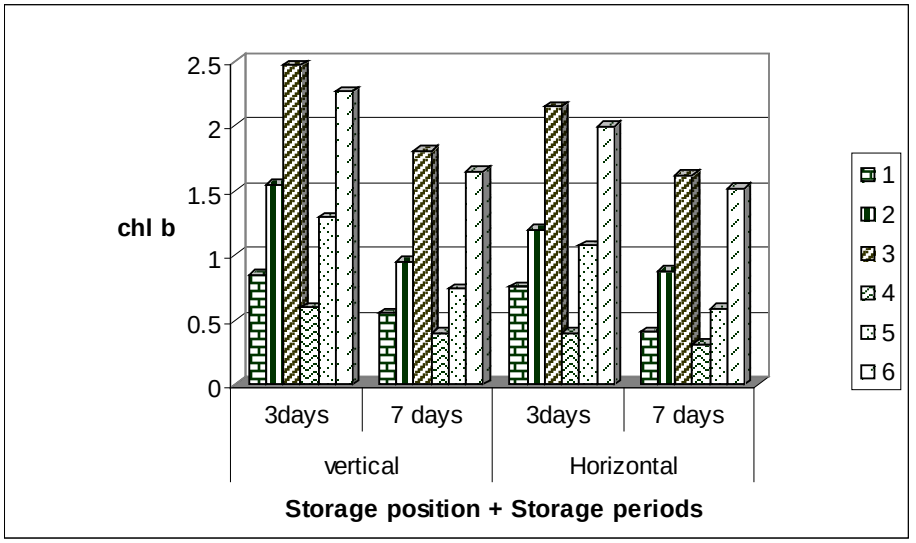
3- D.W + calcium chelater (Ca^{+}) (30 mM)

4- Benzyladenine (BA25mg/l) + calcium chelater (Ca^{+}) (30 mM/l)

5-Suc (30g/l) + BA(25mg/l) + 8-HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

6- Suc (30g/l) + 8- HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

Fig (3): Effect of pulsing solution, storage position and storage periods on chlorophyll (a) content (mg/100g f.w.) of moluccella cut spikes during 2009.



1- Distilled water (D.W)

2- Benzyladenine (BA25mg/l)

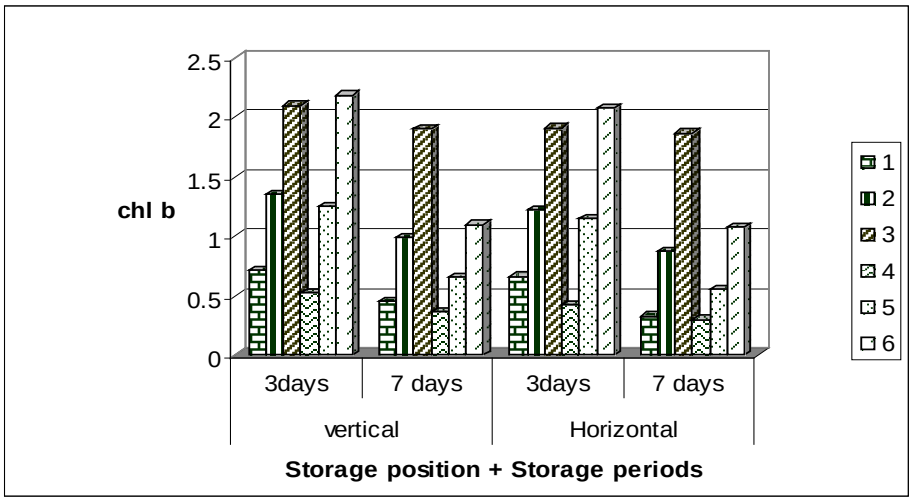
3- D.W + calcium chelater (Ca^{+}) (30 mM)

4- Benzyladenine (BA25mg/l) + calcium chelater (Ca^{+}) (30 mM/l)

5-Suc (30g/l) + BA(25mg/l) + 8-HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

6- Suc (30g/l) + 8- HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

Fig (4): Effect of pulsing solution, storage position and storage periods on chlorophyll (b) content (mg/100g f.w.) of moluccella cut spikes during 2008.



1- Distilled water (D.W)

2- Benzyladenine (BA25mg/l)

3- D.W + calcium chelater (Ca^{+}) (30 mM)

4- Benzyladenine (BA25mg/l) + calcium chelater (Ca^{+}) (30 mM/l)

5-Suc (30g/l) + BA(25mg/l) + 8-HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

6- Suc (30g/l) + 8- HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

Fig (5): Effect of pulsing solution, storage position and storage periods on chlorophyll (b) content (mg/100g f.w.) of moluccella cut spikes during 2009.

Pulsing molucella cut spikes in suc (30g/l) + 8-HQC (250mg/l) + ca (200mg/l) + Ca^{+2} chelator (EDTA) (30mM/l) + BA (25 mg/l) solution was the most effective treatment in retarding chlorophyll (a and b) content, followed by suc (30 g/l) + 8-HQC (250 mg/l) + ca (200mg/l) + Ca^{+2} chelator (EDTA) (30mM/l) in the two seasons.These results were in agreement with those of Hicklenton (1991); and Ben Jacoov *et al*., (1985) who mentioned that inhibitors of chlorophyll degradation such as cytokinins and gibberellic acid, are able to delay leaf yellowing in some sensitive cut flowers like alstromeria, lilies and other potted plants. Also, Young *et al*., (1996) on Asiatic hybrid lily, found that the use of preservative solution containing HQC + sucrose + GA_3 + $MnCl_2$ kept the foliage green until the end of vase life. Moreover, Skutnik *et al*., (2006) found that chlorophyll content remained high in shoots of *Asparagus setacens* treated with BA (benzyladenine).

Moluccella cut spikes placed in a vertical position during dry storage exhibited the highest contents of chlorophyll (a and b) compared with cut spikes placed in a horizontal position, in both seasons.

Data presented in Figures (1, 2, 3 and 4) demonstrate that chlorophyll (a) and (b) contents in moluccella cut spikes decreased with increasing dry storage period from 3 to 7 days, in both seasons. Similar results were found by Khenizy and Zaky (2008) who revealed that tuberose spikes stored for different periods recorded a continuous decrease in chlorophyll a and b content with prolonging the storage period.

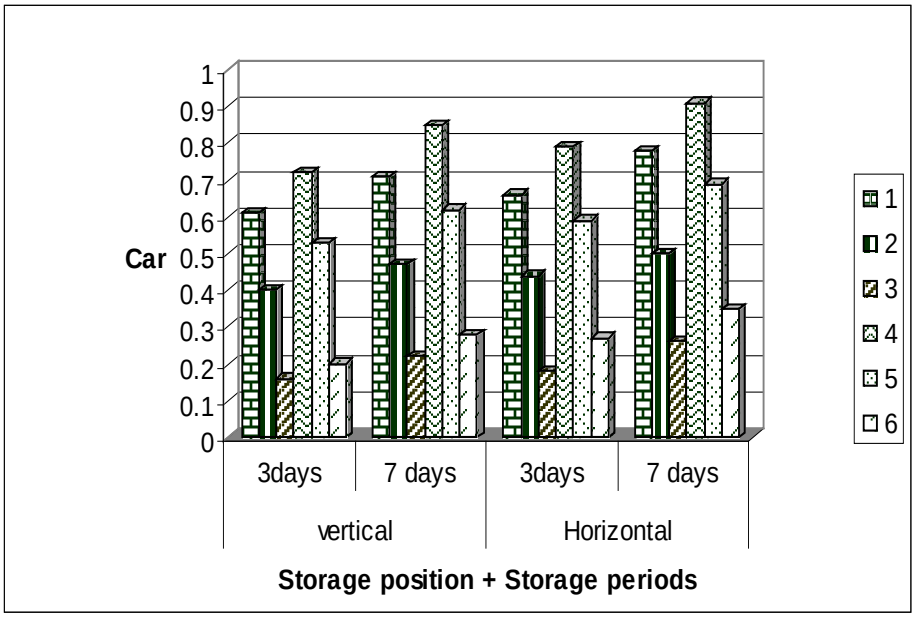
The results of interaction revealed that the highest contents of chlorophyll (a) and (b) were obtained by pulsing moluccella cut spikes for 24 hr before dry storage in a solution containing suc (30 g/l) + 8-HQC (250 mg/l) + ca (200 mg/l) + Ca^{+2} chelator (EDTA) (30 mM /l) + BA (25 mg/l) combined with placing cut spikes in a vertical position during dry storage for 3 days.

This results are in agreement with Khenizy (2000) who mentioned that holding carnation cut flowers in vase solution containing sucrose + 8- HQC + CA+ / or without Tween 20 and stored for different periods decreased chlorophyll contents with extending storage period.

7-Caroteniods content:

Data in Figures (6 and 7) show that pulsing solution containing suc (30 g/l) + 8-HQC (250 mg/l) + ca (200 mg/l) + Ca^{+2} chelator (EDTA) (30m M /l) + BA (25 mg/l) decreased the carotenoids content in moluccella cut spikes, than all pulsing solutions in both seasons.

In this result, Han (2001) on *Lillium sp*. found that pulsing solution containing 25 mg/l each of BA and GA_3 for 4 hr prevented leaf yellowing. Also, Zaky (2008) found that the branches of Eucalyptus with Florissant-400 (4 ml/l) + sucrose (4%) + GA_3 (150 ppm) for 48 hr. was the most effective treatment for reducing leaf yellowing.



1- Distilled water (D.W)

2- Benzyladenine (BA25mg/l)

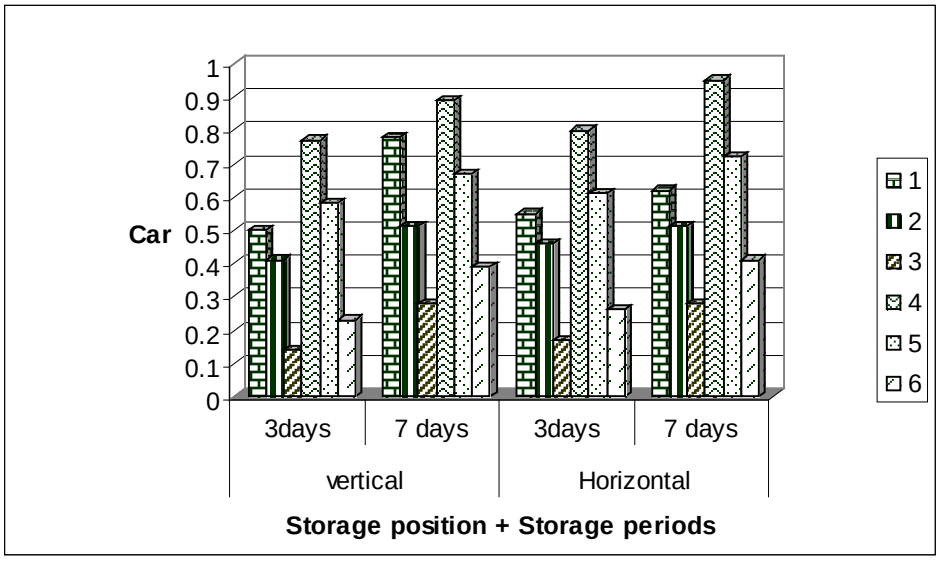
3- D.W + calcium chelater (Ca^{+}) (30 mM)

4- Benzyladenine (BA25mg/l) + calcium chelater (Ca^{+}) (30 mM/l)

5-Suc (30g/l) + BA(25mg/l) + 8-HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

6- Suc (30g/l) + 8- HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

Fig (6): Effect of pulsing solution, storage position and storage periods on carotenoids content (mg/100g f.w.) of moluccella cut spikes during 2008.



1- Distilled water (D.W)

2- Benzyladenine (BA25mg/l)

3- D.W + calcium chelater (Ca^{+}) (30 mM)

4- Benzyladenine (BA25mg/l) + calcium chelater (Ca^{+}) (30 mM/l)

5-Suc (30g/l) + BA(25mg/l) + 8-HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

6- Suc (30g/l) + 8- HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

Fig (7): Effect of pulsing solution, storage position and storage periods on carotenoids content (mg/100g f.w.) of moluccella cut spikes during 2009.

Data in Fig. (6 and 7) show that stored moluccella cut spikes in a vertical position showed decreased carotenoids contents compared with cut spikes placed in a horizontal position, in both seasons.

Data illustrated in Fig. (6 and 7) indicate that the extension of the dry storage period from 3 to 7 days increased the carotenoids in moluccella cut spikes, in both seasons. These results are in agreement with those of Khenizy (2000) who indicated that carotenoids increased in leaves of carnation cut flowers with extending storage periods.

From Figures (6 and 7) it is clear that treated moluccella cut spikes with pulsing solution containing suc (30 g/l) + 8-HQC (250 mg/l) + ca (200 mg/l) + Ca^{+2} chelator (EDTA) (30 mM/L) + BA (25 mg/l) for 24 hr, and then placed in a horizontal position for 7 days in dry storage at 5°C, increased carotenoids contents over the other treatments in both seasons. In this concern, Khenizy (2000) mentioned that holding carnation cut flowers in vase solution containing sucrose + 8- HQC + CA+ / or without Tween 20 and stored for different periods showed increased caroteniods with extending storage period.

8-Curvature:

Results in Tables (10 and 11) show that gravitropic bending response of moluccella cut spikes was significantly inhibited by application of all pulsing solutions containing Ca^{+2} chelator (EDTA).

Pulsing solution containing suc (30 g/l) + 8-HQC (250 mg/l) + ca (200 mg/l) + Ca^{+2} chelator (EDTA) (30 mM/l) + BA (25 mg/l) greatly reduced a geotropic bending angle compared with other treatments (Tables 10 and 11) (Figures 8, 9 and 10).

Fig (8): Effect of treatment with pulsing solution containing suc (30 g/l + 8-HQC (250 mg/l) + ca (200 mg/l) + calcium chelator EDTA (30 mM /l) + BA (25 mg/l) for 240 hr.

Fig (9): Effect of treatment with pulsing solution containing distilled water for 24 hr.

Fig (10): Effect of treatment with different pulsing solutions for 24 hr. from left to right:

1- Distilled water (D.W)

2- Benzyladenine (BA25mg/l)

3- D.W + calcium chelater (Ca^{+}) (30 mM)

4- Benzyladenine (BA25mg/l) + calcium chelater (Ca^{+}) (30 mM/l)

5-Suc (30g/l) + BA(25mg/l) + 8-HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

6- Suc (30g/l) + 8- HQC(250mg/l)+ calcium chelater(Ca^{+}) (30 mM/l) + citric acid (200mg/l)

Table 10

Table 11

These conclusions are in agreement with those of Nowak (1992) who found that pulsing cut gerbera inflorescences in 8-HQC at 200 mg/l with sucrose at 100 g/l for 24 hr at 20°C reduced the number of bent of folded stalks. Also, Halevy (1995) mentioned that manipulation of cytosolic Ca^{+2} levels may become a novel means for controlling geotropic bending of flowers. Seiichi and Koudai (2002) found that cut snapdragon flowers kept in water showed inflorescence bent, while those pretreated with 1 % $CaCl_2$ for 16 hr did not show such symptoms. Friedman *et al*., (2003) mentioned that a differential stem growth pattern was obtained during gravistimulation, which was significantly abolished by calcium antagonists to inhibit stem curvature of snapdragon.

Two storage positions were tested for effectiveness in controlling a geotropic bending angle in moluccella cut spikes (Tables 10 and 11). Cut spikes stored at vertical position showed decreased geotropic bending angle as compared with cut spikes placed in a horizontal position.

Data in Tables (10 and 11) show that as the storage period increased from 3 to 7 days geotropic bending angle increased in moluccella cut spikes, in both seasons.

Data in Tables (10 and 11) indicate the results of interaction between using suc (30g/l) + 8-HQC (250 mg/l) + ca (200 mg/l) + Ca^{+2} chelator (EDTA) (30 mM/l) + BA (25 mg/l) as a pulsing solution and kept in an upright position and storage periods of moluccella cut flowers for 3 days exhibited higher effect on reducing geotropic bending angle over all treatments, in both seasons.

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تثبيط الإستجابة للإنخناء ضد الجاذبية الأرضية لسيقان المولیسیلا المقطوفة بواسطة الكالسيوم المخلبى

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الملخص العربي

أجرى هذا البحث خلال موسمى ٢٠٠٨، ٢٠٠٩ فى قسم بحوث الزينة بمعهد بحوث البساتين بالجيزة.

وتم فيه دراسة تأثير تفاعل ٣ عوامل و هى أولاً مخاليل غمس مختلفة و هى (الماء المقطر ، بنزايل أدينين (٢٥مليجرام /اللتر) ، كالسيوم مخلبى EDTA (٣٠ مليمول / اللتر) ، بنزايل أدينين (٢٥مليجرام /اللتر) + كالسيوم مخلبى EDTA (٣٠ مليمول / اللتر) ، سكروز(٣٠ جرام / اللتر) + ، بنزايل أدينين(٢٥مليجرام /اللتر)+ ٨- هيدروكسى كينولين سترات (٢٥٠ مليجرام / اللتر) + كالسيوم مخلبى EDTA (٣٠ مليمول / اللتر) + حمض الستريك (٢٠٠ مليجرام / اللتر) ، سكروز(٣٠ جرام / اللتر) + ٨- هيدروكسى كينولين سترات(٢٥٠ مليجرام / اللتر) + كالسيوم مخلبى EDTA (٣٠ مليمول / اللتر) + حمض الستريك(٢٠٠ مليجرام / اللتر) و العامل الثانى هو وضع الأزهارأثناء تخزينها تخزيناً مبرداً على درجة ٥ درجة مئوية (وضع أفقى ، وضع رأسى) و العامل الثالث و هو تخزين الأزهار لفترتين و هما ٣ و ٧ أيام و دراسة تأثير هذه العوامل على جودة أزهار المولیسیلا المقطوفة.

و قد أوضحت النتائج الأتى:

أن غمس سيقان المولیسیلا المقطوفة فى محاليل غمس مختلفة لمدة ٢٤ ساعة ثم تخزينها فى وضع رأسى أو عمودى على درجة ٥ درجة مئوية لمدة٣ و ٧ أيام أدت إلى:

١- تحسين إمتصاص الماء.

٢- زيادة النسبة المئوية لوزن الأزهار.

٣- نقص الفقد فى الوزن أثناء فترتى التخزين ٣ و ٧ أيام.

٤- نقص إنحناء سيقان أزهار المولیسیلا المقطوفة.

٥- زيادة من عمر الأزهار فى الفازات.

٦- نقص تحلل الكلوروفيل أ و ب.

٧- نقص محتوى الأزهار من الكاروتينيدات.

و ذلك بالمقارنة بمعاملة المقارنة (الكونترول) (الماء المقطر).

و ذلك يشير إلى أن الكالسيوم المخلبى EDTA قد ثبط الإنخناء ضد الجاذبية الأرضية لأزهار المولیسیلا.

و قد أشارت النتائج المتحصل عليها مع محاليل الغمس المختلفة إلى أن الكالسيوم ربما يلعب دوراً اساسياً فى العمليات المرتبطة بالإنحناء ضد الجاذبية الأرضية لسيقان المولیسیلا المقطوفة.

و فى النهاية توصى الدراسة بأن أحسن المعاملات كانت غمس سيقان الأزهار فى مخلول يتكون من السكروز + بنزيل أدينين + ٨- هيدروكسى كينولين سترات + كالسيوم مخلبى EDTA + حمذض الستريك ثم التحزين فى وضع رأسى أو عمودى لمدة ٣ أيام على درجة ٥ درجة مئوية.

Table (1): Effect of pulsing solution, storage position, storage period and their interaction on weight loss percentage of *Moluccella laevis* L. cut flowers after dry cold storage for 3 and 7 days at 5°C in two season, (2008 and 2009).

Treatment	Storage position									
	2008					2009				
	Vertical		Horizontal			Vertical		Horizontal		
Pulsing solution	Storage period (day)									
	3	7	3	7	Mean	3	7	3	7	Mean
BA (25 mg\l)	1.53	3.65	2.75	6.69	3.66	2.20	5.4	2.81	7.19	4.40
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)	1.38	2.65	1.82	5.62	2.87	1.87	4.81	1.98	6.10	3.69
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)+suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)	0.96	1.60	1.48	3.20	1.81	1.51	3.10	1.66	3.65	2.48
DW	2.30	4.81	3.10	8.71	4.73	2.62	6.10	2.93	7.92	4.89
Ca^{+2} chelator (30 mM\l)	1.41	3.10	1.93	6.54	3.25	1.92	5.11	2.15	6.65	3.96
Suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)+ Ca^{+2} chelator (30 mM\l)	1.20	2.35	1.71	5.45	2.68	1.70	4.11	1.93	5.96	3.43
Mean of storage position	2.25		4.08			3.37		4.24		
Mean of storage period	3 day		7 day			3 day		7 day		
	1.80		4.53			2.11		5.51		

Table (2): Effect of pulsing solution, storage position, storage period and their interaction on vase life (days) of *Moluccella laevis* L. cut flowers during (2008).

Treatment	Storage position (B)						Mean		
	Vertical			Horizontal					
Pulsing solution (A)	Storage period (C)								
	3 days	7 days	Mean A*B	3 days	7 days	Mean A*B	(A)	(A*C)	(A*C)
BA (25 mg\l)	9.00	5.33	7.17	9.00	5.33	7.17	7.17	9.00	5.33
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)	14.67	11.67	13.17	14.33	11.00	12.67	12.92	14.50	11.33
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)+suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)	22.00	19.00	20.50	22.00	18.67	20.33	20.42	22.00	18.83
DW	6.33	5.33	5.83	6.00	5.33	5.67	5.75	6.17	5.33
Ca^{+2} chelator (30 mM\l)	9.33	9.00	9.17	9.00	8.67	8.83	9.00	9.17	8.83
Suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)+ Ca^{+2} chelator (30 mM\l)	18.67	15.00	16.83	18.67	13.33	16.00	16.42	18.67	14.17
Mean (B*C)	13.33	10.89	12.11	13.17	10.39	11.78	------	13.25	10.64

L.S.D at 5 % level

Factor	Pulsing solution (A)	Storage position (B)	Storage period (c)	(A*B)	(A*C)	(B*C)	(A*B*C)
L.S.D at 5 % level	1.28	0.74	0.74	1.82	1.05	1.82	2.57

Table (3): Effect of pulsing solution, storage position, storage period and their interaction on vase life (days) of *Moluccella laevis* L. cut flowers during (2009).

Treatment	Storage position (B)						Mean		
	Vertical			Horizontal					
Pulsing solution (A)	Storage period (C)								
	3 days	7 days	Mean A*B	3 days	7 days	Mean A*B	(A)	(A*C)	(A*C)
BA (25 mg\l)	8.33	5.33	6.83	8.33	5.33	11.67	6.83	8.33	5.33
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)	12.67	10.67	19.17	13.00	9.67	5.33	11.50	12.83	10.17
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)+suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)	20.00	18.33	8.33	20.33	17.67	15.83	19.08	20.17	18.00
DW	5.67	5.00	6.83	6.00	5.67	11.33	5.58	5.83	5.33
Ca^{+2} chelator (30 mM\l)	8.67	8.00	19.00	8.00	7.33	5.83	8.00	8.33	7.67
Suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)+ Ca^{+2} chelator (30 mM\l)	17.67	14.00	7.67	17.67	12.00	14.83	15.33	17.67	13.00
Mean (B*C)	12.17	10.22	11.19	12.22	9.61	10.92	-------	12.19	9.92

L.S.D at 5 % level

Factor	Pulsing solution (A)	Storage position (B)	Storage period (c)	(A*B)	(A*C)	(B*C)	(A*B*C)
L.S.D at 5 % level	1.25	0.72	0.72	1.76	1.02	1.76	2.49

Table (4): Effect of pulsing solution, storage position, storage period and their interaction on abscission percentage of *Moluccella laevis* L. cut flowers during 2008.

Treatment	Storage position (B)						Mean		
	Vertical			Horizontal					
Pulsing solution (A)	Storage period (C)								
	3 days	7 days	Mean A*B	3 days	7 days	Mean A*B	(A)	(A*C)	(A*C)
BA (25 mg\l)	73.33	82.67	78.00	76.00	90.00	83.00	80.50	74.67	86.33
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)	35.00	40.00	37.50	50.33	65.00	57.67	47.58	42.67	52.50
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)+suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)	10.00	15.00	12.50	20.00	45.00	32.50	22.50	15.00	30.00
DW	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ca^{+2} chelator (30 mM\l)	50.0	60.00	55.00	80.00	86.00	83.00	69.00	65.00	73.00
Suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)+ Ca^{+2} chelator (30 mM\l)	20.00	25.00	22.50	40.00	55.00	47.50	35.00	30.00	40.00
Mean (B*C)	48.06	53.78	50.92	61.06	73.50	67.28	------	54.56	63.64

L.S.D at 5 % level

Factor	Pulsing solution (A)	Storage position (B)	Storage period (c)	(A*B)	(A*C)	(B*C)	(A*B*C)
L.S.D at 5 % level	1.75	1.01	1.01	2.47	1.43	2.47	3.50

Table (5): Effect of pulsing solution, storage position, storage period and their interaction on abscission percentage of *Moluccella laevis* L. cut flowers during 2009.

Treatment	Storage position (B)						Mean		
	Vertical			Horizontal					
Pulsing solution (A)	Storage period (C)								
	3 days	7 days	Mean A*B	3 days	7 days	Mean A*B	(A)	(A*C)	(A*C)
BA (25 mg\l)	74.00	82.00	78.00	78.00	95.00	86.50	82.25	76.00	88.50
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)	40.00	45.00	42.50	54.00	65.67	59.83	51.17	47.00	55.33
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)+suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)	15.00	17.00	16.00	23.00	50.00	36.50	26.25	19.00	33.50
DW	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ca^{+2} chelator (30 mM\l)	54.00	63.00	58.50	83.00	90.00	86.50	72.50	68.50	76.50
Suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)+ Ca^{+2} chelator (30 mM\l)	20.00	28.00	24.00	45.00	58.00	51.50	37.75	32.50	43.00
Mean (B*C)	50.50	55.83	53.17	63.83	76.44	70.14	-------	57.17	66.14

L.S.D at 5 % level

Factor	Pulsing solution (A)	Storage position (B)	Storage period (c)	(A*B)	(A*C)	(B*C)	(A*B*C)
L.S.D at 5 % level	1.73	1.00	1.00	2.44	1.41	2.44	3.46

Table (6): Effect of pulsing solution, storage position, storage period and their interaction on water uptake (cm) of *Moluccella laevis* L. cut flowers during 2008.

Treatment	Storage position (B)						Mean		
	Vertical			Horizontal					
Pulsing solution (A)	Storage period (C)								
	3 days	7 days	Mean A*B	3 days	7 days	Mean A*B	(A)	(A*C)	(A*C)
BA (25 mg\l)	120.0	110.0	115.0	115.0	108.0	111.5	113.3	117.5	109.0
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)	160.0	140.0	150.0	150.0	137.0	143.5	146.8	155.0	138.5
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)+suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)	195.0	182.0	188.5	190.0	180.0	185.0	186.8	192.5	181.0
DW	100.0	95.0	97.5	98.00	92.0	95.0	96.3	99.0	93.5
Ca^{+2} chelator (30 mM\l)	148.0	137.0	142.5	142.0	133.0	137.5	140.0	145.0	135.0
Suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)+ Ca^{+2} chelator (30 mM\l)	180.0	168.0	174.0	176.0	153.0	164.5	169.3	178.0	160.5
Mean (B*C)	150.5	138. 7	144.6	145.2	133.8	139.5	------	147.8	136.3

L.S.D at 5 % level

Factor	Pulsing solution (A)	Storage position (B)	Storage period (c)	(A*B)	(A*C)	(B*C)	(A*B*C)
L.S.D at 5 % level	3.09	1.76	1.77	4.30	2.48	4.30	6.08

Table (7): Effect of pulsing solution, storage position, storage period and their interaction on water uptake (cm) of *Moluccella laevis* L. cut flowers during 2009.

Treatment	Storage position (B)						Mean		
	Vertical			Horizontal					
Pulsing solution (A)	Storage period (C)								
	3 days	7 days	Mean A*B	3 days	7 days	Mean A*B	(A)	(A*C)	(A*C)
BA (25 mg\l)	125.0	117.0	121.0	120.0	115.0	117.5	119.3	122.5	116.0
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)	170.0	155.0	162.5	160.0	150.0	155.0	158.8	165.0	152.5
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)+suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)	200.0	191.0	195.5	195.0	187.0	191.0	193.3	197.5	189.0
DW	95.0	90.0	92.5	100.0	87.0	93.5	93.0	97.5	88.5
Ca^{+2} chelator (30 mM\l)	150.0	143.0	146.5	145.0	139.0	142.0	144.3	147.5	141.0
Suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)+ Ca^{+2} chelator (30 mM\l)	195.0	180.0	187.5	193.0	177.0	185.0	183.3	194.0	178.5
Mean (B*C)	155.8	146.0	150.9	152.2	142.5	147.3	-------	154.0	144.3

L.S.D at 5 % level

Factor	Pulsing solution (A)	Storage position (B)	Storage period (c)	(A*B)	(A*C)	(B*C)	(A*B*C)
L.S.D at 5 % level	1.44	0.88	0.88	2.09	1.77	2.09	2.88

Table (8): Effect of pulsing solution, storage position ,storage period and their interaction on fresh weight (g\flower) of *Moluccella laevis* L. cut flowers during 2008.

Treatment	Storage position (B)						Mean		
	Vertical			Horizontal					
Pulsing solution (A)	Storage period (C)								
	3 days	7 days	Mean A*B	3 days	7 days	Mean A*B	(A)	(A*C)	(A*C)
BA (25 mg\l)	1.36	1.27	1.32	1.27	1.18	1.23	1.27	1.32	1.23
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)	1.49	1.42	1.46	1.43	1.34	1.39	1.42	1.46	1.38
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)+suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)	2.31	1.98	2.15	1.84	1.69	1.77	1.96	2.08	1.84
DW	0.82	0.50	0.66	0.46	0.37	0.42	0.54	0.64	0.44
Ca^{+2} chelator (30 mM\l)	1.48	1.28	1.38	1.28	1.16	1.22	1.30	1.38	1.22
Suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)+ Ca^{+2} chelator (30 mM\l)	1.89	1.76	1.83	1.58	1.45	1.52	1.67	1.74	1.61
Mean (B*C)	1.56	1.37	1.46	1.31	1.20	1.26	-------	1.43	1.28

L.S.D at 5 % level

Factor	Pulsing solution (A)	Storage position (B)	Storage period (c)	(A*B)	(A*C)	(B*C)	(A*B*C)
L.S.D at 5 % level	0.11	0.06	0.06	0.15	0.09	0.15	0.21

Table (9): Effect of pulsing solution, storage position, storage period and their interaction on fresh weight (g\flower) of *Moluccella laevis* L. cut flowers during 2009.

Treatment	Storage position (B)						Mean		
	Vertical			Horizontal					
Pulsing solution (A)	Storage period (C)								
	3 days	7 days	Mean A*B	3 days	7 days	Mean A*B	(A)	(A*C)	(A*C)
BA (25 mg\l)	1.30	1.18	1.24	1.25	1.05	1.15	1.20	1.28	1.12
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)	1.46	1.30	1.38	1.40	1.22	1.31	1.35	1.43	1.26
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)+suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)	2.00	1.78	1.89	1.80	1.49	1.65	1.77	1.90	1.64
DW	0.65	0.41	0.50	0.42	0.25	0.34	0.42	0.51	0.33
Ca^{+2} chelator (30 mM\l)	1.35	1.21	1.28	1.28	1.10	1.19	1.24	1.32	1.16
Suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)+ Ca^{+2} chelator (30 mM\l)	1.69	1.60	1.65	1.53	1.35	1.44	1.54	1.61	1.48
Mean (B*C)	1.40	1.25	1.32	1.28	1.08	1.18	-----	1.34	1.16

L.S.D at 5 % level

Factor	Pulsing solution (A)	Storage position (B)	Storage period (c)	(A*B)	(A*C)	(B*C)	(A*B*C)
L.S.D at 5 % level	0.037	0.02	0.02	0.05	0.05	0.03	0.07

Table (10): Effect of pulsing solution, storage position, storage period and their interaction on curvature (angle) of *Moluccella laevis* L. cut flowers during (2008.

Treatment	Storage position (B)						Mean		
	Vertical			Horizontal					
Pulsing solution (A)	Storage period (C)								
	3 days	7 days	Mean A*B	3 days	7 days	Mean A*B	(A)	(A*C)	(A*C)
BA (25 mg\l)	175	170	172.5	75	65	70	121.3	125	117
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)	180	180	180	130	125	127.5	153.8	155	152
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)+suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)	180	180	180	155	140	147.5	163.8	167.5	160
DW	168	165	166.7	70	60	65	115.8	119.2	122.5
Ca^{+2} chelator (30 mM\l)	180	180	180	120	115	117.5	148.8	150	147.5
Suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)+ Ca^{+2} chelator (30 mM\l)	180	180	180	140	130	135	157.5	160	155
Mean (B*C)	177.2	175.8	176.5	115	105.8	110.4	------	146.1	140.8

L.S.D at 5 % level

Factor	Pulsing solution (A)	Storage position (B)	Storage period (c)	(A*B)	(A*C)	(B*C)	(A*B*C)
L.S.D at 5 % level	4.56	2.63	2.63	6.45	3.73	6.45	9.12

Table (11): Effect of pulsing solution, storage position, storage period and their interaction on curvature (angle) of *Moluccella laevis* L. cut flowers during 2009.

Treatment	Storage position (B)						Mean		
	Vertical			Horizontal					
Pulsing solution (A)	Storage period (C)								
	3 days	7 days	Mean A*B	3 days	7 days	Mean A*B	(A)	(A*C)	(A*C)
BA (25 mg\l)	160	158	159	70	50	60	109.5	115	104
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)	180	180	180	120	100	110	145	150	140
BA (25 mg\l) + Ca^{+2} chelator (30 mM\l)+suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)	180	180	180	150	130	140	160	165	155
DW	170	140	155	60	35	47.5	101.3	115	87.5
Ca^{+2} chelator (30 mM\l)	180	180	180	110	100	105	142.5	145	140
Suc (30 g\l) + 8-HQC (250 mg\l) + ca (200 mg\l)+ Ca^{+2} chelator (30 mM\l)	180	180	180	130	120	125	152.5	155	150
Mean (B*C)	175	169.7	172.3	106.7	89.2	97.9	------	140.8	129.4

L.S.D at 5 % level

Factor	Pulsing solution (A)	Storage position (B)	Storage period (c)	(A*B)	(A*C)	(B*C)	(A*B*C)
L.S.D at 5 % level	1.34	0.77	0.77	1.90	1.1	1.90	2.68