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Delaying of Postharvest Senescence of Lisianthus Cut Flowers by Salicylic Acid Treatment

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Salicylic acid (SA) is considered to be plant signal molecule that plays a key role in plant growth, development, and defense responses. The physiological mechanism of exogenous SA to affect the senescence of cut lisianthus flowers during vase life was investigated. Fresh cut lisianthus flowers were treated with distilled water (control), 0.5, 1 and 2 mM SA and then held at 25 °C up to 12 days. Exogenous SA supply at 1 mM extended vase life, which was associated with reduced electrolyte leakage and MDA content. SA treatment also reduced activity of lipoxygenase (LOX), which is responsible for membrane lipid peroxidation. SA treatment also enhanced activities of catalase (CAT) and ascorbate peroxidase (APX) and decreased H2O2 accumulation during vase life. Thus, exogenous SA supply could maintain membrane integrity by increasing antioxidant system activity, thereby retarding the senescence of cut lisianthus flower during vase life.

Keywords: Antioxidant enzyme, Lipoxygenase, Lisianthus, Salicylic acid, Vase life.
INTRODUCTION

Lisianthus (*Eustoma grandiflorum*) is becoming one of the most highly ranked cut flowers in international markets, due to its rose-like flower shapes and beautiful colors (Bahrami *et al.*, 2013). Vase life as a commercial attribute determines the flexibility of the market at any one time, particularly for cut flowers. The short vase life of cut flowers is related to physiochemical processes which affect senescence. These attributes are highly influenced by water loss and wilting during transportation. Water deficit and consequent precocious senescence result in poor quality of cut flowers and loss of markets, and there are many reports on these effects (Ezhilmathi *et al.*, 2007). Maintaining the quality of cut flowers is one of the main challenges of florists in the flower trade worldwide. In floriculture, delaying the onset of senescence in order to prolong the vase life of cut flowers is the focus of many researchers (Hassan and Ali, 2014).

Membrane deterioration is an early and characteristic feature of petal irreversible senescence of cut flowers. Increased lipid peroxidation, mediated and sustained by phospholipid-degrading enzymes, such as phospholipase D (PLD) and lipoxygenase (LOX), results in a loss of membrane integrity, which has been noted in the senescing petal tissues (Brown *et al.*, 1990). It has been observed that flower senescence is accompanied with increased permeability of petal cells and increased ROS production (Reezi *et al.*, 2009). Accumulation of harmful ROS such as superoxide (O$_2^-$), hydrogen peroxide (H$_2$O$_2$) and hydroxyl radical (OH) lead to the oxidation of the cells vital molecules such as loss of membrane integration via lipid peroxidation, protein oxidation, enzymatic activity inhibition, and, finally, damage to DNA and RNA and dictates, ultimately, oxidative stress. In plant cells, ROS accumulation may be due to the inescapable leakage of electrons onto O$_2$; from the electron transport chain in chloroplasts and mitochondria and/or by the activation of LOX or NADPH oxidases located in cell membranes (Aghdam and Bodbo-dak, 2014). Cellular antioxidants are an important buffer against free radical-induced oxidations (Smith *et al.*, 1989). For the survival of plants, appropriate functioning of the antioxidant system is important to maintain a balance between ROS production and scavenging. Several enzymes such as catalase (CAT) and ascorbate peroxidase (APX) are involved in the scavenging of ROS in plant systems (Scelba *et al.*, 1999).

Postharvest treatments have been used to increase cut flowers vase life by regulating water balance, distribution of assimilates, delaying senescence and blocking microbial agents. However, use of nontoxic, easy to use and inexpensive molecules is always crucial in this respect for large-scale applications. Salicylic acid (SA) has been considered a new potential alternative for this purpose and has been found to affect physiological and biochemical functions in plants (Asghari and Aghdam, 2010). In addition, a potential role of SA in response to stresses and gene expression during senescence has been demonstrated (Morris *et al.*, 2000). Recently, it has been found that SA delayed gladiolus and rose cut flower senescence (Ezhilmathi *et al.*, 2007; Alaey *et al.*, 2011). Alaey *et al.* (2011) suggested that the SA is able to increase the vase life of cut rose flowers and delay senescence by regulating the plant water and increasing the scavenging capacity of cells. In the present study, we investigated the effects of pulse treatment with SA on the vase life of cut lisianthus flowers, as well as physiological and biochemical changes during its petal senescence.

MATERIALS AND METHODS

Flowers and treatments

Cut flowers of lisianthus (*Eustoma grandiflorum*) ‘Miarichi Grand White’ were obtained from a commercial greenhouse and were re-cut under tap water to have uniform length of 30 cm. Flowers were then placed in a preservative solution containing distilled water (control), 0.5, 1 and 2 mM SA. All treatments were kept at 25 ± 1°C under a 16:8 h light/dark cycle and 60 ± 5% RH for 24 hours. Subsequently, flowers were transferred to flasks containing only 200 ml$^{-1}$ distilled water. The end of vase life was evaluated as the time which 50% of the open flowers had wilted (Cho *et al.*, 2001).
Membrane integrity evaluation

Membrane permeability, expressed by relative electrolyte leakage rate, was measured by the method of Jiang and Chen (1995). Thirty petal discs were immersed in 20 mL of 0.3 M mannitol solution at 25 °C, followed by shaking for 30 min. Electrolyte leakage was determined with a conductivity meter. Total electrolyte leakage was determined after boiling the samples for 10 min. and cooling to 25 °C. Relative electrolyte leakage rate was expressed as a percentage of total electrolyte leakage. MDA content was measured according to the method of Heath and Parker (1968). Frozen petal tissues (1 g) from 10 flowers were ground finely in liquid nitrogen, then homogenized in 15 mL of 10% trichloroacetic acid (TCA) and finally centrifuged at 5000 × g for 10 min. The supernatant phase was then collected. MDA content was determined by adding 5 mL of 0.5% thiobarbituric acid (dissolved in 10% TCA) to 0.5 mL supernatant. The solution was heated at 95 °C for 20 min, quickly cooled, and centrifuged at 10,000 × g for 10 min to clarify precipitation. Absorbance at 532 nm was measured and subtracted from the non-specific absorbance at 600 nm. The concentration of MDA was calculated with an extinction coefficient of 1.55 n mol L⁻¹m⁻¹. MDA content was expressed as n mol g⁻¹ fresh weight (FW).

According to method of Doderer et al. (1992), for analysis of LOX activity, frozen petal tissues (1 g) from 10 flowers were ground finely in liquid nitrogen and then homogenized in 15 mL of 50 mM phosphate buffer (pH 7.0). After centrifugation at 10,000 × g and 4 °C for 20 min, the supernatant was collected and then used as the crude enzyme extract. LOX activity was assayed at 25 °C by monitoring the formation of conjugated dienes from linoleic acid at 234 nm according to the method of Axelrod et al. (1981). The reaction mixture (3 mL) contained 2.8 mL of 50 mM sodium phosphate buffer (pH 7.0), 0.1 mL of 10 mM sodium linoleic acid solution and 0.1 mL of the crude enzyme solution. One unit of LOX activity was defined as a change of 0.01 in absorbance per minute at 25 °C. The specific LOX activity was expressed as U mg⁻¹ protein.

Antioxidant system activity evaluation

Frozen petal tissues (2 g) from 10 flowers were ground finely in liquid nitrogen and then homogenized in 15 mL of 50 mM potassium phosphate buffer (pH 7.0) containing 1% (w/v) PVP. The homogenate was centrifuged at 10,000 × g for 15 min at 4 °C and then the supernatant was used to determine activities of CAT and APX. CAT activity was assayed by measuring the disappearance of hydrogen peroxide (H₂O₂) according to the method of Oracz et al. (2009). The assay mixture (3 mL) contained 2.95 mL of 44.25 M H₂O₂ in 50 mM phosphate buffer (pH 7.0) and 0.05 mL of enzyme extract. CAT activity was calculated by a decrease in absorbance at 240 nm for 3 min at 25 °C. One unit of CAT activity was defined as the amount of the enzyme that caused a change of 0.001 in absorbance per minute and the specific activity was expressed as U mg⁻¹ protein. APX activity was determined by the method of Nakano and Asada (1981). The reaction mixture (3 mL) consisted of 1.5 M ascorbic acid, 0.3 M EDTA and 0.3 M H₂O₂ solution in 50 mM phosphate buffer (pH 7.0) and 0.1 mL of enzyme extract. Ascorbate concentration was followed by the decrease in absorbance at 290 nm (extinction coefficient 2.8 mM cm⁻¹). One unit of APX activity was defined as 1 M ascorbate oxidized per minute at 290 nm and the specific activity was expressed as U mg⁻¹ protein. The protein concentration of petal extracts was estimated using the method of Bradford (1976) by BSA as standard. The H₂O₂ content measured according to Patterson et al. (1984). Frozen petal tissues (1 g) from 10 flowers were homogenized with 10 ml of acetone at 0 °C. After centrifugation for 15 min at 6000 × g at 4 °C, the supernatant was collected. The supernatant (1 ml) was mixed with 0.1 ml of 5% titanium sulphate and 0.2 ml ammonia, and then centrifuged for 10 min at 6000 × g and 4 °C. The pellets were dissolved in 3 ml of 10% (v/v) H₂SO₄ and centrifuged for 10 min at 5000 × g. Absorbance of the supernatant phase was measured at 410 nm. H₂O₂ content was calculated using H₂O₂ as a standard and then expressed as µmol g⁻¹ fresh weight (FW).

For physiological parameters, results were expressed as mean ± SE from 3 replications.
Statistical significance between mean values was assessed using one way analysis of variance with SAS (Version 9.1) statistical software. Means were compared using the LSD test.

RESULTS AND DISCUSSION

Vase life
As shown in Fig. 1, treatment with postharvest SA at 1 mM resulted in a higher lisianthus cut flowers vase life (P<0.01). Based on these results, 1 mM SA for postharvest treatment was chosen for further analyses.

Salicylic acid treatment and membrane integrity
Electrolyte leakage of the lisianthus cut flowers increased during vase life (Table 1). The electrolyte leakage of lisianthus cut flowers treated with 1 mM SA at postharvest stage remained lower than that in untreated control flowers (P<0.01; Table 1). As well, during vase life, the MDA content in the lisianthus cut flowers increased (Table 1). Compared to the controls, a lower content of MDA was found in the lisianthus cut flowers treated with postharvest 1 mM SA (P<0.01; Table 1). There was a significant increase in the activity of LOX in lisianthus cut flowers during vase life (Table 1). The treatment with SA caused reduction in LOX activity in comparison to the control for the whole 12 days of vase life (P<0.01; Table 1).

Electrolyte leakage is an effective parameter to assess membrane permeability and therefore is used as an indicator of membrane integrity. In addition, lipid peroxidation, responsible for loss
of cell membrane integrity, could be evaluated by the content of malonyldialdehyde (MDA; Aghdam and Bodbodak (2014). Lipid peroxidation could be carried out by enzymatic oxidation of unSFA by LOX or by non-enzymatic oxidation by ROS. MDA is the end product of the peroxidation of membrane fatty acids. The quantity of MDA is used as a marker of oxidative stress and a rise of MDA indicates damage of cell membrane integrity. The main result of both events is the loss of the biomembrane functionality (Sevillano et al., 2009). Hassan and Ali (2014) reported that the 1-MCP or SA treatments significantly prolonged the vase life and minimized the weight loss of gladiolus spikes compared with the control. Both treatments enhanced the relative water content (RWC) of leaves and maintained chlorophyll content compared with the control values, which were decreased. Ethylene production, proline accumulation and MDA content were increased in florets of untreated spikes. 1-MCP or SA reduced ethylene production, decreased both proline content and MDA level and hence maintained membrane stability. The increment in MDA has been described as a biomarker of lipid peroxidation (Bailly et al., 1996) and thus decreased its level in lisianthus cut flowers treated with SA indicates reduced lipid peroxidation. Reduced lipid peroxidation participates to decreased electrolyte leakage in response to SA treatment. Such effect of SA as lipid peroxidation reduction and maintained cell stability was previously reported by Ezhilmathi et al. (2007) and Hatamzadeh et al. (2012). Reduced lipid peroxidation and retained membrane stability have been demonstrated to be inversely proportional with flower senescence in gladiolus (Hatamzadeh et al., 2012).

Mansouri (2012) reported that the SA at 0.1 and 1.0 mM and nitric oxide at 0.1 mM increased vase life and decreased fresh weight loss of chrysanthemum flowers. Anthocyanin content increased in chrysanthemum flowers treated with 1 mM SA and nitric oxide. The electrolyte leakage associated with MDA accumulation reduced in chrysanthemum flowers treated with SA and nitric oxide treatments. Reducing sugar contents increased with SA treatment. Postharvest SA and nitric oxide application at low concentration prolonged vase life of cut chrysanthemums by improving the membrane stability and decreasing the lipid peroxidation. Mansouri (2012) suggested that the extended vase life in SA treated chrysanthemums is associated with decreased fresh weight loss, improved membrane permeability and decreased lipid peroxidation. According to our results, SA might extend vase life through improving membrane permeability and decreasing of lipid peroxidation. Since lipid peroxidation is mediated by ROS (Kellogg, 1975), therefore SA may either be directly scavenging ROS and thus decreasing lipid peroxidation, or it may be modulating the activity of antioxidant enzymes. Senescing plant tissue also experiences an increase in LOX activity, which also promotes the process of membrane polyunsaturated fatty acid peroxidation (Lynch and Thompson, 1984). Similar to lipid peroxidation (MDA content), SA caused a decrease in LOX activity during vase life (Table 1). An increase in LOX activity has been correlated with an increase in cell membrane permeability and senescence in daylily and rose (Panavas and Rabinstein, 1998; Fukuchi-Mizutani et al., 2000).

**Salicylic acid treatment and antioxidant system activity**

As shown in Table 2, lisianthus cut flowers treated with SA showed higher activities of CAT and APX associated with lower H$_2$O$_2$ accumulation during vase life (P<0.01; Table 1). Hassan and Ali (2014) reported that the 1-MCP or SA treatments significantly prolonged the vase life and minimized the weight loss of gladiolus spikes compared with the control. An increase in floret antioxidant enzyme activities (CAT, SOD and POX) was observed in 1-MCP or SA treated spikes compared with the control. The effects of 1-MCP or SA on floret senescence seemed not entirely limited due to their effects on ethylene, but they most likely had a sustainable impact on the membrane integrity. Hassan and Ali (2014) reported that the 1-MCP or SA treatments alleviated the oxidative stress in cut flowers during postharvest senescence. The role of SA treatment in scavenging the ROS and preventing flower senescence is previously indicated (Ezhilmathi et al., 2007;
The activities of antioxidant enzymes are considered as a response against oxidative stress (Zhou et al., 2014). SA treatments enhanced the production of antioxidant enzymes which scavenge the ROS, as indicated by the decreased level of MDA (Table 1 and 2).

Cellular membranes are highly prone to ROS such as H2O2 attack, and it is reasonable to propose that progressive decline in membrane stability assayed by MDA content is probably the consequence of enhanced ROS attack under decreasing antioxidant activity such as CAT and APX enzymes activity during vase life (Table 2). Senescence of flowers has been delayed by the use of commercial ROS scavengers, such as SA (Alaey et al., 2011). In the present study, the decline in membrane integrity of lisianthus cut flowers was alleviated by treatment with SA, which was associated with an increase in CAT and APX activity in treated flower. It is therefore reasonable to propose that SA has a role in the induction of antioxidant enzymes and/or might also be acting as a scavenger of ROS, thus maintaining membrane integrity for extended period. Ezhilmathi et al. (2007) reported that petal wilting in Gladiolus is associated with ROS induced lipid peroxidation, enhanced LOX activity, and decrease in ROS scavenging system in the form of SOD and CAT. Also, Ezhilmathi et al. (2007) reported that the Gladiolus cut flowers treated with 5-sulfosalicylic acid (5-SSA) exhibited significantly higher water uptake, vase life, number of opened florets and lower number of unopened florets. Gladiolus cut flowers treated with 5-SSA also exhibited lower respiration rates, lipid peroxidation and LOX activity, and higher membrane stability, soluble protein concentration, and activity of SOD and CAT. Results suggested that 5-SSA increased vase life by increasing the ROS scavenging activity of the gladiolus cut flowers. Promyou et al. (2012) reported that postharvest treatment with salicylic acid (2 mM for 15 min) alleviated CI in anthurium cut flower, an effect associated with decreasing electrolyte leakage, MDA content and lipoxygenase (LOX) activity, and increasing catalase (CAT) and superoxide dismutase (SOD) activities, which led to a decreasing of spathe browning and fresh weight loss, two detrimental effects of CI on this ornamental. Alaey et al. (2011) reported that the SA treated cut rose flower showed higher water uptake, relative fresh weight, and CAT activity. SA retarded the decrease of CAT activity during flowers senescence. Alaey et al. (2011) suggested that the postharvest SA application prolonged vase life in cut rose flowers by improving the ROS scavenging capacity related to CAT activity and by better regulation of the water balance.

**CONCLUSION**

In conclusion, the study was an attempt to investigate the potential roles of SA in delaying the senescence of cut lisianthus flowers. SA was able to prolong the vase life and delay flower
senescence by maintaining membrane integrity, which was result from decreasing LOX enzyme activity as responsible for membrane lipid peroxidation and increasing the antioxidant enzymes CAT and APX activities, which was led to diminishing H2O2 accumulation. The effects of SA treatment on retarding flower senescence was due to increased antioxidant enzyme activities and thus reduced lipid peroxidation and maintained membrane stability, assayed by electrolyte leakage and MDA content.

**Literature Cited**


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Effect of Agar and Different Culture Media on the Micropropagation of *Rosa hybrida* cv.’Black Baccara’

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Abstract

*In vitro* propagation of plant has played a very important role in rapid multiplication of cultivars with desirable traits and production of healthy and disease-free plants. In the present investigation, the objectives were to optimize the micropropagation of *Rose hybrid* ‘Black Baccarat’ cultivar. In proliferation step, the nodal segments (1.5 cm) was cultured on both liquid and solid media (MS, VS and WPM). The results showed that the highest shoot proliferation was obtained on VS medium. The highest amount of multiplication and the growth rate were obtained in the liquid medium. For rooting, three concentrations of VS mineral salts (full-, half-, and quarter-strength) containing NAA (0.5 µM) were tested in semi-solid and liquid media. Root initiation influenced by mineral concentration in the medium. The investigation showed that the highest number of roots was observed in semi-solid 1/4 VS medium. Variation in multiplication and growth rate of explants can be explained on the basis of water potential and mineral availability to the explants in the liquid medium.

**Keywords:** Agar, Growth, Media, Multiplication, *Rosa hybrida*, Tissue culture.
INTRODUCTION

Roses are the most economically important flowers in the world. There are more than 20,000 commercial cultivars, which are collectively based on only 8 of the approximately 200 wild species in the genus Rosa (Khosravi et al., 2007). In the last few years, in vitro propagation has revolutionized commercial nursery business (Pierik, 1991). Tissue culture on the other hand is becoming increasingly popular as an alternative to the conventional plant propagation methods (Roberts and Schum, 2003). Significant features of in vitro propagation procedure are its enormous multiplicative capacity in a relatively short span of time; production of healthy and disease-free plants; and its ability to generate propagules around the year (Kumar et al., 2006). Micropropagation has five major advantages compared to the conventional methods of plant propagation: (i) it is an valuable aid in the multiplication of elite clones of intractable/recalcitrant species; (ii) it is important in terms of multiplying plants throughout the year, with control over most facts of production; (iii) it is possible to generate pathogen-free plants even from explants of infected mother plants; (iv) plant materials such as male sterile, fertility maintainer and restorer lines can be cloned; and (v) it enables the production of a large number of plants in a short time from a selected number of genotypes (Jafarkhani Kermani et al., 2011).

Horn (1992) marked a clear effect of genotypes on in vitro propagation in different cultivars of Floribunda and Hybrid Tea rose. He observed that it was easy to propagate cultivars Kardinal and Lilli Marleen, whereas it was very difficult to propagate Anthena, Mercedes, Pasadena and Golden Times.

By using liquid medium, it may be possible to reduce costs to a level lower than solid medium and liquid medium is better than solid medium in growth. Both the brand and concentration of agar also affect the chemical and physical characteristics of a culture medium (Debergh, 1983). Agar concentration and agar brand are known greatly influence the growth response of micropropagated plants (Signha et al., 1985; von Arnold and Eriksson, 1984). The effects of agar concentration are on the shoot elongation, and leaf and apex necrosis. Shoot elongation was shown to decrease with increasing agar concentration (von Arnold and Eriksson 1984), leaf mineral deficiency (necrosis of the apex) and their subsequent drying in vitrified plants (Debergh and Maene, 1984). The use of liquid medium for in vitro culture has many advantages and has been the subject of many studies over many years. It has also frequently been considered an ideal technique for mass production as it reduces manual labor and facilitates changing the medium composition (Berthouly and Etienne, 2002). Although many positive results have been founded with liquid culture, vitrification, physiological disorder of tissue cultured plants in which tissue, exhibit translucency, hyperhydric transformation, water loggying or glassiness, has been reported for many crops cultured directly in liquid media (Chu et al., 1993). It is well known that agar as a solidifying agent can have an effect on the growth and development of in vitro cultures (Pierik et al., 1997). Water relation and growth of plant in vitro are assumed to be closely related to the water status of the culture medium. However, only a few studies have concerned water status of plant in vitro. The objective of the study was to investigate the best media for micropropagation of Rosa hybrid cv. ‘Black Baccara’ in vitro condition.

MATERIALS AND METHODS

Plant material and general procedures

Nodal segments (1-1.5 cm) were taken from the stems of ‘Black Baccara’ plants in the rose garden of the Agricultural Biotechnology Research Institute of Iran (ABRII). They were washed thoroughly with running tap water for 30’ and surface sterilized for 30 seconds in 70% (v/v) ethanol, followed by a 15 min soak in 2.5% (v/v) sodium hypochlorite solution with a few drops of Tween-20 as a wetting agent, and then rinsed three times with sterile distilled water. MS (Murashige and Skoog, 1962) basal medium (without hormone) was used for the in vitro of induction of explants in culture; the pH of the medium was adjusted to 5.8 before adding 8 g/L plant agar. Media were
autoclaved for 15 min at 121°C and 1.2 kPa pressure. Cultures were placed under high pressure metal halide lamps on a 16/8 hour light/dark cycle in a culture room maintained at 21 ± 1°C.

**Shoot proliferation step**

Three culture media were employed; MS medium (Murashige and Skoog, 1962), VS medium (van der Salm et al., 1994) and WPM medium (Mc Crown and Lloyd, 1980) macro and micro element (Duchefa). Axillary shoot of *Rosa* was cultured on both liquid and gelled (Fig. A). The pH medium was adjusted to 5.8 before autoclaving medium containing BAP 2 µM/l. Multiplication growth rate were recorded after 21 days for three subsequent subcultures and the averages were calculated.

**Rooting stage and acclimatization**

Shoots were cultured on shoot elongation medium (VS minerale salts and vitamin without hormones) for 27 days prior to rooting treatments. For rooting, three concentrations of VS mineral salts and vitamins (full-, half-, and quarter-strength) containing NAA (0.5 µM) were tested in semi-solid and liquid media. Each treatment involved 3 repeats with 3 explants. After 21 days, number of roots and their lengths were recorded and data for different concentrations of VS media (full, 1/2 and 1/4) and state of media (semi-solid and liquid) were recorded. Plantlets were acclimatized using a soil mixture consisting of peat moss and sand 1:1 (v/v) and successfully transferred to the greenhouse after 3 weeks.

**Experimental design and statistical analyses**

For the proliferation stage experiments were conducted as factorial experiments based on RCD with 5 replications and each replication included 3 explants in one glass baby food jar per treatment. Rooting experiment, *in vitro* conservation and recovery of shoots were carried out in a factorial based completely random design with 3 observations and 3 replications. In the rooting stage, the percentage of rooting, number of roots per plantlet and total root length per plantlet were recorded after four weeks. Analysis of variance was performed and comparisons of means were conducted using Duncan’s Multiple Range Test.

**RESULTS**

**Shoot proliferation**

The results showed that there was significant difference between the effect of media type and vegetative traits of *R. hybrid* cv. ‘Black Baccara’ in proliferation stage (p<0.05). The lowest shoot multiplication was observed on WPM medium while the highest shoots were formed on VS medium and maximum number of leaves per explants (11.07) was production on the VS medium (Table 1). The observation indicates that there were significant differences between solid and liquid media and best result was achieved for proliferation by liquid medium (Table 2). Maximum number of shoot per explants (2.66) was produced on the liquid medium. Maximum number of shoot per explants (3.66) was produced on the VS liquid medium, whereas the maximum shoot length were obtained on the MS liquid medium (Fig. 1 and 2). The growth rate increased from four weeks and continued until the sixth week (Fig. 3).

<table>
<thead>
<tr>
<th>Medium Culture</th>
<th>Number of axillary shoots per explant</th>
<th>Number of new leaves produced per explant</th>
<th>Shoot length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Murashige &amp; Skoog (MS)</td>
<td>2.1 b</td>
<td>9.37 b</td>
<td>2 a</td>
</tr>
<tr>
<td>Van der Salm (VS)</td>
<td>2.49 a</td>
<td>11.07 a</td>
<td>2.1 a</td>
</tr>
<tr>
<td>Woody Plant Medium(WPM)</td>
<td>1.47 c</td>
<td>3.49 c</td>
<td>1.78 b</td>
</tr>
</tbody>
</table>

Numbers followed by the same letter are not significantly different according Duncan Test (P<0.05).
Root initiation

The average number of roots (4.6) and root length (4.5 cm) were significantly higher in 1/4 strength VS (Table 3). Table 3 compares the effect of semi-solid and liquid media. Statistical analysis indicates that there was a significant difference between the average root length in semi-solid and liquid media. The highest root length, root number was recorded in ¼ VS medium. The best results were obtained on VS medium containing 1/2 strength of VS macro- micro- salts and vitamins. The rooted plants were not difficult to acclimatization at ±24 °C and relative humidity of 80% during initial stages of development gradually reduced to 40% after 4 weeks of culture and was transferred to the greenhouse for flowering. Fig. 4 illustrates the morphogenetic responses of the shoots treated with three (full, 1/2 and 1/4) strengths of VS salts and vitamins.

<table>
<thead>
<tr>
<th>Medium</th>
<th>Number of shoot (per explants)</th>
<th>Length of shoot (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid medium</td>
<td>1.66 a</td>
<td>1.65 a</td>
</tr>
<tr>
<td>Liquid medium</td>
<td>2.66 a</td>
<td>1.56 a</td>
</tr>
</tbody>
</table>

Numbers followed by the same letter are not significantly different according Duncan Test (P<0.05).

Fig. 1. Effect of the basic medium (MS, VS, WPM) and the solid and liquid media on number of shoot and height shoot.

Fig. 2. Shoot proliferation; Left) liquid medium, Right) solid medium.

Fig. 3. The growth rate of axillary shoots grown on solid and liquid media within 6 weeks.

Root initiation

The average number of roots (4.6) and root length (4.5 cm) were significantly higher in 1/4 strength VS (Table 3). Table 3 compares the effect of semi-solid and liquid media. Statistical analysis indicates that there was a significant difference between the average root length in semi-solid and liquid media. The highest root length, root number was recorded in ¼ VS medium. The best results were obtained on VS medium containing 1/2 strength of VS macro- micro- salts and vitamins. The rooted plants were not difficult to acclimatization at ±24 °C and relative humidity of 80% during initial stages of development gradually reduced to 40% after 4 weeks of culture and was transferred to the greenhouse for flowering. Fig. 4 illustrates the morphogenetic responses of the shoots treated with three (full, 1/2 and 1/4) strengths of VS salts and vitamins.
DISCUSSION

Plant tissues from numerous species have performed better when cultured in liquid medium rather than on an agar medium (Berthouly and Etienne, 2005). Using liquid media in micropropagation processes is considered to be the ideal solution for reducing plantlet production costs and for considering automation (Debergh, 1983; Aitken-Christie et al., 1995). Indeed, liquid culture systems provide much more uniform culturing conditions, the media can easily be renewed without changing the container, sterilization is possible by ultrafiltration and container cleaning after a culture period is much easier (Berthouly and Etienne, 2005). Agar quality could affect, in principle, all developmental processes, the regeneration of adventitious shoots and roots being the most sensitive (Ahmadi et al., 2013). Previous researches have also indicated that availability on cytokinins different a solid versus liquid medium (Chu et al., 1993). Perhaps, the higher multiplication rate of ‘Black Baccara’ on liquid compared to solid medium (Table 2) in our studies was due to greater availability of BAP or other compounds in liquid medium.

Decreasing agar concentration increased mineral availability and growth. Banana (Musa spp.) was micropropagated in vitro on agar at various concentrations: 0, 4, 6, 8, 10, 12 g l⁻¹ (Amiri and Arzani, 2006). Growth is related to soluble mineral uptake. Mineral availability to the explants depends on its solubility and mobility through the gel, both depend on availability of water (free water). In other words, both solubility and transport of minerals decrease (possibly by precipitation and fixation in the gel matrix) with decreasing water availability. It can be mentioned that the availability of water within the system may be adequate for normal growth, but not sufficient for mineral solubility and mineral transport (water as carrier) (Amiri and Arzani, 2006). Variation in multiplication and growth rate of explants can be explained on the basis of water potential and mineral availability to the explants in the liquid medium.

For G N9, WPM and QL media were found to have a better effect on shoot proliferation rate than either MS or MS medium and the possible explanation given for this was the reduced nitrogen content in WPM (Arab et al., 2014). Hyndman et al. (1982) succeeded in enhancing root

Table 3. Comparing average percentage of rooting, number of roots produced and root length in different concentrations of VS (full, 1/2 and 1/4) salts and vitamins and semi-solid and liquid media. Means in each column with different letters show significant differences according to Duncan’s Multiple Range Test (P ≤ 0.05).

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Number of roots per explant</th>
<th>Root length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VS</td>
<td>1.5 c</td>
<td>2.8 b</td>
</tr>
<tr>
<td>1/2 VS</td>
<td>4.2 a</td>
<td>2.9 b</td>
</tr>
<tr>
<td>1/4 VS</td>
<td>4.6 a</td>
<td>4.5 a</td>
</tr>
<tr>
<td>Semi solid medium</td>
<td>4.9 a</td>
<td>3.9 a</td>
</tr>
<tr>
<td>Liquid</td>
<td>2.7 b</td>
<td>1.8 b</td>
</tr>
</tbody>
</table>

Numbers followed by the same letter are not significantly different according Duncan Test (P<0.05).

Fig. 4. Shoot rooted in three strengths of VS (A: Full, B: 1/2 VS, C: 1/4 VS).
number and length of \textit{in vitro} grown shoots of \textit{R. hybrida} cv. Improved Blaze by lowering total nitrogen concentration of MS salts (6.0 to 7.5 mM) in the culture medium keeping other salt concentrations constant.

The average number of roots and root length were significantly higher in 1/4 strength VS medium which is in accordance with Skirvin \textit{et al}. (1990) who reported that the reduced salt concentration generally increased rooting in MS medium. Kumar \textit{et al}. (2006) demonstrated that a decrease in KNO$_3$ and NH$_4$NO$_3$ concentration was the decisive factor for improving the rooting percentage. Enhanced root initiation and growth in 1/4 strength medium could be attributed to a more favorable nitrogen concentration availability and thus a higher rate of rhizogenesis than provided by full VS mineral salts (Khosravi \textit{et al}.., 2007). Rout \textit{et al}. (1990) also reported that rooting of micro-shoots was better in solid medium than that in liquid medium too. Senapati and Rout (2008) reported rooting was readily achieved upon transferring the microshoots onto half-strength MS medium supplemented with 0.25 mg/l IBA and 2% (w/v) sucrose. Although rose shoots often proliferate readily in vitro, rooting of those shoots is proved to be more difficult. Kim \textit{et al}. (2003) suggested that rooting is affected by genotype; MS medium salts concentration, cold dark treatment, and auxin type. The average number of roots and root length were significantly higher in 1/4 strength VS medium which is in accordance with Skirvin \textit{et al}. (1990) who reported that the reduced salt concentration generally increased rooting in MS medium.

\textbf{CONCLUSION}

A micropropagation system for \textit{Rosa hybrida} cv. ‘Black Baccara’ has been worked out utilizing nodal explants. Our investigation showed that the liquid VS medium with 2 µM/L BAP was the best for proliferation of \textit{Rosa hybrida} cv. ‘Black Baccara’ and micropropagated plants were rooted and established in soil successfully. Also, the VS medium with additive Fe was better than MS medium in all stages of micropropagation of this plant.

\textbf{Literature Cited}


The Effect of Pollination Time and Gibberellic Acid (GA₃) on the Production and Seed Germination of *Phalaenopsis* Orchids

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The germination power of orchids (*Orchidaceae* family) seems to be too weak due lack of albumen. The study carried out with various treatments including pollination time and GA₃ for breaking dormancy and increasing seed germination of orchids. The effect of pollination time (8 periods from January to August) and gibberellic acid (0, 500, 1000 and 1500 mg L⁻¹) were studied on germination of *Phalaenopsis* orchids. Capsules containing seeds with 2, 4, 8 and 10% hypochlorite sodium were disinfected. In order to grow seedlings the culture medium of cocopeat and coal with the ratio of 1:5, and cocopeat, coal, industrial shell, and polystyrene with the ratio of 1:1:2:4 was used. Results indicated that the most appropriate concentration of sodium hypochlorite in order to disinfect the capsules was 2%. The best month for pollination of flowers was January. The highest yield from one capsule obtained 15.3 seedlings in the medium of 1/2 MS containing 1000 mg L⁻¹ gibberellic acid. The produced seedlings were transferred to greenhouse in order to hardening. The highest rate of viability was obtained through the medium of cocopeat, coal, industrial shell, and polystyrene particles.

**Keywords:** Culture medium, *Orchidaceae* species, Seed treatment, Viability.
INTRODUCTION

Orchids have 800 types as well as 2500 species within Orchidaceae family and they are considered as the largest plant families. Orchids have very small seeds as well as defective embryo and no albumen, hence, requiring symbiosis with fungi for germination in the nature. It should be noted that seed germination and seedling growth of orchids are very slow. There has been research conducted in order to stimulate and increase the rate and power of seed germination and seedling growth of orchids. Stimulation of seed germination and seedling growth within the medium containing growth regulators has been more common.

Mahendran and Narmatha Bai (2012) found the highest rate of germination and seedling growth of *Cymbidium bicolor* within a semi-solid MS medium containing 1 mg L⁻¹ BA and 2 mg L⁻¹ 2,4-D. Cooling as well as other treatments including seeding with gibberellic acid were applied to increase the percentage of seeds germination (Najafi et al., 2006). In another study, Sharma and Tandon (2010) looked into the effect of flower age and capsules as well as banana and potato juice on the seed germination rate of *Dendrobium tosaense* within MS medium. It has also been found that pollination time plays an important role in ovule growth and seed germination (Nadeau et al., 1996).

Hence, the present study aims at determining the most appropriate time of pollination, optimized temperature, and different concentrations of gibberellic acid (GA₃) for production and seed germination of *Phalaenopsis* orchids.

MATERIALS AND METHODS

The flowers of *Phalaenopsis* orchids were prepared from a greenhouse in Chalous, Mazandaran, Iran. It should be noted that artificial pollination was done in the greenhouse and seed capsules were provided from there as well. Study treatments include pollination time in 8 levels (from January to August), GA₃ in 4 levels (0, 500, 1000, and 1500 mg L⁻¹) and disinfection method of seeds in 2 levels (30 seconds in alcohol 70% and 30 seconds in sodium hypochlorite with concentration of 2, 4, 8, and 10%). Artificial pollination and seed germination were conducted within 1/2 MS medium. The study was carried out with 48 treatments with 3 replications. Evaluated characters of the experiment were capsule production rate for pollinated flowers in different months, seed germination percentage, seed germination rate, and seedling production yield.

The experiment was done as factorial arrangement based on RCD. The studied factors include pollination time, different concentrations of GA₃, temperature, and disinfection method. Data analysis was done SAS software and means compared with DMRT within 5% probability level.

RESULTS AND DISCUSSION

Analysis of variance regarding the effect of pollination time on the rate of seed production and petals wilting of *Phalaenopsis* orchids indicated that pollination time significantly affected seed production and petals wilting (Table 1).

The first successful sign of pollination has been the wilting of petals. As to the treatments, the interval between pollination and petals wilting has been rather long, in a sense that the longest interval (17 days) was related to flowers pollinated in February, while the shortest (4 days) belonged

<table>
<thead>
<tr>
<th>Treatments</th>
<th>df</th>
<th>Mean Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollination time</td>
<td>7</td>
<td>25.31**</td>
</tr>
<tr>
<td>Error</td>
<td>12</td>
<td>0.53</td>
</tr>
<tr>
<td>cv (%)</td>
<td></td>
<td>25</td>
</tr>
</tbody>
</table>

**: significant difference at 1% probability level.
to pollinated flowers in January (Fig. 1).

Analysis of variance (Table 2) showed that there was a significant relationship (1% probability) between pollination time and the production of seed capsules of orchid flower. Fig. 2 shows different means of capsule production among pollination times highlighting the point that the most capsule production (4.07) among pollination times was found to be in January, while the least one (0.4) observed in August.

The present study indicated that if pollination carried out in cool months of the year (e.g. winter), capsule production rate is possibly high, while in spring and summer, in which the weather seems to be hot, the least production rate of capsules can be seen. There are two external factors (i.e. high temperature and ethylene) and physiological basis (such as short lifetime of ovule and pollen grains as well as ovary growth failure) affecting capsule production.

According to the ANOVA, it was found that capsule disinfection treatment significantly
Findings regarding capsule disinfection highlighted that if the concentration of sodium hypochlorite is lower, pollution rate is high, and to the extent that sodium hypochlorite concentration is high, pollution is reduced. However, high concentration causes physical harms leading to making the seeds black and useless. As to the treatments, the best performance was attributed to alcohol 70% within 30 seconds and 94% percent of cultivated samples were healthy (Fig. 3 and 4), which was in agreement with studies done by Arditi (1993) and Chung et al. (2009) in terms of disinfecting the capsules of Phalaenopsis amabilis.

Concerning Fig. 4, the treatment containing sodium hypochlorite 2% resulted in 78% health of the seeds. When the concentration of sodium hypochlorite reached 8%, it was found that despite the reduction of pollution, 23% of the cultivated samples within the medium of 1/2 MS turned to

(1% probability) affected Phalaenopsis orchids (Table 3).

Table 3. Analysis of variance capsule disinfection treatments.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>df</th>
<th>Mean Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disinfection treatment</td>
<td>3</td>
<td>396</td>
</tr>
<tr>
<td>Error</td>
<td>396</td>
<td>0.09</td>
</tr>
<tr>
<td>cv (%)</td>
<td>15.85</td>
<td>19.22</td>
</tr>
</tbody>
</table>

**: significant difference at 1% probability level.

Fig. 3. Compare effects of sodium hypochlorite 2% and ethanol 70% on disinfect of seed.

Fig. 4. Effects of sodium hypochlorite concentration on disinfect of seed.
black in the second week and only 66% of the samples were healthy.

Fungal pollutions emerged after 7 days of cultivation, and the samples harmed by disinfection process were visible after 9 days. As to the treatment, the highest rate of seed germination was obtained in February while the lowest rate was found to be in July. Data of seed germination showed that the best time for capsule pollination is winter because winter seeds of pollinated flowers showed the highest rate of germination. On the other hand, findings also concluded that summer has been the most inappropriate season for pollination because there were a few produced capsules as well as the least amount of seed germination (Fig. 5).

The first sign of seed germination was the production of green-colored protocorm. There were white-colored rhizoids around these protocorms, which were in contact with the medium surface and acted as the root. After many months, true leaves and roots formed and plantlet emerged completely (Fig. 6). Pierick (1990) found that the required time from seeding to seedling growth can be estimated as 6 months, although nothing presented with respect to the size of seedlings.

The highest treatment (15.3 seedlings) was obtained within the medium of 1/2 MS containing 1000 mg L⁻¹ gibberellic acid (Fig. 7). The least number of seedlings was found in the controlled seeds. The number of active buds in the medium containing GA₃ in relation to the controlled seeds indicated that this growth regulator has the potential to stimulate the buds in order to form the shoots and germinating the seeds. Kosir et al. (2004) argued that the best yeild was obtained through 8.53 seedlings for each seed within the commercial medium of Sigma P 6793 containing 2 mg L⁻¹ BAP and 0.5 mg L⁻¹ NAA.

ANOVA also indicated that there was a significant relationship (1% probability) on the effects of seedlings hardening for produced seedling of Phalaenopsis orchids (Table 4).

The best performance was attributed to the plants produced within enriched medium of 1/2 MS containing 1000 mg L⁻¹ gibberellic acid. In order to make the cultivated seedling compatible with the mentioned medium, the both media were distinguished as appropriate, in the sense that,
after 30 days, 99% (within the culture medium of cocopeat, coal, industrial shells, and polystyrene particles with the ratio of 1:1:2:4) (1) and 96% (within the culture medium of cocopeat and coal with the ratio of 1:5) (2) of seedlings were compatible with greenhouse conditions. It should be noted that these seedlings showed an acceptable compatibility due to having more and longer roots (Fig. 8).

**Literature Cited**


Effect of Magnetic Field on Seed Germination and Early Growth of *Calendula officinalis* L.

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In order to study on effect of magnetic field on germination characteristics and early growth of marigold (*Calendula officinalis* L.) seeds an experiment was carried out in laboratory conditions in Arak University of Iran. Seeds were magnetically exposed to magnetic field strengths, 100 or 200 mT for different periods of time; D1 (control), D2 (1 h), D3 (6 h), D4 (12h), D5 (24 h) and D6 (continuous). Mean germination time (MGT) and the time required to obtain 10, 25, 50, 75 and 90% of seeds to germinate were calculated. The germination time for each treatment were in general, higher than control values, in the other word in treated seeds time required for mean seed germination time increased nearly 4 hours in compared non treated control seeds. T10 for doses D3, D4 and D5 significantly higher than the control values. Mean germination time significantly increased when the time of seed exposed at magnetic field treatments increased, about 3 and 2 hour, respectively. According to experiment results of seedling dry weight (SLDW), seed resource depletion percentage (SRDP) and shoot length (STL) showed more decrease with increasing of the exposure time in the magnetic field.

**Keywords:** Field intensity, Magnet, Seed resource depletion.
INTRODUCTION

Great development in medicinal plants has occurred in countries due to their high added value as a consequence of the reappearance of phitotherapy, among other reasons. Marigold (Calendula officinalis L.) is one of the ornamental and medicinal plants in green space and drug industry, which it can grow in unfavorable conditions. In recent years, physical techniques take an interest not only in the common and valued crop-farming factors, but also in those less expensive and generally underestimated such as ionizing, laser or ultra violet radiation and electric and magnetic field, and therefore, plants mean an attractive model for the study of biological effects of magnetic fields (Racuciu and Creangia, 2005; Sharafi et al., 2010a).

Studies on wheat (Sharafi et al., 2010 a,b), rice and onion showed that magnetic pre-treatment improved the germination of seedling vigor of low viable seeds (Alexander and Doijode, 1995). Magnetic field pre-treatment had also positive effect on cucumber, such as stimulating seedling growth and development (Yinan et al., 2005). Also, research study reported that 125 and 250 mT magnetic treatment produces a bio-stimulation on the initial growth stages and increase the germination rate of several seeds as rice (Carbonell et al., 2000; Flórez et al., 2004), wheat (Martínez et al., 2002), tomato (De Souza et al., 2005) and barley (Martínez et al., 2000).

Grewal and Maheshwari (2011) investigated on the effects of magnetic treatment of irrigation water on snow pea and Kabuli chickpea seeds emergence, early growth and nutrient contents under glasshouse conditions. Hozayn and Qados (2010) investigate the application of magnetic water for wheat crop production. It materializes that the study on utilization of magnetic water can led to improve quantity and quality of wheat. So, using magnetic water treatment could be a promising technique for agricultural improvements but extensive research is required on different crops.

External constant magnetic field may exert influence on speed and displacement direction of polarized particles of the substances. Stimulation of plants with magnetic field, as a way to increase the quantity and quality of yields, has caught the interest of many scientists in the entire world (Chastokolenko, 1984). The purpose of this study is to synchronize emergence, which leads to uniform stand and improved yield and also to shorten the time between planting and emergence and to protect seeds during critical or induced phase of seedling establishment.

MATERIALS AND METHODS

Germination tests were carried out at laboratory conditions with marigold (Calendula officinalis L.) seeds in Arak University of Iran. Germination tests were performed according to the guidelines issued by the International Seed Testing Association (ISTA, 2004). The petri dishes were placed in incubator at 25°C with 60% relative humidity with 14/10 photoperiod. The data regarding germination, days to 50% germination (G50) and mean germination time (MGT) were recorded up to 20th day of experiment. After 20 days of experiment, the data regarding shoot and

![Fig. 1. (left) Magnet and (right) vessel containing distilled water. Roll of filter paper with seeds and the hollow cylindrical magnet. N, S: North and South poles of magnet (Fig. from Sharafi et al., 2010).](image-url)
(root length, shoot and root fresh and dry weights were also recorded. The rate of germination was assessed by determining the mean germinating time (MGT).

The procedure of study was conducted according to Florez et al., (2007). The magnetic fields generated by ring magnets with magnetic induction values B1 =100 mT and B2 = 200 mT; the geometric characteristics are 7.5 cm external diameter, 3 cm internal diameter, 1cm high for B1 and 1.5 cm high for B2 (Fig. 1). The magnet was placed at the top of the vessel to generate each magnetic dose, and each roll containing 20 seeds was placed into hole of the magnet. All the vessels containing rolls with seeds were labeled with numbers and randomly located to carry out the test. The results were subjected to an analysis of variance (ANOVA) to detect differences between mean parameters. Means were compared using with LSD test at 5% level of probability to detect differences between parameters of treated plants and control (Steel and Torrie, 1984).

RESULTS AND DISCUSSION

The variable magnetic field is a very significant factor in influencing the germination process of marigold grains. It must be remembered, however, that this influence is varied and depends on the power of magnetic field. Both for a weak magnetic field (100 mT) and for a strong one (200 mT) the effect was very short-lasting and appeared in the initial phase of germination. The percentage of germinated seeds (Gmx), time required for germination (parameters MGT, T10-T90) were determined for each treatment, expressed as the means of the 3 replicates and are provided in Table 1. The germination time for each treatment were in general, higher than corresponding control values, in the other word in treated seeds time required for mean seed germination time increased nearly 1 (D2) and 12 (D4) hours in compared non treated control seeds. Thus the rate of germination of treated seeds was lower than the untreated seeds (Table 1). Results showed that time required for T10 for doses D1 and D2 for 100 mT, and D1 for 200 mT were 130, 140 and 120 hours respectively, the same or significantly higher than the control values for marigold (Table 1).

As T10 in closely related to the onset of germination, these results indicate no response (for 5 treatments) and the delay of germination (for 3 treatments) of marigold seeds to magnetic field. Mean germination time (MGT) significantly increased when the time of seed exposed at magnetic field treatments increased, about 1 and 12 hours respectively, for marigold.

Magnetic field treatments exerted a significant effect on seedling dry weight, weight of mobilized seed reserve, seed reserve utilization rate and seed reserve depletion percentage. According to experiment results, seedling dry weight (g), weight of mobilized seed reserve (mg seed^-1), seed reserve depletion percentage (%) and seed reserve utilization rate (g g^-1) characteristics in marigold exposure of seed at magnetic field with D3, D5 and D6 caused seed germination significantly reduced but germination at D2 and D4 significantly increased (Fig. 2).

<table>
<thead>
<tr>
<th>B=100mT</th>
<th>T10 h</th>
<th>T25 h</th>
<th>T50 h</th>
<th>T75 h</th>
<th>T90 h</th>
<th>MGT h</th>
<th>Gmx %</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>140</td>
<td>170</td>
<td>240</td>
<td>270</td>
<td>330</td>
<td>230</td>
<td>96.05</td>
</tr>
<tr>
<td>D1</td>
<td>150</td>
<td>170</td>
<td>210</td>
<td>252</td>
<td>330</td>
<td>220</td>
<td>96</td>
</tr>
<tr>
<td>D2</td>
<td>155</td>
<td>195</td>
<td>243</td>
<td>305</td>
<td>362</td>
<td>250</td>
<td>97.95</td>
</tr>
<tr>
<td>D3</td>
<td>150</td>
<td>180</td>
<td>270</td>
<td>350</td>
<td>390</td>
<td>270</td>
<td>90.5</td>
</tr>
<tr>
<td>D4</td>
<td>170</td>
<td>200</td>
<td>250</td>
<td>310</td>
<td>340</td>
<td>258</td>
<td>98</td>
</tr>
<tr>
<td>D5</td>
<td>230</td>
<td>290</td>
<td>330</td>
<td>360</td>
<td>400</td>
<td>325</td>
<td>96.2</td>
</tr>
<tr>
<td>D6</td>
<td>270</td>
<td>310</td>
<td>360</td>
<td>400</td>
<td>-</td>
<td>270</td>
<td>79.22</td>
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<table>
<thead>
<tr>
<th>B=200mT</th>
<th>T10 h</th>
<th>T25 h</th>
<th>T50 h</th>
<th>T75 h</th>
<th>T90 h</th>
<th>MGT h</th>
<th>Gmx %</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>120</td>
<td>157</td>
<td>187</td>
<td>225</td>
<td>300</td>
<td>190</td>
<td>96.5</td>
</tr>
<tr>
<td>D2</td>
<td>140</td>
<td>180</td>
<td>201</td>
<td>285</td>
<td>315</td>
<td>226</td>
<td>94</td>
</tr>
<tr>
<td>D3</td>
<td>142</td>
<td>165</td>
<td>185</td>
<td>240</td>
<td>285</td>
<td>204</td>
<td>96.5</td>
</tr>
<tr>
<td>D4</td>
<td>205</td>
<td>255</td>
<td>295</td>
<td>325</td>
<td>352</td>
<td>285</td>
<td>90</td>
</tr>
<tr>
<td>D5</td>
<td>355</td>
<td>382</td>
<td>412</td>
<td>450</td>
<td>480</td>
<td>417</td>
<td>89.2</td>
</tr>
<tr>
<td>D6</td>
<td>315</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
</tbody>
</table>

*Means sharing similar letters in a column are statistically non significant at p≤0.05.
The stimulatory effect of the application of different magnetic doses on the germination is in agreement with that obtained by other researchers. Florez et al. (2007), observed an increase for initial growth stages and an early sprouting of rice and maize seeds exposed to 125 and 250 mT stationary magnetic fields. Martinez et al. (2000; 2002), observed similar effects on wheat and barley seeds magnetically treated. Alexander and Doijode (1995) reported that pre-germination treatment improved the germination and seedling. Vigor of low viability rice and onion seeds. Kavi (1977) found that seeds exposed to a magnetic field absorbed more moisture. Carbonell et al. (2000) found that magnetic treatment produced a bio-stimulation of the germination. Also, the results of three-year investigation into the influence of constant magnetic field on the dynamics of growth, development and yield of spring wheat showed that in general it was not favorable to development and yield of the plant (Zhu, 2001). But, the mechanisms at work when plant and other living systems are exposed to a magnetic field are not well known yet, but several theories have been proposed, including biochemical changes or altered enzyme activities by Phirke et al. (1996).

Seed germination rate is an important parameter to analyze the initial growth of seed under laboratory condition and also useful to evaluate the effectiveness of any particular endeavor to enhance the crop yield. It was observed from the experiment that seed germination start one to three days earlier with the application of magnetic field as compared to control (Fig. 3). Similar finding...
were found by other researchers as Florez et al. (2004) affirmed an increase for the initial growth stages and an early sprouting of rice seeds exposed to 125 and 250 mT stationary magnetic field. Furthermore Sharafi et al. (2010 a,b) and Martinez et al. (2000, 2002) observed similar effects on wheat and barley seeds. Dry weight was decreased due to magnetic field (Fig. 1a). The increased plant biomass might be due to synchronized germination and early stand establishment in treated seeds (Penuelas et al., 2005). These findings are similar with earlier research on pepper (Zhang et al., 1994) and Canola (Zhu, 2001). An increase in root length was recorded in magnet treatment which might be the result of higher embryo-cell wall extensibility (Fig. 3b).

**CONCLUSION**

Results of the present laboratory experiments revealed few beneficial effects of magnetic field for marigold seed germination. The germination time for each treatment were in general, higher than control values, in the other word in treated seeds time required for mean seed germination time increased nearly 4 hours in compared non treated control seeds. T10 for doses D3, D4 and D5 significantly higher than the control values. Mean germination time significantly increased when the time of seed exposed at magnetic field treatments increased, about 3 and 2 hour respectively. According to experiment results of seedling dry weight (SLDW), seed resource depletion percentage (SRDP) and shoot length (STL) showed more decrease with increasing of the exposure time in the magnetic field. As magnetic field treatment is environment friendly technique and easy to handle but further studies are needed to understand the mysterious mechanism behind magnetic treatment and in turning it into technique to technology for end user benefits.

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Study on Interaction Effects of Mechanical and *Geranium* Essential Oil Treatments on Vase Life of Cut *Chrysanthemum* (*Dendranthema grandiflorum* L.)

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Abstract

The aim of this study is investigation on effect of stem end splitting and *Geranium* essential oil on vase life on quality of cut chrysanthemum (*Dendranthema grandiflorum* L.). This experiment arranged as factorial based on RCD with 2 factors of stem end splitting at 2 levels (with splitting and without splitting) and *Geranium* essential oil at 6 levels (0, 1, 2, 4, 8 and 10 %), with 12 treatments, 3 replications, 36 plots and 144 cut flowers. In this experiment traits such as vase life, water absorption, fresh weight, dry matter percent and °brix were measured. ANOVA showed that different among treatments was significant for vase life, °brix and fresh weight in 1% probability and for dry matter percent and water absorption in 5% probability. Results showed that different treatments improved vase life compared to control and maximum vase life was achieved in 5 cm splitting + 10% *Geranium* essential oil with 18.41 days compared to control (7.05 days).

Keywords: *Chrysanthemum*, *Geranium* essential oil, Stem end splitting, Vase life.
INTRODUCTION

Chrysanthemum (Dendranthema grandiflorum L.) belongs to the Asteraceae family. This is a native plant of China and cultivated for thousands of years. Today's new varieties of this plant were bred for using as cut flowers, potted plants and garden plants and has a high economic value in the global market (Kandil et al., 2011). Chrysanthemum is a non-climactric flower with a long vase life and its long vase life is also due to non-sensitivity to ethylene. However, the formation of air embolism in the vascular of stem that prevents water transport in stem and leads to close the vascular tubes which ultimately leads to increase hydraulic resistance in the stem and water stress, and reduces the vase life of chrysanthemum (Halvey and Mayak, 1981; Van Leperen et al., 2001).

Bactericidal compounds such as essential oils and plant extracts were used as environmentally friendly compounds and as new factors that affect postharvest life of cut flowers (Solgi et al., 2009). The use of herbal essences in the preservative solution for cut flowers is relatively new and the positive effect of these compounds have been reported (Solgi et al., 2009; Diy, 2008; Mousavi Bazaz and Tehranifar, 2011).

Geranium is a flowering plant and is also valuable because of having ingredients or secondary metabolites. Parts of the plant used for preparing essence are the leaves and air parts. Aromatic geranium essence is similar to the rose flower and its main compound include geraniol, citronellol, terpineol and alcohols (Mithila et al., 2011). Solgi et al. (2009) stated that the use of essential oils of garden thyme and Shiraz thyme, and their active ingredients increased vase life of cut flowers. The purpose of this study was to evaluate the effect of aromatic geranium extract and 5 cm split on postharvest life and durability of chrysanthemum cut flower and introduce the best treatments.

MATERIALS AND METHODS

In October 2014, chrysanthemum cut flowers harvested at commercial stage from a greenhouse in Isfahan and immediately were transferred to post-harvest laboratory. This study was performed in factorial experiment based on RCD with 2 factors, the split of 5 cm of stem end and without split and the second factor of aromatic geranium extract in 6 levels (0, 1, 2, 4, 8 and 10%) with 12 treatments, 3 replications, 36 plots and 4 flowers in each plot. Vase life room was with 12 h photoperiod, light intensity of 12 µmol s⁻¹ m⁻², relative humidity of 60 to 70% and the temperature of 20 ± 2° C.

Vase life was defined as the time from the start of treatment until the senescence of flowers. Regarding the final weight of flower in the last day, recut weight, weight of losses and weight of the first day, the increase of fresh weight was calculated according to the following equation:

\[ \text{Fresh weight increasing} = (\text{weight of losses} + \text{weight of recut} + \text{final weight at last day of the control life}) - \text{initial weight} \]

Considering initial volume of vase solution (500 mL) and rate of evaporation in room and reduction of volume of vase solution, water absorption was calculated by using following equation:

\[ \text{Water absorption (ml g}^{-1} \text{FW)} = 500 - (\text{mean evaporation of room} + \text{remained solution at the end of vase life}) ÷ \text{the average of fresh weight cut flowers} \]

After ending the vase life of the control, fresh weight of each flower was measured at the end of the vase life, it was placed at 70 °C for 24 hours. After ensuring complete drying of flowers, they were weighted by a digital scale. Dry matter percent was calculated from the following equation:

\[ \text{Dry matter percent} = (\text{dry weight} ÷ \text{fresh weight of flowers at the last day of the control vase life}) × 100 \]

°Brix was measured manually in 2 stages by a refractometer, N-1α model, manufactured by ATAGO Company, Japan and the increase of °Brix was calculated by the following formula:

\[ \text{The increase of °Brix} = °\text{Brix of the last day} - °\text{Brix of the first day} \]
Data analysis was performed using SAS software and comparison was performed according to LSD test.

RESULTS AND DISCUSSION

Vase life

Analysis of variance showed that the effects of aromatic geranium extract, split and the interaction of them are statistically significant at the 1% level (Table 1). The results of the comparison showed that all treatments increased vase life compared with the control. So that the control with 8.06 days had the minimum vase life and the split along with 10% aromatic geranium extract with 18.41 days had the maximum vase life among treatments (Fig. 1).

The use of antimicrobial compounds along with stem end split caused a significant improvement in the life of chrysanthemum cut flowers compared with the control.

Since the vase life is directly related to water absorption, it can be said that germicidal composition with the split used in *Alstroemeria* cut flowers increases water absorption through exposing wide surface of stem with vase life solution and reduces microbial loads of vase solution and thus helps maintaining freshness and durability of this cut flower by the continuation of water absorption (Mehri, 2014). Solgi et al. (2009) studied on cut gerbera flowers and reported that the use of herbal essences as a disinfectant and environmentally-friendly compound significantly increases with the postharvest life of this cut flowers. Mousavi Bazaz and Tehrainfar (2011) also found similar results regarding the positive effect of essences of cumin, mint and thyme on durability of *Alstroemeria* cut flowers. The researchers stated that treatment with 50 mg l⁻¹ of thyme essence improves the vase life of *Alstroemeria* for 2 days compared with the control.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Vase life</th>
<th>Dry matter percent</th>
<th>°Brix</th>
<th>Fresh weight</th>
<th>Water absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil (O)</td>
<td>5</td>
<td>15.043**</td>
<td>33.51*</td>
<td>4.88**</td>
<td>53.61**</td>
<td>1.328*</td>
</tr>
<tr>
<td>Splitting (S)</td>
<td>1</td>
<td>91.52**</td>
<td>38.19*</td>
<td>1.416**</td>
<td>156**</td>
<td>28.81**</td>
</tr>
<tr>
<td>O*S</td>
<td>5</td>
<td>14.62**</td>
<td>34.84*</td>
<td>0.795**</td>
<td>58.39**</td>
<td>2.492*</td>
</tr>
<tr>
<td>Error</td>
<td>24</td>
<td>1.913</td>
<td>6.33</td>
<td>0.173</td>
<td>6.95</td>
<td>0.497</td>
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<tr>
<td>cv (%)</td>
<td></td>
<td>9.31</td>
<td>8.57</td>
<td>23.81</td>
<td>20.73</td>
<td>17.29</td>
</tr>
</tbody>
</table>

**: Probability 1%  *: Probability 5%

Table 1. ANOVA of effects of mechanical and *Geranium* essential oil treatments on traits.

Fig. 1. Effects of mechanical and *Geranium* essential oil treatments on vase life.

S0 = Without splitting  S1 = With 5cm splitting
O0 = No *Geranium* essential oil  O20 = *Geranium* essential oil 4%
O5 = *Geranium* essential oil 1%  O40 = *Geranium* essential oil 8%
O10 = *Geranium* essential oil 2%  O50 = *Geranium* essential oil 10%
Water absorption

Analysis of variance of data showed that geranium extract and interaction of them are statistically significant at the 1% level but splitting was significant at 5% probability (Table 1). Mean Comparison of these two factors showed that 5 cm splitting + 10% geranium extract with 5.743 ml g⁻¹ FW and the control with 2.320 ml g⁻¹ FW had the highest and the lowest water absorption, respectively (Fig. 2).

Inability to water absorption is the main cause of aging of cut flowers and reducing the longevity of them. This is often done by closing the vessels. The use of antimicrobial compound in vase solution by preventing the growth and performance of microbes, protects xylem from obstruction and thus water absorption occurs without interruption and consequently the freshness of the flowers is maintained (Kim and Lee, 2002; Shanan, 2012; Anjum et al., 2001). In this study, all of the antimicrobial treatments and 5 cm split increased water absorption compared with the control. Anjum et al. (2001) reported that the addition of antimicrobial compounds in vase solution life prevents microbe growth and increases water absorption by the cut flower. El-Hanafi (2007) argued that the use of antimicrobial compounds such as herbal essence in vase solution, by reducing the solution's pH, causes balancing and water absorption by the stem of cut carnation. Shanan (2012) reported that herbal essences by preventing the vascular occlusion improves the absorption of water in rose cut flowers that the results of this study is in agreement with the current study. Nabigol et al. (2006) found that antibacterial, anti-ethylene and antibiotics compounds significantly increase water absorption in chrysanthemum cut flowers.

Fresh weight

Analysis of variance of data showed that geranium extract, splitting and interaction of them are statistically significant at the 1% level (Table 1). Results showed that all treatments in this experiment increased fresh weight compared to control and maximum increase is related to the split treatment and geranium extract of 8% with 20.06 g and the minimum is related to the control treatment with 5.60 g (Fig. 3).

Several studies have shown that the use of antimicrobial compounds in vase solution of cut flowers by reducing the microbial load and preventing the obstruction of the vessels increases water absorption and finally increases the fresh weight and freshness of cut flowers and thus increases the durability and good marketing of flowers. In this study, the use of antimicrobial com-
pounds by increasing water absorption caused increasing the fresh weight compared with the controls. Jalili Marandi et al. (2011) reported that the Carum copticum essence at 500 mg l⁻¹ increases the fresh weight by 1.8 g compared with the control.

Increasing °Brix

Analysis of variance showed that effect of geranium extract, effect of splitting and interaction of them are statistically significant at the 1% level (Table 1). Mean comparison showed that the maximum increase in °Brix is associated with the split treatment and geranium extract of 10% with 3.886% and the minimum one is related to the control treatment with 0.586% (Fig. 4).

The most important factor in delaying senescence of cut flowers is the increase in the amount of carbohydrates in the flower. Sugar (TSS) is one of the most important factors of determining the life of cut flowers. Therefore, carbohydrate increases the vase life (Mutui et al., 2011). Researchers believe that the recutting the cut flower stems under water and the efficacy of antimicrobial compounds on reducing the microbial load and enhancing the solution absorption causes maintaining and increasing carbohydrates in the stem of cut flowers (Basiri et al., 2011; Bartoli et al., 1997). Elgimabi and Ahmad (2009) reported that the antimicrobial compounds increase the amount of carbohydrates in the stem of rose cut flowers. Sugars had an important osmotic potential that by entering into the vacuole of the petals cells reduce cell osmotic potential and delay aging by increasing respiration (Edrisi, 2009).

![Fig. 3. Effects of mechanical and Geranium essential oil treatments on fresh weight.](image)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fresh weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S0 (Without splitting)</td>
<td>5.60 bc</td>
</tr>
<tr>
<td>S1 (With 5 cm splitting)</td>
<td>14.45 ef</td>
</tr>
<tr>
<td>O0 (No Geranium essential oil)</td>
<td>8.22 ef</td>
</tr>
<tr>
<td>O20 (Geranium essential oil 4%)</td>
<td>13.77 cd</td>
</tr>
<tr>
<td>O5 (Geranium essential oil 1%)</td>
<td>12.18 def</td>
</tr>
<tr>
<td>O40 (Geranium essential oil 8%)</td>
<td>10.33 cde</td>
</tr>
<tr>
<td>O10 (Geranium essential oil 2%)</td>
<td>17.80 ab</td>
</tr>
<tr>
<td>O50 (Geranium essential oil 10%)</td>
<td>11.93 cde</td>
</tr>
<tr>
<td>O100 (Geranium essential oil 10%)</td>
<td>20.06 a</td>
</tr>
</tbody>
</table>

![Fig. 4. Effects of mechanical and Geranium essential oil treatments on °Brix.](image)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>°Brix (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S0 (Without splitting)</td>
<td>0.36 g</td>
</tr>
<tr>
<td>S1 (With 5 cm splitting)</td>
<td>1.42 ef</td>
</tr>
<tr>
<td>O0 (No Geranium essential oil)</td>
<td>1.56 de</td>
</tr>
<tr>
<td>O20 (Geranium essential oil 4%)</td>
<td>2.62 bc</td>
</tr>
<tr>
<td>O5 (Geranium essential oil 1%)</td>
<td>2.53 de</td>
</tr>
<tr>
<td>O40 (Geranium essential oil 8%)</td>
<td>3.86 def</td>
</tr>
<tr>
<td>O10 (Geranium essential oil 2%)</td>
<td>2.83 f</td>
</tr>
<tr>
<td>O50 (Geranium essential oil 10%)</td>
<td>3.386 a</td>
</tr>
<tr>
<td>O100 (Geranium essential oil 10%)</td>
<td>3.186 a</td>
</tr>
</tbody>
</table>
Dry matter percentage

Analysis of variance of data showed that effect of geranium extract, splitting and interaction of them are statistically significant at the 5% level (Table 1). Mean comparison of interaction of two factors showed that split treatment with 10% aromatic geranium extract with 32.41 percent, had the highest dry matter compared with the control with 24.69 percent (Fig. 5).

Sucrose provides required energy for more survival of flowers and affects the structure of the flower tissues cell wall and delays aging through this and causes increasing the dry weight and the water retention (Sun and Gubler, 2004). Hashemabadi (2012) by an experiment on carnation cut flowers, showed that the effect of compounds extending the vase life of cut flowers on the prevention of dry weight loss by preventing the degradation of carbohydrates. Nabigol et al. (2006) showed that the antimicrobial compounds increase the biomass of chrysanthemum by controlling microorganisms and improving water uptake. In this study, split and geranium extract increase the absorption of water and sucrose in vase solution and the percentage of dry matter.

CONCLUSION

The results showed that the split of 5 cm and geranium extract causes significantly an increase in postharvest life of the chrysanthemum cut flowers. In current study, the split of 5 cm at the end of stem with 10% geranium extract improved the vase life of chrysanthemum cut flowers more than 10 days compared to control. Therefore, these treatments as an extended solution for the vase life of chrysanthemum cut flowers are recommended to retailers and consumers of this flower.

Literature Cited


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Effect of Different Preservatives on Vase Life of Tuberose

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This study was carried out to investigate the effect of different preservative solutions to improve the keeping quality of tuberose (Polianthes tuberosa cv. Single). These preservative solutions (treatments) were: T1= 2% sucrose + 200 mg/l AgNO3, T2= 2% sucrose + 200 mg/l AgNO3 + 25 mg/l citric acid, T3= 2% sucrose + 300 mg/l HQS, T4 = 2% sucrose + 300 mg/l HQS+ 25 mg/l citric acid, T5= 2% sucrose + 200 mg/l AgNO3 + 300 mg/l HQS, T6= 2% sucrose + 200 mg/l AgNO3 + 300 mg/l HQS+ 25 mg/l citric acid, T7= 0.01 % sodium hypochloride, T8= 0.05 % sodium hypochloride, T9= 0.10 % sodium hypochloride and T10= tap water (control). The results showed that all treatments had improved the keeping quality and vase life of the cut flowers comparing to control ones. Among all these treatments, 2% sucrose + 200 mg/l AgNO3 + 300 mg/l HQS+ 25 mg/l citric acid showed best water uptake, water loss uptake ratio, percentage of maximum increase in fresh weight of the cut flower stem and vase life which was extended up to 10 days. According to the results of this research it is concluded that, 2% sucrose + 200 mg/l AgNO3 + 300 mg/l HQS+ 25 mg/l citric acid are suitable for prolongation of tuberose vase life.

Keywords: Citric acid, Keeping quality, Polianthes tuberosa, Preservative solution, Sodium hypochloride, Sucrose.
INTRODUCTION

Tuberose (*Polianthes tuberose* L.), a member of Amaryllidaceae family was originated in Mexico and grown on large scale in Asia. It is an important cut flower crop from aesthetic as well as commercial point of view. In Bangladesh, its commercial cultivation was introduced during 1980 by some pioneer and innovative farmers at Panishara union of Jhikorgachathana under Jessore district near the Benapol border (Hoque *et al.*, 1992). Tuberose occupies a very selective and special position to flower loving people. It has a great economic potential for cut flower trade and essential oil industry. Apart from ornamental value, tuberose is extensively utilized in medicines for headache, diarrhea, rheumatism and allied pains. In Bangladesh, for the last few years, tuberose has become a popular cut flower for its attractive fragrance and beautiful display in the vase. Now it has high demand in the market and its production is highly profitable (Ara *et al.*, 2009).

Improvement of keeping quality and extend of vase life of cut flowers are important areas in floricultural research. Senescence of cut flowers is induced by several factors e.g. water stress, carbohydrate depletion, microorganism (Gowda, 1990; Van Doorn and Witte, 1991) etc. Accomplishment of the extension of vase life depends on proper harvesting, postharvest handling and a preservative solution for ensuring an ample supply of water, metabolites and regulatory substances to petals and leaves. Water balance is determined by transpiration and water uptake and is the main factor affecting longevity and quality characteristics of cut flowers (Da Silva, 2003). Occlusion at the end of the basal stem is the primary cause of low water uptake by cut flowers (He *et al.*, 2006).

Investigations pertaining to extend the vase life of cut flowers by several preservative/chemicals i.e. silver nitrate, sucrose, HQS, HQC, aluminium sulphate, cobalt sulphate, kinetin, boric acid, citric acid, ascorbic acid after harvest in different formulations and combinations to enhance the vase life of cut flowers have been made with varying success (Van *et al.*, 1991; Reddy *et al.*, 1997; Anjum *et al.*, 2001; Saini *et al.*, 1994 and Pruthi *et al.*, 2002) in many countries of the world. But in Bangladesh, a little work has been done in respect of using floral preservative to enhance the vase life of cut flowers. Considering the facts, such research is very important for the greater interest of the scientist as well as the growers and flower shop-keeper of our country. The present study was therefore undertaken to investigate different preservative solutions and determining the best ones which extend vase life and improve the keeping quality of tuberose cut flower.

MATERIALS AND METHODS

This experiment was conducted at the Laboratory of Landscape, Ornamental and Floriculture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur during the period from April 2013 to May 2013.

Experimental materials

Spikes of tuberose were selected as experimental material. Fresh tuberose spikes of about 55 cm was harvested from the field of Landscape, Ornamental and Floriculture Division of Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur in the morning to avoid excessive heat and immediately the spikes were placed in plastic buckets containing cold water in order to rehydrate the flowers. The spikes were brought to the laboratory within ½ hour after harvest. Spikes were sorted into different groups (based on the size and number of florets per spike) in order to maintain uniformity in the material used for experiment. The spikes were again cut to uniform length of 50 centimeter and all the leaves were removed to avoid contact with the solution.

Treatments

The study consisted of ten treatments-

- **T**₁= 2% sucrose + 200 mg/l AgNO₃
- **T**₂= 2% sucrose + 200 mg/l AgNO₃ + 25 mg/l citric acid
- **T**₃= 2% sucrose + 300 mg/l HQS
T4 = 2% sucrose + 300 mg/l HQS + 25 mg/l citric acid
T5 = 2% sucrose + 200 mg/l AgNO3 + 300 mg/l HQS
T6 = 2% sucrose + 200 mg/l AgNO3 + 300 mg/l HQS + 25 mg/l citric acid
T7 = 0.01 % sodium hypochloride
T8 = 0.05 % sodium hypochloride
T9 = 0.10 % sodium hypochloride and
T10 = Control (Tap water)

Experimental design
The experiment was laid out in Completely Randomized Design (CRD) with three replications.

Methods
Single spike was used for each bottle. A total number of 30 flowers were used to hold the floral preservatives which were prepared freshly and dispensed into the bottles. Bottles were kept at room temperature (25-35 °C) and relative humidity (RH) of 65-80% with adequate aeration.

Preparation of vase solutions
The required concentrations of sugar solution (2%), AgNO3 solution (200 mg/l), HQS solution (300 mg/l), sodium hypochloride solution (0.01-0.05-0.10%) and citric acid (25 mg/l) were prepared by dissolving calculated amount of these chemicals in water. Tap water was used as control solution.

Collection of data
Data were recorded for floret opening (%), floret deterioration (%), total quantity of water uptake, total quantity of water loss, loss uptake ratio, fragrance of the flowers (on 6th day), fresh weight of spike, vase life, incidence of stem rotting etc. Floret opening, recorded from the day when the first floret opened till the spike was discarded and expressed in percentage. Floret deterioration, recorded from the day when the first basal floret became dry and closed and expressed in percentage. The water uptake by the cut spikes was estimated by subtracting the amount of water at the end of experiment from the initial volume and expressed in grams. Water loss is the difference between the initial and final weights of bottle with solution and spike represents the loss of water and expressed in grams.

Statistical analysis
The data recorded on different parameters were statistically analyzed with the help of ‘MSTAT’-C software. The difference between treatment means were compared by Duncan’s Multiple Range Test (DMRT) according to Steel and Torrie (1960).
RESULTS AND DISCUSSION

Floret opening (%)

Floret opening for a period of 10 days by the spikes differed in case of different vase solution (Fig. 1). Spikes held in T6 (97.76%) recorded the maximum % of floret opening which was statistically similar to T5 (95.24%) while, the minimum floret opening was found in control (65.78%). Similar results have been recorded in gladiolus and carnation (Halevy, 1987 and Mayak et al., 1973). When sucrose was present in the holding solution, the activities of sucrose synthetase, sucrose-P synthase and sucrose-6P isomerase in the flowers remained high for bud opening. In absence of sucrose, enzyme activity decreased as the flower aged. The decrease in activity appeared to be related to very low protein synthesis (Bose et al., 1999).

Water uptake (g/spike)

Total water uptake for a period of 10 days by the spike differed significantly in case of different vase solutions (Table 1). The spikes held in T6 (62.0 g) had the highest water absorption compared with the control and other treatments. These may be due to a synergistic effect, which improved water balance by maintaining turgidity. The high absorption of water uptake by T6, as observed in the present investigation, similar with previous results obtained in tuberose (Anjum et al., 2001). When flowers are detached from the plant, water loss from these continues through transpiration. The ideal flower preservative is that which allows water absorption in flower tissues (Salunkhe et al., 1990). Water absorption from the preservative solution maintains a better water balance and flower freshness (Reddy and Singh, 1996) and saves from early wilting resulting in enhanced vase-life.

Water loss (g/spike)

Water loss from the tissue during the experimental period was significantly affected by different vase solutions (Table 1). The spikes held in T10 (control) with lower water uptake, recorded the lowest water loss (36.0 g); those held in T6 (2% sucrose + 200 mg/l AgNO3 + 300 mg/l HQS

---

**Table 1.** Water uptake and water loss from tuberose spikes during 10 days.

<table>
<thead>
<tr>
<th>Vase Solution</th>
<th>Water Uptake (g)</th>
<th>Water Loss (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>55.0</td>
<td>30.0</td>
</tr>
<tr>
<td>T2</td>
<td>57.0</td>
<td>28.0</td>
</tr>
<tr>
<td>T3</td>
<td>58.0</td>
<td>26.0</td>
</tr>
<tr>
<td>T4</td>
<td>59.0</td>
<td>24.0</td>
</tr>
<tr>
<td>T5</td>
<td>60.0</td>
<td>22.0</td>
</tr>
<tr>
<td>T6</td>
<td>62.0</td>
<td>20.0</td>
</tr>
<tr>
<td>T7</td>
<td>64.0</td>
<td>18.0</td>
</tr>
<tr>
<td>T8</td>
<td>66.0</td>
<td>16.0</td>
</tr>
<tr>
<td>T9</td>
<td>68.0</td>
<td>14.0</td>
</tr>
<tr>
<td>T10</td>
<td>70.0</td>
<td>12.0</td>
</tr>
</tbody>
</table>

---

**Fig. 1.** Effect of preservatives on % floret opening of tuberose.

T1 = 2% sucrose + 200 mg/l AgNO3, T2 = 2% sucrose + 200 mg/l AgNO3 + 25 mg/l citric acid, T3 = 2% sucrose + 300 mg/l HQS, T4 = 2% sucrose + 300 mg/l HQS + 25 mg/l citric acid, T5 = 2% sucrose + 200 mg/l AgNO3 + 300 mg/l HQS, T6 = 2% sucrose + 200 mg/l AgNO3 + 300 mg/l HQS + 25 mg/l citric acid, T7 = 0.01 % sodium hypochloride, T8 = 0.05 % sodium hypochloride, T9 = 0.10 % sodium hypochloride and T10 = Control (tap water)
+ 25 mg/l citric acid) with maximum water uptake, recorded the maximum water loss (57.5 g). These results supported by Reddy et al. (1997) in tuberose that an adequate moisture level can be maintained in cut vases given sufficient water uptake or sufficient water retention.

**Water loss uptake ratio**

This ratio was not significantly affected by different vase solutions (Table 1). However, the minimum water loss and uptake ratio of was recorded in T6 (0.8) and the ratio was highest for the spikes held in control solution (1.3). According to Kabir et al. (2011), the minimum water loss-uptake ratio indicated better relation with flower quality.

**Fragrance of flower**

The results presented in Table 1. demonstrated that the flowers in T6 and T5 were more fragrant other treatments. No fragrance was found in the solution which contains NaOCl (T7, T8 T9) indicating adverse effects of this chemical on fragrance of the flowers. Fragrance is an important quality parameter when flowers are kept for interior decoration, it makes the environment pleasant. Fragrance might be lost due to the fungal attack at stem cut ends; hence if a suitable preservative is added in the vase solution, this may helps in maintain the fragrance of flowers for a longer period. Almost similar result has also been reported by Anjum et al. (2001) in tuberose.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Water uptake (g/spike)</th>
<th>Water loss (g/spike)</th>
<th>Water loss uptake ratio</th>
<th>Fragrance of flower</th>
<th>Incidence of stem rotting</th>
</tr>
</thead>
<tbody>
<tr>
<td>2% sucrose + 200 mg/l AgNO3</td>
<td>43.9 cd</td>
<td>44.0 c</td>
<td>1.0 ab</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>2% sucrose + 200 mg/l AgNO3 + 25 mg/l citric acid</td>
<td>50.0 bc</td>
<td>49.9 ab</td>
<td>1.0 ab</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>2% sucrose + 300 mg/l HQS</td>
<td>47.9 bc</td>
<td>48.0 b</td>
<td>1.0 ab</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2% sucrose + 300 mg/l HQS + 25 mg/l citric acid</td>
<td>44.9 c</td>
<td>45.0 bc</td>
<td>1.0 ab</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2% sucrose + 200 mg/l AgNO3 + 300 mg/l HQS</td>
<td>51.1 b</td>
<td>51.3 ab</td>
<td>1.0 ab</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>2% sucrose + 200 mg/l AgNO3 + 300 mg/l HQS + 25 mg/l citric acid</td>
<td>62.0 a</td>
<td>52.5 a</td>
<td>0.8 b</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>0.01 % sodium hypochloride</td>
<td>35.6 e</td>
<td>38.0 de</td>
<td>1.1 ab</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>0.05 % sodium hypochloride</td>
<td>39.0 d</td>
<td>41.1 d</td>
<td>1.1 ab</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>0.10 % sodium hypochloride</td>
<td>32.7 ef</td>
<td>37.0 de</td>
<td>1.1 ab</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Control (tap water)</td>
<td>30.0 f</td>
<td>36.5 e</td>
<td>1.3 a</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

**Table 1. Effect of different preservatives on postharvest physiology of tuberose.**

Fig. 2. Stem rotting in different preservative solutions of tuberose. T1= 2% sucrose + 200 mg/l AgNO3, T2= 2% sucrose + 200 mg/l AgNO3 + 25 mg/l citric acid, T3= 2% sucrose + 300 mg/l HQS, T4 = 2% sucrose + 300 mg/l HQS + 25 mg/l citric acid, T5= 2% sucrose + 200 mg/l AgNO3 + 300 mg/l HQS+ 25 mg/l citric acid, T6= 0.01 % sodium hypochloride, T7= 0.05 % sodium hypochloride, T8= 0.10 % sodium hypochloride and T10= Control (tap water)
Incidence of stem rotting

At first rotting of stick was started in control solution (6th day), then rotting was observed on sticks which held in T7 (7th day) and T9 (7th day) (Fig. 2). No stem rotting incidence was found in case of T1, T2, T5 and T6. This might be due to the fact that the sucrose, AgNO₃, HQS and citric acid prevents in the holding solution acted as a biocide inhibiting microbial population that might have resulted in blockage of the vascular tissues.

It was in conformity with the findings of Nagaraja et al. (1999) who opined that sucrose, AgNO₃, HQS and citric acid prevents microbial occlusion of xylem vessels in tuberose thereby enhancing water uptake and increasing longevity of flowers. The findings of the experiment are further supported by those of Khondakar and Majumdar (1985) in tuberose and Acock and Nichols (1979) in cut carnations.

Changes in fresh weight of spikes

Fig. 3. represent the changes of fresh weight of spikes held in different vase solution up to 10th day at one day interval. It was observed from the graphical presentation that in all treatments including control, a gentle increase in weight of spike was noted up to the 3rd day. There after depletion in weight of spike was observed, those held in tap water and solution containing NaOCl. Increasing trend continued up to 6 days in the spikes held in solution containing sucrose, AgNO₃, HQS and their combinations with citric acid. However, the maximum fresh weight of spike was observed in T₆ (65 g). Spikes held in solutions with different concentration of sucrose, AgNO₃, HQS and citric acid maintained their weight above the initial one even up to 7th day of vase life, while those held in tap water and solutions free from sucrose, AgNO₃, HQS and citric acid gained their weight below their initial weight after 4th day. These results indicated that sucrose, AgNO₃, HQS and citric acid help the spike to maintain their weight.

Floret deterioration (%)

Floret deterioration percentage was maximum in T₁₀ and minimum in T₆ (Fig. 4). Combination of 2% sucrose + 200 mg/l AgNO₃ + 300 mg/l HQS + 25 mg/l citric acid inhibited climacteric ethylene synthesis, increased invertase activity in developing buds and significantly reduced floret deterioration.
From this study it is observed that vase life differed in case of different vase solutions (Fig. 5). Maximum vase life was recorded in T6 (10 days) followed by T5 (9 days). The minimum vase-life was noted in control (6 days). Water absorption was greatly influenced by a mixture of sucrose, AgNO3, HQS and citric acid. Tuberose spikes held in T6 (2% sucrose + 200 mg/l AgNO3 + 300 mg/l HQS + 25 mg/l citric acid) had a highest absorption index than other treatments. Sucrose in preservative solution can replaces with the losses carbohydrates and prevents all activity related to senescence (Goszczynska and Rudnicki, 1988). Also, Van doorn (2001) reported that flowers in present of sugar, are resistant to ethylene.

Microorganisms, which grow in vase water, include bacteria, yeasts and molds are harmful to cut flowers through their development in, and their consequent blockage of xylem at cut ends, preventing the water absorption. They also produce ethylene and toxins, which accelerate flower

senescence and reduce vase life. Adding a suitable germicide in vase water can check the growth of microbes. Silver salts, mainly AgNO₃ is an effective bactericide, which is often added in vase water at a concentration of 10-200 mg/l for the extension of vase-life (Singh et al., 2003). Sulphate of hydroxyl quinolene also influenced the vase-life of flowers. Their mode of action is associated with control of microbial activity or control of metabolism in flowers (Singh et al., 1994). This might be due to the inhibition of vascular blockage by sucrose + AgNO₃ + HQS+ citric acid, as suggested by Pathak (1981) in tuberoses, as well as retardation of microbial growth, as suggested by Reid (2002) in cut flowers. Cut flower longevity has been shown to be associated with maintenance of fresh weight (Gowda and Gowda, 1990). Spike held in 2% sucrose + 200 mg/l AgNO₃ + 300 mg/l HQS + 25 mg/l citric acid solution maintained their fresh weights above initial weight even up to 7 days of vase life, while those held in tap water and other treatments gained their weight below their initial weight after 4th day.

These results indicated that AgNO₃, sucrose, HQS and citric acid helped the spike to maintain their weight. These results are in agreement with previous workers who have reported increased vase-life of tuberose cut flowers when placed in solutions of AgNO₃ (Anjum et al., 2001) or HQS (Singh et al., 1994). Soaking of tuberose flower stems in 200 mg/l AgNO₃ also improved flower longevity by over 50% (Singh et al., 2000).

**CONCLUSION**

Based on the results of this study, it could be concluded that all chemicals used in this study have improved the vase life of the cut tuberose flower over control. The present study indicates that 2% sucrose + 200 mg/l AgNO₃ + 300 mg/l HQS + 25 mg/l citric acid treatment has improved tuberose cut flower quality by increasing vase life as measured by number of days, water uptake, maximum increase in fresh weight and inhibiting stem rot incidence. Therefore, 2% sucrose + 200 mg/l AgNO₃ + 300 mg/l HQS + 25 mg/l citric acid solution has potentiality to be used as a commercial cut flower preservative solution for prolonging vase life and postharvest quality of tuberose cut flowers.

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Enhancement of Growth Performances of *Ophiopogon japonicas* Ornamental Foliage Plant

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*Ophiopogon japonicus* is a perennial, ornamental foliage plant, which belongs to the family Liliaceae. It has a high demand in the local and international export market due to the presence of glossy white-green stripped lanceolate leaves. Improved leaves and plants of *O. japonicus* will be more popular in the floriculture industry. Hence, objective was to investigate the growth responses of *O. japonicus* for best potting media and fertilizer treatments. Shoots of *O. japonicus* trimmed up to 4 cm from the root-shoot junction were potted in two potting media as soil type 1, coir dust, compost and sand as 1:1:1 and soil type 2, sand, coir dust 1:1 by volume. High nitrogen fertilizer, balanced fertilizer and high phosphorous fertilizer were applied as foliar sprays in three concentrations (×1/2, ×1 and ×2 times of the RBG recommended dosages) and distilled water was used as the control. There was a significant (p<0.05) effect of growing media on the *O. japonicus* leaf length, plant fresh weight, shoot dry weight, root dry weight, number of leaves and number of shoots. However, there was no significant difference between the control and fertilizer treatments on leaf length, shoot dry weight, number of leaves and number of shoots while there was a significant difference among fertilizer treatments on plant fresh weight and root dry weight. Most effective potting media and fertilizer treatment for *O. japonicus* were sand:coir dust media (1:1) and Royal Botanic Gardens, Sri Lanka-recommended dosage (RBG) of fertilizer treatments (high nitrogen (2.5 g/L), balanced (1.25 g/L) and high phosphorous fertilizer (2.5 g/L), respectively.

Keywords: Fertilizer, Floriculture industry, Potting media.
INTRODUCTION

*Ophiopogon japonicus* is a perennial, ornamental foliage plant, belonging to the family Liliaceae (USDA, 2013). It is an easy crop to grow and leaves can be harvested 5-8 months after planting hence earnings from the crop is quick compared to other crops. It is a very valuable and widely utilized plant species in indigenous Chinese medicine as well (Ye et al., 2005). *O. japonicus* has a high demand in the international foliage export industry due to the presence of attractive white-green stripped lanceolate leaves. However, one of the selection criteria for this foliage species is the demand for long leaves (50-60 cm), which is a limiting factor at the moment. Improved leaves and plants of *O. japonicus* will be more popular in the floriculture industry. The long, bright coloured, shiny, straight, healthy leaves with increased postharvest longevity will increase the prevailing demand.

In ornamental plant production, selecting the most appropriate media is essential (Fitzpatrick, 1981). There are different types of potting medium components such as peat, pine bark, animal manure, calcined clay (Dewayne et al., 1993) coir dust: sand: compost (Herath et al., 2013).

Compost is produced by recycling organic disposal materials with the aid of micro flora under specific temperature and aeration conditions (Badar and Qureshi, 2014). Due to the increment of organic matter content the physical, chemical and biological properties of soil can be enhanced with compost (Liu et al., 2013). Kiran et al. (2007) recommended leaf mold or house waste compost as the best potting media for development of bulbs of *Dahila* sp. Furthermore, Castro et al. (2008) reported urban waste compost as the most suitable media for *Chrysanthemum* production.

Coir dust is a dominant by-product in coconut fiber production. It can be used to improve depleted soil by maintaining its organic matter content (Vidhana Arachchi and Somasiri, 1997). According to Rubasinghe et al. (2009), *Chiritamoonii*, which is an endemic wild flowering plant, produced less vigorous roots with less number of adventitious roots in sand media compared to sand: coir dust medium. Moreover, the highest fresh weight of root, highest root length and highest shoot length was observed in sand: coir dust medium.

Fertilizers are supplied as nutrient improvers for soil and enhance the productivity of crops (Ingles, 2004). However, optimum nutrient range varies with the plant species. A complete fertilizer should consist of nitrogen (N), phosphorous (P) and potassium (K), which are essential for plant growth. Nitrogen increases leaf length (Rademacher and Nelson, 2001) while P enhances the rapid growth of plants. Potassium in volves in many functions in plants such as enzyme activity, protein synthesis, photosynthesis, osmoregulation, stomatal movement, energy transfer, phloem translocation, ionic balance and stress resistance (Wang et al., 2013). El-Naggar and El-Nashorty (2009) stated that the number of leaves per plant of *Hippeastrum vittatum* had increased significantly by using complete fertilizer of N:P:K (19:19:19) at 5 g/plant. Kapugama and Peiris (2010) showed that the balance complete fertilizer with 20:20:20 ratio performed well on *Anthurium* sp. cv “Tropical Red”. Chemical fertilizers such as anhydrous ammonia, ammonium nitrate, urea, super phosphate, ammoniated phosphates, potassium nitrate and potassium chloride are the most commonly used fertilizers (Ingles, 2004). Hence, in this study the objective was to investigate the growth responses of *O. japonicus* for different potting media and fertilizer treatments.

MATERIALS AND METHODS

Study site

The experiments were conducted in the semi glass house of the Department of Botany, Faculty of Science, University of Peradeniya, Sri Lanka during the period of January to June 2013 (mean average temperature 27 ± 2 °C, mean average humidity 78 ± 2%).

Plant material

Healthy plants of *O. japonicus* were obtained from the Royal Botanic Gardens (RBG), Peradeniya (7° 15' 47" N, 80° 36' 10"E) and Kandyan home gardens (7° 17' 47" N, 80° 38’ 6" E).
Establishment of plant material in different potting media

Plastic pots of 14 cm in diameter and 13 cm in depth were used for the trial, filled with two types of media. Soil type 1 contained a mixture of coir dust, compost and sand 1:1:1 by volume. Soil type 2 contains a mixture of sand and coir dust 1:1 by volume. Shoots of *O. japonicus* trimmed up to 4 cm from the shoot-root junction were potted.

Fertilizer application

Three different fertilizer treatments; high nitrogen fertilizer (30:10:10), balanced fertilizer (20:20:20) and high phosphorous fertilizer (10:52:10) were applied in three concentrations (×1/2, ×1 and ×2 times of the RBG recommended dosages; i.e. recommendations made by the Royal Botanic Gardens, Sri Lanka) as foliar sprays. Distilled water was used as the control. Fertilizer treatments were given four weeks after plant establishments. High nitrogen fertilizer and balanced fertilizer were sprayed at ten days intervals, for a period of two and half months. Consequently, high phosphorous and balanced fertilizer treatments were carried out same as above for the same duration. Two types of potting media and four fertilizer treatments as a factorial design were established. Each treatment consisted of 15 replicates. Pots were arranged randomly in a completely randomized design. Three trials were carried out separately.

Growth parameters measured

Six months after the plant establishment, length of leaves, number of new shoots and number of new leaves were measured. Roots and shoots were oven dried separately at 70°C for 48 hours and dry weight of shoots and dry weight of roots were taken (Hettiarachchi *et al.*, 2010). Data were analyzed using the two-way ANOVA procedure in the SAS statistical software (version 9.13). Duncan mean separation test was used to identify the significant differences among the treatments.

RESULTS

Most suitable potting media and fertilizer application

Leaf length

Results showed that different potting media had a significant effect (p<0.05) on *O. japonicus* leaf length while there was no significant difference between the control and fertilizer treatments on leaf length. The highest leaf length (12.4 cm) was recorded in S2F1 (coir: sand media with RBG recommended dosage of fertilizer) treated plants while lowest leaf length (3.5 cm) was recorded in S1F2 (compost: coir: sand media with twice of RBG recommended dosage of fertilizer) treated plants. When comparing highest leaf lengths of plants grown in both soil types, leaf length of plants grown in S2 media showed a 3.5 fold increment than plants grown in S1 media. Furthermore, according to the results, in both potting media, the lowest leaf length was reordered in F2 (twice of RBG recommended dosage of fertilizer) treated plants. This may be due to over dose of fertilizer treatments causing retardation of the increment of leaf length (Table 1).

Number of new shoots

There was a significant difference (p<0.05) on the number of shoots of *O. japonicus* when grown on sand:coir dust mixed potting media than compost:sand:coir dust media. Number of shoots were higher in plants grown in S2 compared to S1. The highest number of new shoots (1.47) was observed in S2F1 treated plants compared to other treatments. The lowest number of new shoots (0.47) was recorded in S1F1 treated plants. However, there was no significant difference between fertilizer treatments on number of shoots (Table 1).

Number of new leaves

There was no significant difference in the number of new leaves with different concentra-
ions of fertilizer treatments. The highest number of new leaves were obtained in S2F1 (8.93) treated plants whereas lowest number of leaves were recorded in S1F2 (2.67) treated plants. Number of new leaves were higher in plants grown in S2 compared to S1 (Table 1).

### Fresh weight of plants

There was a significant difference (p<0.05) between potting media as well as fertilizer treatments on the fresh weight of plants of *O. japonicus*. Highest fresh weight of plants was recorded in S2F1 (7.27 g) treated plants while the lowest fresh weight of plants was recorded in S1F2 (1.13 g) treated plants. Thus, fresh weight of plants was higher in plants grown on S2 compared to S1 (Table 1).

### Dry weight of shoots

Regarding the dry weight of shoots, different potting media showed a significant difference (p<0.05) while similar trend was observed in different fertilizer treatments. The highest dry weight of shoots (0.31 g) was observed in S2F1 treatment while lowest (0.04 g) obtained with S1F2 treated plants (Table 1).

### Dry weight of roots

Results in Table 1, indicates the significant difference (p<0.05) of root dry weight due to different potting media as well as fertilizer treatments. Highest average root dry weight (0.42 g) was recorded in S2F1 treatments while lowest (0.05 g) obtained S1F2 treated plants (Table 1).

### DISCUSSION

Two types of potting media: compost: sand (S1) and sand (S2) and three different fertilizer treatments (×1/2, ×1 and ×2 times of the RBG recommended dosages) of high N, P and balanced fertilizer were used in this study. Growth of *O. japonicus* was investigated under 6 parameters; length of leaves, number of new shoots, number of new leaves, fresh weight of the plants, dry weight of shoots and dry weight of roots. Results of the present study showed that S2 media promoted *O. japonicus* plant growth than S1 media.

Coir dust can retain high amount of water due to its high water holding capacity. Roots tend to absorb water and thus leaf length can be increased. Furthermore, particle density of coir is low and it indicates the presence of high specific surface. These characters of coir are the evidence of high absorption capability of water and ions (Rubasinghe et al., 2009). In general, pore size contributes to the distribution of water and air in the soil and affects growth of a plant (Vidhana Arachchi and Somasiri, 1997). Coir is used as a substitute to peat and is commercially popular.
worldwide as a potting media for ornamental plants. Further, it is environmentally friendly and low cost (Ahmad et al., 2012).

Plants grown in S1, which contained compost, showed a reduction of leaf length compared to the plants grown in S2 potting media. This can be due to many reasons such as, release of nutrients in compost at a very slow rate that are not in readily available form to plants. Thus, plants may be unable to absorb essential amount of nutrients (Seran et al., 2010). Further, compost medium can vary in content and may consist of heavy metals and pathogens as well. However, some compost media contain inherent deficiencies such as high salinity, leading to stunted growth and chlorosis of plants (Bugbee, 2002), inappropriate pH value and high heavy metal concentration (Wilson et al., 2001). Burger et al. (1997) suggested that, composted green waste have to be blended with other growing material such as perlite and peat moss in order to minimize above mentioned deficiencies. In contrast to Burger et al. (1997), Wilson et al. (2001) recorded that a perennial ornamental plant, Orthosiphon stamineus reduced its growth in peat or coir dust amended with compost media, which is also in accordance with our results.

Fain and Paridon (2004) reported that calcined clay produced higher quality O. japonicus plants than standard nursery media. According to their view it reduces labor cost, which is required to harvest bare root production. Herath et al. (2013) reported that leaf mould: soil: sand in 1:1:1 was the best soil medium for the growth of O. japonicus. High levels of N, P, K can be toxic to plants and retard its growth (De Lucia et al., 2013). According to results obtained, there was no significant effect of different concentrations of fertilizer treatments on leaf length, number of leaves, and number of shoots and dry weight of shoots. Further, findings of Broschat et al. (2008) concluded that the visual quality of Sienotaphrum secundatum ‘Floratam’, Pentas lanceolata, Nandina domestica, and Allamanda cathartica ‘Hendersoni’ were similar for all fertilizer types tested. Three different fertilizer concentrations (×1/2, ×1 and ×2 times of the RBG recommended dosages) of high N, P and balanced fertilizer were used in this study. Half a dosage of fertilizer was used to compare the yield with the RBG recommended dosage in order to reduce the cost on fertilizer. Meanwhile, twice the RBG dosage was used to check whether it gives a higher yield than RBG recommended dosage. However, there was a significant difference among fertilizer levels on root dry weight and plant fresh weight. Fresh weight and dry weight are factors, which are used to assess plant growth (Taiz and Zeiger, 1991). Maximum growth and best quality yield can be harvested with the accurate combination of nutrients with a suitable potting media (Ahmad et al., 2012).

According to the results, we recommend coir: sand media and RBG recommended dosages of fertilizer for speedy increment of leaf length in O. japonicus, which will enhance the marketability this ornamental foliage plant.

CONCLUSION

Most effective potting media and fertilizer treatment for O. japonicus were sand: coir media with Royal Botanic Gardens, Sri Lanka recommended dosage of fertilizer treatment i.e., high nitrogen (2.5 g/L), balanced (1.25 g/L) and high phosphorous fertilizers (2.5 g/L), respectively.

ACKNOWLEDGEMENT

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The Impact of Drought Stress of the Cultivation Medium on the Growth and Postharvest Life of *Lilium* and Chlorophyll in Different Potassium Concentrations of Nutrient Solution

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To study the effect of different concentrations of potassium in the nutrient solution and water stress on the quality and quantity yield of *Lilium* LA cv. Termoli, a pot experiment was conducted based on completely randomized design in sand and perlite medium (50:50) in three levels of potassium (K-free, 6 mM K and and 12 mM K in Hoagland solution) with three replications. In the present study, the growth indices, post-harvest life of flower and potassium and chlorophyll contents were measured in shoots. The results showed that the plant dry/fresh weight and vegetative height was highest in 6 mM potassium treatments. Lily postharvest life at 6 mM K was increased 5.7 days relative to k-free conditions. The chlorophyll a, b and total content in nutrient solution without K were lower than in nutrient solution with 6 and 12 mM potassium.

**Keywords:** Chlorophyll, Growth medium, Perlite, Postharvest life.
INTRODUCTION

Among the various kinds of bulbous plants, Lilium is uniquely beautiful flowers that its colorful plants favor high price and is grown as cut flowers or pot (Sajid et al., 2009). This plant is ranked fourth followed by rose, carnation and chrysanthemums. Every year, this plant in Netherland flower auction market is sale about 150 million cut (Burchi et al., 2010). One of the most important factors affecting the quality of the flowers is appropriate nutrition. Nutrients supply affects on plant growth and metabolism. Nutritional studies on bulbous flowers are difficult, because the nutrients are in storage form in the bulb. So to overcome nutritional problems mentioned above, cultivation experiments on mediums without nutrients along with nutrient solution are recommended (Naseri and Ibrahimi, 2002). Potassium has considerable importance in Lilium nutrient. This element lead to optimal improves in plant growth and increases flowers post harvesting life because of the role in the protein synthesis process, neutralizing anions and adjusting osmotic potential (Pardo et al., 2006). This element play a role in protein synthesis, photosynthesis and transport materials from its. In the case of potassium deficiency, the activity of some enzymes, uptake and transport of some nutrients will reduce (Kanai et al., 2007). Morgan (1992) and Ma et al. (2004) reported that lines of rapeseed and mustard that showed high osmotic adjustment had high concentration of potassium in their tissues.

Potassium ions catalyze the transfer of materials from photosynthesis. This is probably related to photophosphorylation processes. Increasing photophosphorylation and photosynthetic electron transport in plants having sufficient good potassium ions is observed. Photosynthetic electron transport system is the major source of reactive oxygen production in plant tissues (Asada, 1994) that have the potential to produce single oxygen and superoxide. The present study was designed to investigate the effect of different concentrations of potassium in nutrient solution under conditions of drought stress on yield of lily.

MATERIALS AND METHODS

Premature bulbs of lilium LA hybrid cv.‘Termoli’ were prepared and were transferred to the Islamic Azad University, Science and Research Branch, Guilan, Iran. A completely randomized design with three treatments in three replicates in a medium sand and perlite (50:50) was designed. The medium moisture and water-holding capacity condition was always faced dry between two irrigations. Treatments were consisted of three levels of zero (nutrient solution without potassium), 6 mM potassium and 12 mM potassium in Hoagland solution.

Perlite with a diameter of 1 to 2 mm (fine) was used and several times washed with double distilled water for reduce fluoride. River sand was washed several times to be free of any mud and then packed in cellophane bags and were disinfected using an autoclave (120°C for 15 min). Lily bulbs incubated with 10g Benomyl fungicide solution in ten liters of water for 15 minutes before planting. And then, were placed on paper without rinsing and were completely dried by air flow. Pots made with a height of 15 cm and two liters volume were disinfected with sodium hypochlorite 1%. Bulbs was planted after disinfect inside the pot with a depth of 10 cm and then were placed in a greenhouse spacing 20×20 cm and irrigated with 300 mL of deionized water immediately for each pot. Average, minimum and maximum temperatures during the growing period were measured by the thermometer that was 18-22 and 17-16°C at day and night, respectively.

Hoagland solution was used in the experiment (Hoagland, 1950). Salts present in the Hoagland formula are including potassium phosphate, potassium nitrate, calcium nitrate and magnesium sulfate which containing six elements of phosphorus, potassium, nitrogen, calcium, sulfur and magnesium. Then, a molar solution of each of them was prepared as a mother or stock solutions. Applying a certain amount of each salt stock solution, sufficient amount of needed nutrients is provided. However, to control or change one or more nutrient concentrations, concentrations of other elements in the formula will change. Due to changes in potassium concentration in the nutrient solution (in standard mode, 6 mmol), potassium nitrate in K-free condition is not intake.
Decrease in the amount of nitrogen in the nutrient solution due to decreased intake of calcium nitrate compensated from ammonium nitrate salt. The main reason for the use of ammonium nitrate is to supply nitrogen both in nitrate (NO$_3^-$) and ammonium (NH$_4^+$). Increase in potassium concentration in the nutrient solution at a concentration of 12 mM is supplied through potassium sulfate. Potassium salts used in any concentration can be seen in Table 1.

The nutrient solution system was an open system and nutrient solution with irrigation water (300 mL) was used once every three days. The status to maintain moisture in sand and perlite medium was in such a way that medium was encountered with drought and the plant faced with drought stress during both irrigations. To measure the flowering time, the number of days from bulbs planted in pots to the first appearance of bud was counted. Lilies stem end height, stem diameter, reproductive height (distance between the lowest pedicel to tip of the longest bud), and shoot dry weight were measured. To measure the durability of the cut flowers, cut flowers are placed in water and the number of days from harvesting cut flowers until when 50% of petals falling from each sample, were counted.

To measure potassium, 0.3 g dried sample in oven with 2.3 mL mixture of sulfuric and salicylic acids were soaked for 24 hours. Then, the samples were heated to 180 °C and the solution was colorless adding intermittent and low hydrogen peroxide. Then the solution is brought to the related volume with distilled water and filtered (Emami, 1996).

Chlorophyll content was determined using Arnon (1949) method. To measure chlorophyll content, 0.5 g of green leaves in liquid nitrogen in a porcelain mortar in ice container without light with 0.5 g magnesium carbonate was ground and gradually adds about 10 ml of acetone 80%. One ml of the prepared extract after centrifugation was placed in a spectrophotometer cell and the amount of light absorbed by chlorophylls a and b was read at 645 and 663 nm wavelengths, respectively. The amount of chlorophyll a, b and total were determined by the following formula:

\[
\text{Cchl.a: } (0.0127) \times (\text{oD 663}) - (0.000259) \times (\text{oD 645}) \\
\text{Cchl.b: } (0.0229) \times (\text{oD 645}) - (0.000469) \times (\text{oD 663}) \\
\text{CchlT: } (0.0202) \times (\text{oD 645}) - (0.0080) \times (\text{oD 663}) \times V/W
\]

Where, C is chlorophyll a, b and total concentration in mg/g leaf fresh weight and oD is the light absorption rate at corresponding wavelengths and V is the acetone 80% volume and W is leaf fresh weight.

RESULTS AND DISCUSSION

Table 2 shows the results of data analysis of variance related to the effect of potassium concentration in nutrient solution on plant growth indices. Effect of treatments on shoot dry weight, postharvest life, shoots potassium concentrations and the number of secondary buds was significant at 1% and shoot fresh weight, bud coloring time, vegetative and reproductive height, initial number of buds, stem diameter and flower diameter was significant at 5%.

Tables 3-5 show the effect of treatment on the growth indices of lilium. The highest shoot fresh/dry weight is related to 6 mmol of potassium with 16.6 g and 14.1g, respectively. Shoot fresh...
weight in 12 mM potassium showed significant reduction compared with the control, and the 6 mM potassium. It seems that in 6 mM potassium, potassium had been adequately and plants with potassium stock lost less water. As a result, water conservation increased shoot fresh weight. Sulter (1957), Tisdale \textit{et al}. (1985) and Huber (1985) also stated that, due to its role in the growth and development of plant cells and making cell turgor and opening and closing of stomata, potassium maintain water in plant and this has greatly increased plant fresh weight.

It seems that shoot fresh weight reduction in treatment 12 mM potassium than 6 mmol is due to an antagonistic effect of these element and other nutrients. Bould (1964) stated that increase potassium levels in the nutrient solution due to antagonist’s effect of potassium with magnesium and calcium reduced their uptake by the plant. These findings are corresponded to Barra-aguilar \textit{et al}. (2012) in lily and Wang (2007) in the orchid flowers.

There is no significant difference between the time of bud coloring in K-free and 6 mM potassium medium (Table 3). Double increasing the potassium reduce bud coloring time. The results are corresponded to Wang (2007) on the orchid flowers. Stem diameter in 12 mM potassium treatments was significantly decreased compared to K-free treatment (Table 4). According to the results of Table 5, the reduction in diameter of open flowers was found in 12 mM potassium con-

Table 3. The effect of treatment on Fresh and dry weight of shoot, vegetative and reproductive height, time to appearance flower bud and buds coloring time.

<table>
<thead>
<tr>
<th>K concentration in nutrient solution</th>
<th>Fresh weight of shoot (g)</th>
<th>Dry weight of shoot (g)</th>
<th>Vegetative height (cm)</th>
<th>Reproductive height (cm)</th>
<th>Time to appearance flower bud (day)</th>
<th>Buds coloring time (day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without K</td>
<td>121.3 c</td>
<td>9.9 c</td>
<td>86.9 b</td>
<td>9.2 b</td>
<td>28.2</td>
<td>42.8 b</td>
</tr>
<tr>
<td>6 mM</td>
<td>158.3 a</td>
<td>15.4 a</td>
<td>98.5 a</td>
<td>9.5 a</td>
<td>26.7</td>
<td>43.0 a</td>
</tr>
<tr>
<td>12 mM</td>
<td>133.0 b</td>
<td>13.0 b</td>
<td>94.0 b</td>
<td>11.0 b</td>
<td>28.2</td>
<td>30.2 b</td>
</tr>
</tbody>
</table>

Table 4. The effect of treatment on first flower bud length, leaf number, bud number and stem diameter.

<table>
<thead>
<tr>
<th>K concentration in nutrient solution</th>
<th>First flower bud length (mm)</th>
<th>Leaf number</th>
<th>Primary flower bud number</th>
<th>Secondary flower bud number</th>
<th>Flower bud aborted number</th>
<th>Stem diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without K</td>
<td>59.8</td>
<td>92.9</td>
<td>5.4 a</td>
<td>1.6 a</td>
<td>0.88</td>
<td>14.6 a</td>
</tr>
<tr>
<td>6 mM</td>
<td>64.6</td>
<td>90.8</td>
<td>6.0 a</td>
<td>2.0 a</td>
<td>0.62</td>
<td>15.2 a</td>
</tr>
<tr>
<td>12 mM</td>
<td>50.4</td>
<td>86.5</td>
<td>4.2 b</td>
<td>0.5 b</td>
<td>0.67</td>
<td>13.8 b</td>
</tr>
</tbody>
</table>

Table 5. The effect of treatment on flower diameter, fresh weight of underground organ and fresh and dry weight of rooted stem.

<table>
<thead>
<tr>
<th>K concentration in nutrient solution</th>
<th>Opened flower diameter (mm)</th>
<th>Fresh weight of underground organ (g)</th>
<th>Fresh weight of rooted stem (g)</th>
<th>Dry weight of rooted stem (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without K</td>
<td>146.6 a</td>
<td>48.4</td>
<td>8.0</td>
<td>1.8</td>
</tr>
<tr>
<td>6 mM</td>
<td>134.2 a</td>
<td>46.5</td>
<td>7.8</td>
<td>1.4</td>
</tr>
<tr>
<td>12 mM</td>
<td>102.8 a</td>
<td>48.6</td>
<td>5.6</td>
<td>1.2</td>
</tr>
</tbody>
</table>
concentration compared to without K. It seems in the plant fed with nutrient solution 12 mM potassium, potassium content of the nutrient solution was sufficiently high (luxury consumption). The plants first grew normally, but gradually during plant reproductive development, high concentrations of potassium left its negative effects through agonistic effect on the uptake of other nutrients; especially calcium which is contributes in the increase of cell wall and increase the flower diameter. And thus the diameter of the opened flower in the treatment was decreased. Barrera-Aguilar et al. (2012) in study on *Lilium* in Mexico examined the effect of 4 potassium levels (0, 5, 10, 20 mM) in Hoagland solution on *Lilium* growth and photosynthesis grown in acidic peat. The results showed that at concentrations 5 to 10 mM, flower diameter, plant height and plant dry weight was increased; however, higher concentrations of potassium had adverse effect on the listed traits. Wang (2007) examined the impact of different levels of potassium (50, 100, 200, 300, 400, 500 ppm) on the *Phalaenopsis* orchid. The results showed that the largest and tallest inflorescence regardless of the medium was obtained at level of 300 ml/l. The higher amount had an inverse effect on all traits.

Lily postharvest life at a concentration of 6 mM potassium was increased 5.7 days than in the potassium-free conditions (Fig. 1); however there is not found significant difference between postharvest in 12 mM potassium in nutrient solution and potassium-free conditions.

Increase potassium in the nutrient solutions based on the antagonistic action between potassium, magnesium and calcium may decrease the uptake of magnesium and calcium (Bould, 1964).
Another reason for reducing flowers postharvest life in 12 mM potassium than 6 mmol of potassium can be high concentration of potassium in the root environment which prevents the uptake of calcium and magnesium in the plant. It is worth noting that among other elements, calcium and magnesium play the most important role in increasing the postharvest life of cut flowers. The effect of calcium on the lily postharvest longevity (Seyedi et al., 2011), Robichuax (2008) in poinsettia and Sosanan (2007) in sunflower has been reported. Probably the reason for no significant difference in the lily postharvest in 12 mM potassium with potassium-free is that lilies are bulbous plants and nutrients stored in its bulb (Naseri and Ebrahim, 2002). According to the results in Fig. 2, the increase of nutrient solution potassium increased in potassium concentrations in shoots. This increase was more than twice the concentration of potassium in potassium-free nutrient solution. This is due to the greater supply of potassium by nutrient solution and more potassium uptake by the plant. Increasing potassium uptake can be a reason in the increase of vase life.

The results in Table 6 show that chlorophyll a, b and total chlorophyll content in nutrient solution without K was lower than in nutrient solutions 6 and 12 mM potassium. It seems that, as a non-organic osmolit in osmotic adjustment, potassium has been effective to reduce the negative effects of drought stress (Ma et al., 2004 and 2006) and consequently to improve metabolic processes including forming chlorophyll. Potassium is involved in the synthesis of chlorophyll pigment precursor (Kumar and Kumar, 2008). This element play a role in protein synthesis, photosynthesis and transport materials from its. In the case of potassium deficiency, the activity of some enzymes, uptake and transport of some nutrients will reduce (Kanai et al., 2007).

CONCLUSION

Results showed that the plant fresh and dry weight and plant vegetative height in the treatments 6 mM potassium was highest. Lily postharvest at a concentration of 6 mM potassium was increased 5.7 days relative to k-free condition. The amount of chlorophyll a, b and total in the nutrient solution k-free was lower than in the nutrient solution with 6 and 12 mM potassium.

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Literature Cited


اثر تنش خشکی حاصل از بستر کشت بر رشد، عمر پس از برداشت و مقدار کلروفیل سوسن در غلظت‌های مختلف پتاسیم در محلول غذایی

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کلید واژگان: کلروفیل، بستر رشد، پرپاش، عمر پس از برداشت.
افزایش عملکرد گیاه زینتی

Ophiopogon japonicus

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پیشنهاد باغ سلطنتی گیاهشناسی سریلانکا به کار رفته. آب مقطّع و به عنوان تیمار شاهد استفاده شد. برای رشد بر طول بزرگ، وزن تر گیاه، وزن خشک اندام هواپی و ریشه و تعداد ببرگ و ساقه در سطح 5 درصد اثر معنی داشت. اثر معنی‌داری بین تیمار شاهد و تیمارهای کودو به طول بزرگ، وزن خشک اندام هواپی و تعداد ببرگ و ساقه دیده شد. در حالی که بین تیمارهای کودو تفاوت معنی‌داری در اثر بر وزن تر گیاه و وزن خشک ریشه مشاهده شد. مؤثرترین بستر کشت، بستر 30 درصد ارزش، 30 درصد ارزش و سایر تیمارهای کودو تفاوت معنی‌داری در اثر بر وزن تر گیاه و وزن خشک ریشه مشاهده شد.

شکل و ارگان: کود، صنعت گل کاری، است. گیاه.
اثر محلول‌های نگهدارنده مختلف بر عمر گلدانی گل مرمی

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این مطالعه برای بررسی اثر چند محلول نگهدارنده در حفظ کیفیت گل مرمی (Polianthes tuberosa cv. `Single) انجام شد. تیمارها (محلول‌های نگهدارنده) عبارت بودند از: T۱: ۲ درصد ساکر + ۲۰۰ میلی‌گرم در لیتر P۰۴، T۲: ۲ درصد ساکر + ۲۵۰ میلی‌گرم در لیتر AgNO۳ + ۲۵ میلی‌گرم در لیتر اسید سیتریک، T۳: ۲ درصد ساکر + ۳۰۰ میلی‌گرم در لیتر HQS + ۳۰ میلی‌گرم در لیتر AgNO۳ + ۲۵ میلی‌گرم در لیتر P۰۴ و T۴: ۲ درصد ساکر + ۳۰۰ میلی‌گرم در لیتر HQS + ۲۵ میلی‌گرم در لیتر AgNO۳ + ۲۰۰ میلی‌گرم در لیتر P۰۴ و T۵: ۳ درصد ساکر + ۲۵۰ میلی‌گرم در لیتر P۰۴ + ۳۰ میلی‌گرم در لیتر AgNO۳ + ۲۰۰ میلی‌گرم در لیتر P۰۴ و T۶: ۲ درصد ساکر + ۲۵۰ میلی‌گرم در لیتر AgNO۳ + ۲۰۰ میلی‌گرم در لیتر P۰۴ و T۷: ۱۰/۰ درصد هیپوکلراید سدیم + ۳۰ میلی‌گرم در لیتر P۰۴. T۸: ۵/۰ درصد هیپوکلراید سدیم و T۹: ۱۰/۰ درصد هیپوکلراید سدیم و T۱۰: آب شهري (شاهد). نتایج نشان داد که همه تیمارها کیفیت نگهداری و عمر گلدانی گل‌های شاخه برجسته را نسبت به شاهد بهبود دادند. در بین تیمارها، بیشترین جذب آب، نسبت جذب به هدر روز آب، افزایش وزن تر ساچه در تیمار T۲ درصد ساکر + ۲۰۰ میلی‌گرم در لیتر P۰۴ + ۲۵ میلی‌گرم در لیتر AgNO۳ + ۳۰۰ میلی‌گرم در لیتر HQS، T۳: ۲ درصد ساکر + ۲۵ میلی‌گرم در لیتر AgNO۳ + ۳۰۰ میلی‌گرم در لیتر HQS و T۴: ۲ درصد ساکر + ۲۵ میلی‌گرم در لیتر AgNO۳ + ۳۰۰ میلی‌گرم در لیتر HQS، T۵: ۳ درصد ساکر + ۲۵ میلی‌گرم در لیتر AgNO۳ + ۳۰۰ میلی‌گرم در لیتر HQS و T۶: ۲ درصد ساکر + ۲۵ میلی‌گرم در لیتر AgNO۳ + ۳۰۰ میلی‌گرم در لیتر HQS دیده شد که عمر گلدانی گل به ۱۰ روز افزایش یافت. طبق نتایج تحقیق حاضر، تیمار مذکور بهترین تیمار در طولانی‌ترین عمر گلدانی گل مرمی محسوب می‌شود.

کلید واژگان: اسید سیتریک، کیفیت نگهداری، گل مرمی، محلول نگهدارنده، هیپوکلراید سدیم ساکر.
بررسی اثرات تیمارهای مکانیکی و عصاره شمعدانی عطری بر عمر گلچایی گل شاخه بریده دادی (Dendranthema grandiflorum L.)

به منظور بررسی اثر شکاف ۵ سانتیمتری و عصاره شمعدانی عطری بر عمر گلچایی و خصوصیات گل بریده دادی (Dendranthema grandiflorum L.) آزمایش فاکتوریل ۵ عاملی بر张家口 طرح کاملاً تصادفی با دو فاکتور، شکاف انتها ساقه در ۲ سطح (شکاف و بدون شکاف) و عصاره شمعدانی عطری در ۶ سطح (۰، ۱، ۲، ۴، ۸ و ۱۰ درصد) با ۱۲ تیمار، ۳ تکرار، ۳۶ پلاک و ۱۴۴ شاخه گل انجام شد. در این مطالعه از فاکتورهای قرار گرفته، نتایج نشان داد که عمر گلچایی، افزایش وزن تر، ماده خشک و افزایش داشته درجه برعکس مورد ارزیابی قرار گرفت. نتایج نشان داد که عمر گلچایی، افزایش وزن تر در سطح ۱ درصد آماری معنی‌دار شده است و صفات ماده خشک و جذب آب در سطح ۳ درصد آماری معنی‌دار شده است. همه تیمارها نسبت به شاهد موجب بهبود عمر گلچایی شدند ولی بیشترین عمر گلچایی مربوط به تیمار شکاف ۵ سانتیمتری همراه با ۱۰ درصد عصاره شمعدانی بود. نسبت به شاهد (۰/۰۸۳) روز مانندگاری این گل بریده را افزایش داد.

کلید واژگان: گل دادی، شکاف انتهای ساقه، عصاره شمعدانی عطری، عمر گلچایی.
اثر میدان مغناطیسی روی جوانه‌زنی بذر و پیشرس کردن همیشه بهار

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به منظور بررسی اثر میدان مغناطیسی روی خصوصیات جوانه‌زنی و پیشرسی همیشه بهار یک آزمایش در شرایط آزمایشگاهی در دانشگاه اراک انجام شد. بذرها D1 در معرض ۱۰۰۰ با ۲۰۰ میلی‌تسلا در دوره‌های زمانی مختلف ۱۸ (شاهد)، ۲۴ (D2) ساعت، ۵۲ (D3) ساعت، ۶۲ (D4) ساعت و ۷۲ (D5) ساعت برای دوره‌های ۱۰، ۵۰ و ۹۰ درصد پذیرش مواد محاسبه شد. از نظر جوانه‌زنی میان میزان تیمارها بهتر از شاهد بودند. به عبارت دیگر در بذرهای تیمار شده مدت زمان لازم برای میانگین زمان جوانه‌زنی تقریبا در مقایسه با شاهد ۴ ساعت افزایش پیدا کرد. میانگین زمان جوانه‌زنی ۴ ساعت ۵۰ و ۵۶ ساعت افزایش پیدا کرد. میانگین زمان جوانه‌زنی بطور معنی‌داری بیشتر از شاهد بود. میانگین زمان جوانه‌زنی بطور معنی‌داری بیشتر از شاهد بود. میانگین زمان جوانه‌زنی بطور معنی‌داری افزایش یافت و این عدد حدود ۲ و ۳ ساعت بود. مطابق نتایج بدست آمده از وزن خشک دانه‌ها (SLD)، درصد کاهش ذخایر بذر (SRDP) و طول شاخس‌های (STL) مشخص شد که با افزایش زمان میدان مغناطیسی این خصوصیات کاهش یافته.

کلید واژگان: مغناطیس، شدت میدان، کاهش ذخایر بذر.
اثر زمان گرده‌افشانی و اسید جیبرلیک (p<sub>GA</sub>) روی تولید و جوانه‌زنی بذر آرکیده فالانپوسیس

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قدرت جوانه‌زنی ارکیده‌ها (از خانواده ارکیداسه) بنظر می‌رسد بسیار ضعیف باشد. قدرت جوانه‌زنی ارکیده‌ها (از خانواده ارکیداسه) بنظر می‌رسد بسیار ضعیف باشد. یک ناشی از فقدان آلبومن است. این مطالعه با تیمارهای مختلف شامل زمان گرده‌افشانی برای شکست خواب و افزایش جوانه‌زنی ارکیده‌ها انجام شد. اثر زمان گرده‌افشانی (۸ دوره از زمانهای تا آگوست) و اسید جیبرلیک (۲۰۰۰، ۳۰۰۰ و ۴۰۰۰ میلی‌گرم در لیتر) روی جوانه‌زنی ارکیده فالانپوسیس بررسی شد. برای رشد دائمی‌ها از محبی کشت کوکوپیت و زغال به نسبت ۱ به ۲ و کوکوپیت، زغال، بیوسه درختان و دلی استین به نسبت ۱۰۰:۹:۱ استفاده شد. نتایج نشان داد که بهترین غلظت هیپوکرت سدیم برابر ضدعفونی کپسولها درصد بود. بهترین ماه باید گرده‌افشانی کپسولها به تعداد ۱۵/۶۵ دانه‌الی در بستر MS/۲ راه‌اندازی شود. این مطالعه در بستر اسید جیبرلیک بدست آمد. دانه‌الهای تولیدی برای مقاوم‌سازی به غلخانه منتقل شدند. بهترین میزان قدرت زغال در بستر کوکوپیت، زغال، بیوسه درختان و دلی استین حاصل شد.

کلید واژگان: محبی کشت، گونه‌های ارکیداسه، تیمار بذر، قوه نامیه.
اثر آگار و محيط کشت‌های مختلف در ریزازدایی رز رقم 'بلک باکارا' 

('Rosa hybrida cv. 'Black Baccara')

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ریز ازدیادی نقش بسیار مهمی در تکثیر ارقام با صفات مطلوب و تولید 
گیاهان عاری از بیماری دارد. این پژوهش به منظور بهینه‌سازی شرایط تکثیر رز 
هیرید رقم 'بلک باکارا' انجام شد. برای این منظور در مرحله پراوری، قطعات 
فیس WPM و MS، و فیس NAA میانگین (1/5 سانتی‌متری) در محيط کشت‌های VS و مايع 
کشت شدند. نتایج نشان داد که بالاترین پراوری در محيط کشت 
VS به و سرعت بود و بالاترین ضریب تکثیر و سرعت رشد در محيط کشت مايع 
VS به منظور بهینه‌سازی ریشه‌زایی گیاه‌ها آزمایشی با محيط کشت‌های 
NAA 1/4 در حالی مايع و نیمه جامد حاوی 50 میکرومولی VS 
انجام شد. نتایج نشان داد که آغاز ریشه تحت تاثیر غلظت‌های مواد معدنی 
میچه کشت است و پراوری و سرعت رشد بالای ریزگونه‌ها می‌تواند به دلیل 
پتانسیل آبی و در دسترس بودن مواد معدنی در محيط کشت مايع باشد.

کلید واژگان: آگار، رشد، محيط کشت، ریزازدایی، رز هیرید، کشت بافت.
به تأخیر انداختن پیبر یکس از برداشت گل بریزه لیزیانتوس توسعه تیمار سالیسیلیک اسد

داوود عطایی، روح‌الله، نادری و عزیزآقاخان، میرکوهی
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**کلید واژگان:** آنزیم‌های آنتی‌اکسیدان، لیپوکسیژن‌زای، لیزیانتوس، اسد سالیسیلیک، عمر گل‌جاوبی

اسید سالیسیلیک (SA) به عنوان یک مولکول سیگنال گیاهی در نظر گرفته می‌شود که نقص کلیدی در رشد گیاه، تهیه و واکنش‌های دفاعی بازی می‌کند. مکانیسم فیزیولوژیکی که کاربرد اسد سالیسیلیک پری گل شاخه بریزه لیزیانتوس را در طول عمر گل‌جاوابی تحت تأثیر قرار می‌دهد مورد بررسی قرار گرفته است. گل‌های شاخه بریزه لیزیانتوس با آب موقت (شاده)، 5/0، 1 و 2 میلیمیلیاً می‌توانند اسد سالیسیلیک تیمار شریفند و در دمای 25 درجه سانتی‌گراد تا 12 روز نگهداری شدند. کاربرد اسد سالیسیلیک با معنی 1 میلی‌میلیاً عمر گل‌جاوبی را افزایش داد که با کاهش نشان و محتوای مالون دی‌آلیسید (MDA) مرتبط بود. تیمار اسد سالیسیلیک فعالیت آنزیم لیپوکسیژن‌زای (LOX) همچنین فعالیت آنتی‌اکسیدان را افزایش داد. تیمار اسد سالیسیلیک و آسکوربیت پراکسیداز (APX) و آسکوربیت پراکسیداز (CAT) و تجمیع پراکسید هیدروژن (H₂O₂) باعث کاهش کاهش داد. بنابراین کاربرد اسد سالیسیلیک می‌تواند توانایی حذف گیاهی به وسیله افزایش فعالیت سیستم آنتی‌اکسیدان حفظ کند و در نتیجه پری گل شاخه بریزه لیزیانتوس را در طول عمر گل‌جاوبی به تأخیر بیندازد.
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