Use of a Nitric Oxide Donor Compound to Extend the Vase Life of Cut Flowers

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Abstract. Snapdragon (Antirrhinum majus L. ‘Chichat’), delphinium (Delphinium ajacis L. ‘Bellissimo’), chrysanthemum (Dendranthema grandiflora RAM. ‘Regan’), tulip (Tulipa hybrid ‘Golden Brush’), gerbera (Gerbera jamesonii H. Bolus ‘Manovale’), oriental lily (Lilium asiaticum L. ‘Specisimion Simplo’), rose (Rosa hybrid L. ‘Carnavale’) and iris (Iris hollandica Tub. ‘Blue Magic’) cut flower stems were placed at 20 °C in water containing the NO donor compound 2,2′-(hydroxynitrosohydrazino)-bisethanamine (DETA/NO) at 10 and 100 mg·L−1 and after 24 h, transferred to humidified air containing 0.1 µL·L−1 ethylene. Compared with flowers kept in water, the vase life of all eight flowers was extended by DETA/NO with an average extension of about 60% with the range being about 200% for gerbera to 10% for chrysanthemum. DETA/NO appears to have widespread applicability to cut flowers and offers a simple technology to extend vase life.

Postharvest senescence is a limiting factor in the marketing of many species of cut flowers with ethylene being an important endogenous and exogenous factor that enhances this process. Flowers that are sensitive to ethylene are often pulse-treated soon after harvest with silver ion, applied as silver thiosulphate (STS) to delay senescence. Silver reduces ethylene-binding capacity and suppresses endogenous ethylene production thereby delaying the appearance of senescence characteristics (Van Doorn and Woltering, 1991). However, silver is a heavy metal and environmental concerns has many countries actively moving towards its use. NO and 1-MCP are alternative treatments to STS, the gaseous nature of both compounds allows them to penetrate the floral tissues and be impermeable to gases, in order to prevent contact between any NO gas escaping from the solution and the flower head. Flowers were held in the treatment solution in ambient air at 20 °C and about 60% relative humidity (RH) for 24 h to permit compound uptake to occur in a low ethylene environment. The tubes containing the treatment solutions and flowers were then transferred to a sealed 20 L polystyrene container that was ventilated with humidified air (75% RH) containing ethylene at 0.1 µL·L−1 at 20 L·h−1. This ethylene concentration was used to simulate a likely commercial exposure (Wills et al., 2000). The ethylene concentration was generated by mixing gas from a cylinder containing 100 µL·L−1 ethylene in air with humidified air. The ethylene concentration of the gas mixture was checked at regular intervals by gas chromatography (Wills et al., 2000). The flowers were examined every 12 h and the time for each stem to deteriorate to a quality that was considered as just acceptable on the basis of moderate discoloration, mold growth or wilting was recorded as the vase life. A mean value of vase life for all the stems in a treatment unit was calculated and the data for vase life were statistically analysed using SPSS version 11 (Chicago, III.). Least significant differences (LSD) at P = 0.05 were calculated to compare differences between means.

Results and discussion

Flower stems kept in water containing DETA/NO at 10 and 100 mg·L−1 had significantly increased vase life relative to the water control for all eight flower types (Table 1). The use of 10 mg·L−1 DETA/NO resulted in a greater extension in vase life than 100 mg·L−1 for four...
similar effectiveness for 10 and 100 mg·L–1. For flowers exposed to 10 mg·L–1 DETA/NO, the flower types with the other four flowers having a
Oriental lily Low 181 a 251 b 250 b Bud opening, leaf yellowing and wilting
Iris Low 69 a 103 b 98 b Wilting and petal inrolling
Gerbera Low 103 a 314 c 257 b Petal discoloration, wilting and mold
Tulip Low 75 a 116 b 119 b Wilting and bud opening
Chrysanthemum Low 296 a 322 c 313 b Stem mold, petal wilting and yellowing abscission and browning

| Flower        | Ethylene sensitivity | Vase life (h) in DETA/NO solution (mg·L–1) | Cause of senescence            |
|---------------|----------------------|------------------------------------------|-------------------------------|
| Snapdragon    | High                 | 77 a 111 b 108 b                        | Flower abscission              |
| Delphinium    | High                 | 158 a 228 c 196 b                      | Flower abscission              |
| Rose          | High                 | 120 a 148 c 139 b                     | Bud opening and dropping, petal abscission and browning |
| Chrysanthemum | Low                  | 296 a 322 c 313 b                     | Stem mold, petal wilting and yellowing |
| Tulip         | Low                  | 75 a 116 b 119 b                      | Wilting and bud opening        |
| Gerbera       | Low                  | 103 a 314 c 257 b                     | Petal discoloration, wilting and mold |
| Iris          | Low                  | 69 a 103 b 98 b                       | Wilting and petal inrolling    |
| Oriental lily | Low                  | 181 a 251 b 250 b                     | Bud opening, leaf yellowing and wilting |

\*Mean separation in rows by LSD at P = 0.05. Values are the mean of two replications each with 10 flowers per treatment.

flower types with the other four flowers having a similar effectiveness for 10 and 100 mg·L–1. For flowers exposed to 10 mg·L–1 DETA/NO, the greatest proportional extension in vase life was obtained for gerbera at about 200%. Tulip and iris showed about a 50% increase, snapdragon, delphinium and oriental lily about 40%, while the lowest extension was for rose at about 20% and chrysanthemum at about 10%. To these should be added our previously published value for carnation of about 50% (Bowyer et al., 2003). Thus, DETA/NO has generated a 40% to 50% extension in vase life for most flowers but with substantial variation from this level for a few types. It is of considerable interest that DETA/NO was highly effective on the four flowers that have been categorised as having a low sensitivity to ethylene (Woltering and Van Doorn, 1988) with gerbera the most responsive and rose which has a high sensitivity to ethylene giving a relatively low response. The apparent widespread effect of DETA/NO across many types of flowers suggests that it may have commercial application. Its effectiveness on flowers with low ethylene sensitivity would indicate a wider usage than STS and 1-MCP as they are claimed to only inhibit ethylene action but no such studies have thus far been conducted. As a solid that dissolves in water and with effectiveness from a single initial application at a relatively low concentration, DETA/NO could find usage in the florist trade and domestic situations to extend vase life. It is concluded that the relative effectiveness of DETA/NO and other NO-releasing compounds should be examined in more comprehensive studies including comparisons made with current commercial florist preparations as well as STS and 1-MCP. Stability of DETA/NO is an issue that will also need some investigation. Preliminary examination indicated a half-life for DETA/NO of about 2 months at 20 °C but in the absence of water vapour and carbon dioxide.

**Table 1. Vase life at 20 °C of flowers continuously immersed in the water containing DETA/NO and stored in humidified air containing 0.1 µL·L–1 ethylene.**

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