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Stem end blockage in cut *Grevillea* 'Crimson Yul-lo' inflorescences

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Abstract

Grevillea 'Crimson Yul-lo' inflorescences have cut flower potential, but their vase life is short. End of vase life is characterized by early wilting. The possibility of physiologically mediated stem end blockage was investigated. Hydraulic conductance of 2 cm long stem end segments declined rapidly and remained lower throughout vase life than that of 2 cm long stem segments from immediately above. Re-cutting daily to remove basal 2 cm stem ends increased solution uptake, delayed declines in inflorescence water potential and water content, and improved inflorescence vase life. S-carvone is a potential inhibitor of wound related suberin formation, via inhibition of phenylalanine ammonia-lyase. Vase solution treatments with S-carvone (0.318 and 0.636 mM) delayed the decline in hydraulic conductance of basal 2 cm long stem end segments and decreases in vase solution uptake and relative fresh weight of cut stems, and extended vase life. Treatments with the catechol oxidase inhibitor 4-hexylresorcinol (2.5–10 mM) also delayed stem end blockage. These findings suggest that stem end blockage in cut *G.* 'Crimson Yul-lo' stems is physiologically mediated.

Keywords: Cut flowers; *Grevillea*; Hydraulic conductance; Vase life; Water relations

1. Introduction

There are over 300 *Grevillea* species (Proteaceae) (Joyce and Beal, 1999). Some species and many hybrids with large colourful inflorescences have cut flower potential (Costin and Costin, 1988; Joyce and Beal, 1999; Joyce, 2004; French et al., 2005). However, their vase life is often <1 week (Faragher, 1989; Joyce et al., 1996; Joyce and Beal, 1999; Joyce, 2004). End of vase life is often associated with rapid wilting of the inflorescence (Joyce et al., 1996).

Blockage of water conducting xylem vessels contributes to the short vase life of most cut flowers (Mayak et al., 1974; Halevy and Mayak, 1981; van Doorn, 1997). Stem blockage may be microbial and/or physiological. Louband and van Doorn (2004) reported stem blockage in *Viburnum opulus* (cv. Roseum) and rose (*Rosa* × *hybrida* cv. Red One) due mainly to living bacteria and their decay products. However, stem blockage in *Astilbe* × *arendsii* (cvs. Gult and Erica) was related mainly to wound induced physiological processes involving catechol oxidase and peroxidase. Wound related deposition of lipid–phenolic complexes (e.g. suberin) has been identified as a possible cause of stem end blockage (Williamson et al., 2002).

Formation of phenolic suberin compounds begins with synthesis of trans-cinnamic acid from phenylalanine, and is catalysed by phenylalanine ammonia-lyase (PAL) (Stafford, 1974). Treatment with S-carvone delayed the increase of PAL activity and suberin formation in potato tubers (Oosterhaven et al., 1995b). S-carvone supplied in the vase solution extended the vase life of cut *Hakea francisiana* (Proteaceae) (Williamson et al., 2002). Treatment with 4-hexylresorcinol (4-HR), an inhibitor of catechol oxidase which oxidizes phenolics (Dawley and Flurkey, 1993), delayed the wilting of chrysanthemum stems (van Doorn and Vaslier, 2002). As PAL and catechol oxidase are involved in wound reactions, stem end blockage may be a response to cutting.

G. 'Crimson Yul-lo' [*G. banksii* (red form) × *G.* 'Misty Pink'] has attractive bright red terminal inflorescences. However, its vase life is short and early wilting of inflorescences

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may be due to stem end blockage. The present study investigates the hypothesis that physiological stem end blockage occurs in *G.* 'Crimson Yul-lo' flower stems during vase life and results in inflorescence wilting.

2. Materials and methods

2.1. Plant material

G. 'Crimson Yul-lo' flowering stems were harvested when most florets on an inflorescence were at the commercial maturity stage of 'mature flowers with style looped to length of perianth tube' (Setyadjit et al., 2004). They were harvested from 4 year old in-ground plants at a flower farm near Gatton (152°20′E, 27°33′S), Queensland, Australia. Harvests were in the morning (ca. 09:00 h) from May through June in Autumn 2005. Harvested flowering stems were immediately stood upright in buckets partially filled with tap water. They were kept in shade in the field until transported within 1 h of harvest to the postharvest laboratory at The University of Queensland, Gatton. During transport, buckets containing stems were covered with a plastic film shroud to minimize moisture loss. Upon arrival at the laboratory, the lowermost leaves from all stems were trimmed off. The stem ends were re-cut under deionised water to give stem lengths of approximately 35 cm. Thereafter, all stems with their single terminal inflorescence and four to five leaves were stood in plastic buckets containing deionised water.

2.2. Experiment design and treatments

Four experiments were conducted in a vase life evaluation room at 20 ± 1 °C, 60 ± 10% relative humidity (R.H.) and 12 μmol m^{-2} s^{-1} light intensity (cool white fluorescent tubes) under a daily light period of 12 h. In each experiment, all stems were placed individually in 150 mL capacity glass vases containing an anti-microbial vase solution of 10 mg L^{-1} available chlorine provided as the sodium salt of dichloroisocyanuric acid (DICA) (Joyce et al., 2000). That is, DICA was the base constituent in all treatment solutions and was the control vase solution. DICA is a stabilized chlorine formulation that maintains free chlorine availability under chlorine demand conditions. A sheet of aluminium foil was used to cover the mouth of each vase to limit vase solution evaporation. Vases with cut flowering stems were arranged on benches in a randomized complete block (RCB) design. All solutions were freshly prepared at the beginning of the experiments and were not renewed in the course of the experiment.

2.2.1. Experiment 1: hydraulic conductance

Each day during vase life evaluation, the basal 0–2 cm segment and the 2 cm segment immediately above this (denoted the 2–4 cm segment) was excised under deionised water, and hydraulic conductance was measured. This destructive sampling was carried out on a new stem each day.

2.2.2. Experiment 2: re-cutting

Cut flowering stems were either retained intact or the basal 2 cm from the stem end was excised daily under water. This was carried out on the same stems each day.

2.2.3. Experiment 3: S-carvone treatments

Three concentrations of S-carvone (Sigma–Aldrich) were compared to the control vase solution; viz. 0, 0.032, 0.318 and 0.636 mM. S-carvone has reported anti-microbial activity (Stammati et al., 1999; Iacobellis et al., 2005). However, efficacy against a range of plant pathogenic fungi and bacteria was at ≥1 mM (Oosterhaven et al., 1995a), which is above the concentrations used in the present experiments.

2.2.4. Experiment 4: 4-HR treatments

Three concentrations of 4-HR (Sigma) were compared to the control vase solution; viz. 0, 2.5, 5 and 10 mM.

The effects of S-carvone (Experiment 3) and 4-HR (Experiment 4), as reported in Section 3 were confirmed in an experiment conducted later (July) in the 2005 flowering season.

2.3. Measurements

2.3.1. Hydraulic conductance

Stems were removed from their vase solution and 2 cm long segments were excised under deionised water. These segments were used to measure potential hydraulic conductance through the stems as described by Durkin (1979). They were maintained under a pressure head of 100 cm of freshly prepared base vase (i.e. DICA) solution. The eluant was collected overnight (ca.15 h).

2.3.2. Water potential

Water potentials of inflorescences from intact cut flowering stems were measured using a Scholander pressure chamber (Turner, 1988). Individual inflorescences were sampled daily. They were enclosed in a plastic bag immediately after excision. The rachis was inserted into a rubber gland within the lid of the pressure chamber, and the sealed chamber was pressurised with industrial grade N_2 at a rate of 0.03 MPa s^{-1}. Water potential was recorded from the pressure gauge at the point where xylem fluid started to exude from the surface of the cut rachis.

2.3.3. Vase solution uptake

The weights of vases without their cut flowering stems were recorded daily during the vase life evaluation period using a balance. Average daily vase solution uptake was calculated by the formula: vase solution uptake rate (g $stem^{-1}$ day^{-1}) = $(S_{t-1} - S_t)$; where, S_t is the weight of vase