THE PHYSIOLOGY AND CONTROL OF BRACT BROWNING IN WARATAHS (*TELOPEA* SPP.)

by

Amelia Martyn

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Dedicated to my parents, Greg and Evelyn Martyn

(with waratah flowers in the Royal National Park in 2003)

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Certificate of originality

The text of this thesis contains no material which has been accepted as any part of the requirements of any other degree or diploma in any University and to the best of my knowledge, is original and contains no material previously published or written by another person, except where due reference is made.

Amelia Martyn
October 2004

Abstract

The waratah, *Telopea speciosissma* and its hybrids with other *Telopea* species, is an Australian native species grown for domestic and export cut flower markets. The showy floral bracts surrounding the inflorescence often suffer from bract browning, reducing the market value and export potential of the blooms. Prior to this project, the physiological cause of the disorder was not known, although bract browning had been attributed to water stress, heat stress, high light (particularly after frost), wind and mechanical damage. Bract browning was reportedly minimised when waratahs were grown in shaded conditions, although the reduction in browning by shade had not been quantified. The aim of this project was to examine the physiological cause of the bract browning disorder and investigate methods for control.

The appearance, timing, and severity of the bract browning disorder was initially characterised by dissecting waratah buds from commercial growers throughout NSW. Bract browning became evident in the six to eight weeks prior to harvest, coinciding with rapid bract and flower expansion. A survey of commercial waratah growers, initiated by NSW Agriculture and the Waratah Industry Network and analysed by the author, corroborated these results. The survey showed that bract browning was observed in all years between 1999 and 2003, with relatively high severity (scores from three to five out of a possible five) in three of those years. Scores or counts of brown bracts were used to assess the severity of the disorder, the latter including the number of senesced floral bracts following browning as a measure of browning severity. The position and timing of browning suggest light damage or localised calcium deficiency could play a role in the development of browning.

The bract browning disorder was studied in further experiments on potted red waratahs of cultivars ‘Fire and Brimstone’, ‘Olympic Flame’ and ‘Sunflare’ at the Mount Annan Botanic Garden; on commercially grown ‘Wirrimbirra White’ waratahs at Jervis Bay; and on natural populations in the Royal National Park. The effect of calcium nutrition on bract browning was studied at Mount Annan in 2001 and 2002, testing the hypothesis that browning may be caused by a localised calcium deficiency similar to lettuce tipburn or poinsettia bract necrosis. Waratah bracts had significantly less calcium in all fractions than leaves, with the procedure of Ferguson *et al.* (1980) used to separate physiologically active, oxalate associated and residual calcium. Calcium chloride sprays applied to developing bracts increased total bract calcium by about 25%

in ‘Sunflare’ and ‘Olympic Flame’ cultivars, but not in ‘Fire and Brimstone’. However, application of calcium as a spray to the developing bracts, or as gypsum to the potting medium did not significantly reduce bract browning scores. These results and the development of bract browning in exposed, rather than enclosed tissue, suggest that factors other than calcium are involved in the development of bract browning.

The light environment (full sun or 50% shade cloth) had a greater effect than irrigation frequency on bract browning of ‘Sunflare’ and ‘Olympic Flame’ waratahs in 2001. Waratahs grown under 50% shade cloth showed less bract browning at flower maturity than waratahs grown in full sun. This result was corroborated by subsequent experiments in 2002 and 2003. For example, in 2002, shade cloth reduced browning and bract loss by 30-60% at flower maturity, compared to waratahs grown in full sun. Shading waratahs from bud initiation in late summer (December-January) or bud opening in late winter (July-August) was equally effective in reducing browning. Shade cloth (50%) significantly reduced the light intensity experienced by waratah plants throughout the day, as well as reducing the daily maximum temperature and minimum relative humidity. Natural shade conditions at the Royal National Park effectively prevented browning of floral bracts, although the smaller basal bracts still turned brown and senesced.

The development of bract browning as waratahs matured was linked to the development of chronic photoinhibition, measured as a decrease in predawn photosynthetic efficiency using chlorophyll fluorescence techniques. Waratah bracts were unable to maintain efficient photosynthesis in full sun conditions and reached saturation of non-photochemical quenching at lower light intensities than leaves. This suggests that bract tissue is adapted to a lower light environment than leaf tissue. Outer bracts had a significantly lower photosynthetic efficiency (Fv/Fm) than leaves early in flower development, as they were exposed to the environment for a prolonged period. Outer bracts also began to senesce towards flower maturity, particularly in full sun, increasing their susceptibility to damage. Inner waratah bracts were able to maintain a high photosynthetic efficiency prior to exposure, but photosynthetic efficiency decreased significantly at the intermediate stage of floral development, as inner bracts were no longer protected by outer bracts. Waratah leaves were more resilient than bracts, and did not suffer from chronic photoinhibition or browning during flower development. The increased susceptibility of bracts to photoinhibition and browning parallels results in

other species, such as *Dendrobium*, where floral tissue experiences photoinhibition, bleaching and necrosis at lower light intensities than leaf tissue.

Bracts on shaded waratahs maintained higher chlorophyll, carotenoid and anthocyanin concentrations than sun-exposed bracts, giving more intense flower colour and higher quality blooms. The significant decrease in bract pigmentation in the sun is likely to be a result of pigment destruction following photoinhibition, and has been noted in susceptible tissues of other species, such as *Illicium* (star anise) leaves. The presence of anthocyanins did not reduce bract browning in waratahs, with the concentration of UV-absorbing compounds showing a stronger positive correlation with protection from photoinhibition than the concentration of anthocyanins. However, anthocyanin concentrations were significantly lower in sun-exposed bracts, and brown compounds appeared to replace anthocyanins in the epidermal cells of brown bracts.

Thus, it seems likely that browning in waratah bracts is the visible manifestation of oxidative damage to cell components, following chronic photoinhibition. Light-induced oxidative damage can lead to yellowing and pigment bleaching, lipid peroxidation, the development of necrotic lesions and senescence. However, lipid peroxidation as measured by the malionaldehyde assay gave no indication of oxidative damage to waratah bract tissue. This was probably due to the presence of anthocyanins and other flavonoids and sugars other than sucrose in bract tissue interfering with the colourimetric measurement of thiobarbituric acid reactive substances.

The extensive planting of waratahs in NSW in the last five years suggests that the total value of lost production due to bract browning is likely to increase in the future. The browning disorder may also prevent the establishment of waratahs in other markets, as international cut-flower markets demand high quality blooms free from blemishes. The results of this study show that bract browning, photoinhibition and pigment loss are minimised by protecting waratahs from high light intensities from bud opening until harvest. However, the consequences of shading waratahs throughout the year require further investigation, as does the use of different percentages of shade cloth or other methods to reduce incident light.

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