Superior Callas: More Than Just Great Flowers©

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INTRODUCTION

In recent years callas have gained significant prominence as a fashionable international cut flower crop. Often referred to as "calla lilies," they belong to the genus *Zantedeschia* in the arum family (Araceae). *Zantedeschia* taxa are endemic to Africa, particularly the southern regions. The "flower" comprises the often-colourful spathe with a central spadix, the inflorescence, which is made up of numerous male and female flowers. *Zantedeschia* taxa are often classified into winter- and summer-flowering groups with *Z. aethiopica* and *Z. odorata* making up the former. In contrast to all other species, *Z. aethiopica* is evergreen and largely unaffected by soft rots. The summer group has a wide flower colour range including cream (e.g. *Z. albomaculata*), yellow (e.g., *Z. elliottiana*), and pink and red flowers (e.g., *Z. rehmannii*). Hybridization within this group has provided the many distinctive colours seen in modern callas.

THE GLOBAL INDUSTRY

New Zealand has played a leading role in establishing calla as an international flower crop. Starting in the 1930s, hybridisers such as Tony Brljevich and, later, his son Trevor, produced well known cultivars such as, 'Black Magic', 'Classic Harmony' (Harmony), 'Hawaii', 'Majestic Red', 'Red Sox', 'Elegant Swan' (Swan Lake), and 'Treasure'. Greater awareness of the value of intellectual property (IP) associated with new germplasm has increasingly led breeders to protect cultivars with Plant Variety Rights (PVR). At present 47 calla cultivars are protected in New Zealand by PVR, half of which were granted rights in only the past 3 years. In addition to breeding programmes in New Zealand, numerous programmes are established in other countries.

New Zealand is still a significant breeder and producer of callas. Annual exports of flowers, tubers, and tissue culture plants were worth approximately $13 million in 2004, making callas the second most important flower crop after orchids. An estimated 6 million calla plants are propagated by tissue culture annually in New Zealand — more than any other plant. The Netherlands has the greatest flower production area (100 ha in 2000) with 58 million calla stems passing through the Dutch auctions in 2002, an increase of 17% on the previous year. Much of the tissue culture propagation for The Netherlands is carried out in Asia and Eastern Europe.

Calla production is a competitive global business. International companies capitalise on the resources and climatic conditions in various countries to maximise efficiencies at the various production stages, whether it be breeding, propagation, or tuber and flower production. For example, a New Zealand-bred calla can be micropropagated in New Zealand or India, grown on to produce tubers in Kenya or Ecuador, and flowered in Columbia or The Netherlands for consumers in North America and Europe.

PRODUCTION CYCLE

Cultivated callas grow rapidly over the summer months with tuber growth greatest in autumn when foliage growth has ceased. A period of tuber resting or dormancy follows as shoots senesce until new shoots sprout in the spring. Tubers are typically lifted during the winter months, cured, and stored. Starting from seed or tissue culture plantlets, two seasons growth is usually required before the tubers reach sufficient size to produce flowers. For clonal propagation, tubers with consistently high quality attributes and free from known viruses should be selected. For any sizable tissue culture production, cultures need to be initiated at least 1 year before the plantlets are required, after which there is a further 1 to 2 years of tuber growth followed by another season for flower production.

PRODUCTION ISSUES AND DISORDERS

Traditionally cultivars were largely selected for their flower colour, shape, and size. However, increasingly plants are being selected for a wider range of criteria, including in vitro multiplication rates and the field performances of tubers leading up to flower production. Although calla tissue culture protocols involving proliferating tissue on media supplemented with the cytokinin BAP are well established (Cohen, 1981), large production runs require carefully customised media for specific cultivars to reduce the likelihood of instability during subsequent growth. Cultivar sensitivity to BAP can lead to over prolific and abnormal in vitro growth, which can affect subsequent tuber development and lead to tubers with multiple buds often with reduced apical dominance and flowers with reduced spathe length (D'Arth et al., 2002). Similarly, excessive amounts of cytokinins can stunt growth (Chang et al., 2003) producing small plants at deflasking time. Deflasked plants with larger shoot diameters are ideal because they give rise to larger tubers at the end of the first growing season (Chen et al., 2000).

To maximize favourable growing conditions in temperate climates calla tissue culture plantlets must be rapidly acclimatized. However, growth rates are cultivar dependent. We have seen cultivars grown under identical conditions produce tubers at the end of the first season that vary in mean tuber weight from 4 to 35 g, although mean weight for most cultivars was larger than 12 g. Survival under "standard acclimatization" conditions can vary from 100% down to less than 20% for some cultivars. Unless optimized acclimatization procedures are adopted for some cultivars these cultivars may not be cost effective for commercial production. An alternative strategy for producing large first-year tubers with minimal acclimatization issues is to produce in vitro calla microtubers (Seelye et al., 2003). The compact and relatively robust form of microtubers makes them easy to handle and transport. In addition, they can be quickly scatter-planted on to prepared greenhouse beds. However, the breaking of dormancy in these in vitro tubers must be synchronized for rapid and even sprouting.

Although calla cultivars may have similar flower colour and form, they may behave very differently during the various production stages. Producers must be aware of this, and if necessary, screen out lines that do not perform. For many cultivars in commercial production the exact breeding lineage is unknown, especially of cultivars derived from plants originating from some of the early breeding programmes. Molecular techniques, e.g. RAPD profiles, have been used to successfully differentiate between calla cultivars (Hamada and Hagimori, 1996).

In recent years there have been reports of distorted and reduced leaves in commercial calla hybrid crops, often with mottled leaf colourings (virescent forms) giving the appearance of a severe virus infection. Virescent and albino lines were observed a decade ago when *Z. aethiopica* was hybridized with the summer-flowering species in an attempt to transfer soft rot resistance from the winter-flowering *Z. aethiopica* to the summer-flowering callas (Yao et al., 1995). This leaf disorder is due to plastome-genome incompatibility, resulting in incomplete leaf chloroplast development and albino plants. The pattern of inheritance of leaf disorders within the summer species also shows these incompatibility issues (Brown et al., 2004), but the effect is less severe, resulting in leaf regions with reduced chlorophyll content, which are expressed as a mottle effect. Studies also show that soft rot resistance is reduced in these plants (Snijder et al., 2004). Although the frequency and degree of leaf mottling differs between seasons, it can affect up to 40% of plants in the field. Environmental and chemical influences during the production stages leading up to flowering may influence the already fragile inherited plastids in some of the cultivars in commercial production. Often symptoms do not appear until the second season out of tissue culture and the effect frequently declines later in the season as new leaves are formed. However, the presence of malformed plants in the field can lead to complex liability issues over quality, often involving parties in different countries.

Flowering performance varies between cultivars, but plant management and the growing environment can also have a major influence on flowering. For example, incomplete dormancy-breaking periods due to early tuber replanting can have a negative effect on the physiological development of apical buds, the source of future flowers (Halligan et al., 2004).

A QUALITY ASSURANCE SCHEME

Crop and Food Research in conjunction with Multiflora Laboratories Ltd and Pukekaroro Exotics Ltd, major New Zealand propagators and calla producers/exporters respectively, have assembled a library of selected cultivars and breeding lines. These are maintained in high health greenhouse facilities. In addition, calla lines developed by a large Dutch calla breeding company have recently been incorporated into the scheme. This quality assurance scheme involves closely monitoring tuber and flower performance, and routinely checking plants for known viruses. Tissue cultures for commercial production are initiated from these tubers either annually, or for very large production runs, twice yearly. Sufficient tubers are maintained so that individual tubers are only initiated biannually, thereby giving a full 12-month growth cycle during which tubers may recover from any wounding effects. All tubers, including break-offs from larger tubers, have unique identification codes. Data are captured on the origin of the selected tubers as well as flowering performance, tuber quality, health status, key dates in the production cycle and the movement of tissue into and out of the scheme. All relevant data are logged into a customised database where they remain indefinitely. The system enables flowering plants to be tracked back and compared to the original tuber, ensuring plants have remained true to type. In addition, tissue cultures of recently initiated material are stored in vitro so that any issues suspected of being related to the tissue culture production phase can be referenced against the original stock cultures. Regular reviews of the stock plants in the high health system are made and improved lines pe-

riodically introduced to replace existing lines. However, the longer a plant remains in the system, the more data are captured over a number of seasons to support the quality status of a particular tuber.

SUMMARY

Calla cultivars for flower production not only require superior flower characteristics but must also have well defined production protocols for in vitro propagation, acclimatization, and tuber development stages so that growth is maximized, but susceptibility to abnormalities is minimized. A high health scheme that monitors individual selected tubers over multiple seasons ensures that only tubers with a high health status and good growth attributes are used as the starting material for large-scale clonal production runs.

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