Developing *leptospermum* for cut flowers
Developing *Leptospermum* for cut flowers

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Foreword

Wildflowers are cultivated in all States, Australia’s annual wildflower production is valued at around $30 million at the farm gate, and the value of exports amounted to just under $6.7 million in 2011/2012. The key commercial wildflowers are Geraldton wax, kangaroo paw, Thryptomene, and species of Banksia, Telopea, Leucadendron and Protea, a key factor in the growth of this industry is the development of new products.

*Leptospermum* (tea-tree) is a diverse group of plants, and includes some highly attractive forms that are considered to be a valuable ornamental crop. The group has been limited in its use as a cut flower due to postharvest problems of some cultivars. Other cultivars have a good vase life and there is a strong interest in *Leptospermum* in export markets.

This project was conducted to produce superior *Leptospermum* hybrids that can continuously supply cut flowers for the market, through a breeding program based on superior selections, and the development of postharvest techniques to maximise vase life.

This project was funded from RIRDC Core Funds which are provided by the Federal Government.

This report is an addition to RIRDC’s diverse range of over 2000 research publications and it forms part of our Wildflowers and Native Plants R&D program, which aims to improve the profitability, productivity and sustainability of the Australian wildflower and native plant industry.

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**Craig Burns**
Managing Director
Rural Industries Research and Development Corporation
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Virginia Williamson contributed to the experiments reported in Tables 4.14 and 4.16.

Abbreviations

a.i. active ingredient
ANOVA Analysis of Variance
DI deionised
LSD least significant difference
1-MCP 1-methylcyclopropene
RH relative humidity
STS silver thiosulphite
> greater than
Definitions

Clone – one of a population of identical plants multiplied by vegetative means

Cultivar – a cultivated variety, and therefore a plant possessing superior commercial attributes

Hybrids – progeny from crossing parents of different species

Hybrid family – siblings from a cross using parents of different species

Intergeneric hybrid – a cross between two species from different genera

Interspecific hybrid – individual product of a cross between two species within the same genus

Parents – female and male used in breeding

Selection(s) – individual selected plant(s) from a group of plants

Style – combination of commercially desirable attributes identifiable as a characteristic form; individual cultivars possessing the same style need not belong to the same cross, family or species.

Superior selections – individuals exhibiting superior characters
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Executive Summary

What the report is about

This report describes the development of superior *Leptospermum* hybrids through a breeding program and the evaluation of post-harvest performance and techniques.

Who is the report targeted at?

This report is targeted at wildflower growers interested in producing *Leptospermum* for cut flowers and similarly for growers looking to exploit the landscape potential of the species. These growers should seek out the superior forms to determine their performance under their growing conditions.

Background

To ensure exports continue to increase it is necessary to improve the quality and continuity of supply of existing products, and increase the available product range with high quality new flower crops. *Leptospermum* has been identified as a wildflower cut flower crop that is very popular in Australia’s export markets, but is undersupplied. The cut flowers are only available for a few weeks, but there are a number of species that are undeveloped and have good characteristics for cultivars to be developed as cut flowers.

*Leptospermum* cultivars have been used as cut flowers and as ornamental shrubs for a number of years. The majority of these cultivars were derived from New Zealand forms of *Leptospermum scoparium*. Some of these forms have been popular as container plants, but their use as cut flowers has been limited by their short vase life.

During earlier work, other species of *Leptospermum* with potential for use as cut flowers were assessed for their suitability as cut flowers (Slater et al. 2001). There are a number of Australian *Leptospermum* species that have an acceptable vase life that are not prone to flower abscission, and are suitable for cut flower production. Variations within the species were identified to determine the better forms of each species. The postharvest behaviour of the cut flowers was determined, methods to extend the vase life was explored and the reproductive biology was investigated in order to establish a breeding program. The development of superior hybrids with good vase life and a range of colours can only increase the market demand for leptospermums.

Objectives

The objectives of this project were to produce superior *Leptospermum* hybrids that can continuously supply cut flowers for the market, through a breeding program using superior selections and through developments in postharvest techniques which maximise vase life.

Methods used

*Superior forms of Leptospermum for use as cut flowers*

The genus *Leptospermum* includes a diverse group of plants. There are a range of flower colours and sizes, and between August and March a member of the group will be in flower. These are important commercial characters for a floral crop, as they allow continual supply to the market, and provide diversity within the crop.

The cut flower characteristics of a range of *Leptospermum* cultivars have been assessed to identify species and cultivars of *Leptospermum* with greatest potential for use as cut flowers. The better species and cultivars are listed in section 3.1. In the process of assessing the performance of the cultivars, we have described the plant structure, foliage type and colour, flowering time in Victoria, flowering duration, flower characteristics and postharvest behaviour. Whilst the flowering time for
each species and cultivar can be quite short, especially for optimal harvest time, a range of species and cultivars have been identified that flower between late August and early January. This should enable growers to provide a range of species and cultivars that will allow them to market *Leptospermum* over an extended season.

**Leptospermum breeding**

The breeding of *Leptospermum* has targeted the production of superior cut flower forms, by using the best available cut flower forms as parents. This process is continuous, in that on-going assessment of species and cultivars (both in the wild, and breeding progeny) continually identifies new parents.

The breeding program was extensive with a total of 1443 interspecific hybrid pollinations conducted. This was supplemented with 521 intergeneric hybrid pollinations with closely related species. During this work over 1800 interspecific hybrid seedlings from the earlier breeding work and this program were germinated, and prepared for field planting. From the intergeneric hybrid pollinations, 116 seedlings were prepared for field planting. In total from this and the earlier work there are now over 2200 hybrids growing at the field site.

**Hybrid evaluation**

The hybrid seedlings were monitored at the field site over the three flowering seasons of the project. Due to the juvenility period of the seedlings, which was not foreseen at the start of the project, none flowered in the first year after planting and few in the second year. Generally the plants needed to be grown for at least 18 months in the field and be over 50 cm tall for flowering to occur. The flowering response desirable for cut flower use occurred in the third and fourth flowering season in the field.

When the hybrids flowered, the flowering times were noted and the flowering display and flowers were described. Material was collected for postharvest assessment of each hybrid. The vase life was monitored and the postharvest behaviour described. All the hybrids that had an acceptable vase life, exhibited the ability for mature buds to continue to develop and open after harvest. This will enable these hybrids to be harvested when they are just starting to flower to maximise vase life.

**Hybrid style descriptions**

From the field and postharvest observations 13 different hybrid styles are described in section 3.3. These styles can be easily distinguished on petal colour, size and other floral characters. The hybrid styles have been described in full, and a number of cut flower and landscape cultivars should be obtainable from each of the hybrid styles.

**Postharvest**

The best way to achieve good postharvest quality is to grow species, hybrids or selections that have an inherently good quality and vase life. Some of the selections identified and bred in this project provide excellent quality and vase lives greater than 10 days.

The response of several selections to simulated export (3 days in a carton at 15 °C) was determined. From these and previous experiments we found that the following species had vase lives greater than 7 days after simulated export: *L. morrisonii* ‘Burgundy’, *L. rotundifolium* ‘Lavender Queen’ and *L. ‘Ruffles’* (a hybrid from the breeding program). The following had vase lives of less than 7 d: *L. grandifolium, L. morrisonii* ‘LMBLR1’, *L. obovatum, L. polygalifolium* ‘Bronze’, *L. spectabile and L. turbinatum* ‘LTPR1’ and ‘LTPR3’. Our results so far indicate that if selections have a long vase life as a freshly picked flower they will have an acceptable vase life after export, but will lose vase life approximately equal to the time spent in transport. However, it would be wise to continue to assess elite selections for their export performance.
Several treatments have been shown to delay drying and overcome wilting. Continuous deep water treatment (20 cm compared with 5 cm), recutting stems and a commercial postharvest solution (Chrysal Professional #2) prevented tip wilting of foliage, although chlorine germicide or citric acid did not.

*Botrytis cinerea* has been found on several samples of *Leptospermum* flowers from different species, different farms and in different years. It is probably worth investigating whether this has a role in petal drop, as it does in flower drop in Geraldton waxflower.

Further research is needed into: the commercial use of deep water, stem recutting and certain postharvest solutions to improve water uptake and vase life; the role of *Botrytis* and ethylene in flower drop and the end of vase life; and the effect of anti-ethylene treatments (i.e. silver thiosulphate and 1-methylecyclopropene).

**Implications and recommendations**

Wildflower growers interested in producing *Leptospermum* should seek out the superior forms to determine their performance under their growing conditions. Whilst the flowering time for each species and cultivar can be quite short, especially for optimal harvest time, the range of species and cultivars flower between late August and early January. This range of flowering times will allow *Leptospermum* to be marketed over an extended season, and will provide growers with the opportunity to supply the market over this extended season by growing a range of species and cultivars.

The breeding program has been extensive and thirteen different hybrid styles have been described. The hybrids have interesting and attractive flower colours and there are potential cultivars within most of the hybrid styles that have a good vase life of over ten days. Cultivars from each of the hybrid styles still need to be commercially assessed to determine the better commercial cultivars, although we believe that a number of cut flower and landscape cultivars should be obtainable from each of the hybrid styles.

Our recommendations for postharvest handling are:

- to grow species with a long vase life;
- cut stems when about 20% of buds are open;
- consider treating species that are prone to drying in a deep postharvest solution;
- consider treating species that are prone to petal drop with anti-ethylene compounds;
- use good practices of cooling and an effective postharvest vase solution;
- handle and sell the flowers quickly; and
- encourage the end user to re-cut the stems and hold them in a deep postharvest solution.


**Conclusions**

This project has identified the superior species and cultivars of *Leptospermum* that can be used as cut flowers. The project has extended this series by using the superior selections as parents in a breeding program and producing a series of 13 hybrid styles that could continuously supply *Leptospermum* cut floral forms for the market. This work has also looked at the postharvest behaviour of these cut flower leptospermums to enable the development of superior hybrids with good vase life that should increase the demand for this cut flower.

The next steps required in the development of *Leptospermum* as a cut floral crop include:
• The commercial evaluation of cultivars that have shown promise in field and vase life evaluations
• The commercial evaluation of cultivars that have shown promise for use in market sectors other than the cut flower sector, such as flowering container plants or landscape plants
• The development of a commercialisation strategy for commercial cultivars
• The continued primary assessment of hybrids as they flower, and
• The communication of the results of this work through industry articles.
1. Introduction

1.1. Background

The Australian cut flower export industry expanded from approximately $6.7 million in 2011/12. Wildflower production is currently estimated to be worth approximately $30 million pa. To ensure exports continue to increase it is necessary to improve the quality and continuity of supply of existing products and to increase the available product range with high quality new flower crops.

Leptospermum has been identified as a wildflower cut flower crop that is very popular in Australia’s export markets, but is under supplied. The cut flowers are only available for a few weeks, but there are a number of species that are undeveloped and have good characteristics to be developed as cut flowers. Leptospermum has been identified in the top group in both Export Best Bet Analyses conducted with Victorian cut flower exporters (Slater 1997; 1999), and in the Australian Export Best Bet Analysis (Slater 2002; Slater and Carson 2003) conducted with cut flower exporters from Queensland, NSW and Victoria.

Leptospermum cultivars have been used as cut flowers and as ornamental shrubs for a number of years. The majority of these cultivars were derived from New Zealand forms of Leptospermum scoparium. Some of these forms have been popular as container plants, but their use as cut flowers has been limited by their short vase life due to ethylene sensitivity, petal drop and drying out (Zieslin and Gottesman 1983, 1986). A limited breeding program has been under way in New Zealand using L. scoparium as a main parent to produce cultivars with an improved vase life, but the majority of the progeny are noted as still having a short vase life (Bicknell 1995).

Leptospermum contains 83 species, that are mainly found in southern and eastern Australia, although they extend to South-East Asia and New Zealand (Wrigley and Fagg 1993). They are commonly known as tea-trees, and are renowned for their hardiness and fast growth. They will tolerate a range of conditions from dry sandy locations through to wet, marshy areas, and some are frost tolerant. Most species are extremely floriferous, with the entire stems being covered in flowers. As branches contain large numbers of attractive flowers, they can make an excellent focal filler crop.

Currently a limited number of L. spectabile and L. rotundifolium are in production, and stems are sold on both domestic and export markets, although numbers of L. rotundifolium in production have increased following the early Export Best Bet Analyses conducted in Victoria. Both these species have a longer vase life than L. scoparium, and hybrids have been reported between these species (Harris et al. 1995, Ollerenshaw 1995).

The introduction of a range of Leptospermum species will help to ensure that expansion of the export flower trade continues, for a number of reasons. Leptospermum (tea-tree) is sold be sold as a focal filler, as flowers are large and stems are showy. Some forms of tea-tree closely resemble cherry blossom, and are very popular in Japan, indicating that a niche market already exists in the most important export market for Australian flowers. Furthermore, between September and March there is always a species of Leptospermum in flower.

During earlier work (Slater et al. 2001), other species of Leptospermum with potential for use as cut flowers were assessed. The characteristics sought after by export markets were identified, and used to identify leading species. Species that show an acceptable vase life (over 10 days), and/or those that do not suffer from petal drop were targeted. There are a number of Australian Leptospermum species that are not prone to flower abscission, and are suitable for cut flower production.

These selections were assessed for their suitability as cut flowers by determining their physical characteristics, vase life, and field performance. The work identified the variations within the species to determine the better forms of each species.
The postharvest characteristics of the cut flowers have been observed and methods to extend the vase life of the cut stems are being determined. We also investigated the reproductive biology of appropriate species and determined techniques to accelerate the production of hybrid seedlings.

1.2. Selection and Breeding

The collection of *Leptospermum* species and cultivars started in earlier work (Slater et al. 2001), provided some extremely interesting variations in important characters. *Leptospermum sericeum* flowers in early spring and has pink and mauve flowers and attractive silver-green foliage. *Leptospermum lanigerum* produces a mass display of white flowers at the end of branches. *Leptospermum turbinatum* has large bright white flowers (3 cm diameter), that are located closely together and produce a continuous display. *Leptospermum rotundifolium* has large pink flowers and attractive glossy green leaves. *Leptospermum spectabile* has large red flowers (3 cm diameter). *Leptospermum macrocarpum* has very large flowers (4 cm diameter) with pink/red petals and green sepals that are a similar size and produce an interesting display. *Leptospermum morrisonii* has medium sized white flowers that are produced in December, while *L. deuence*, *L. liversidgei* and *L. grandiflorum* flower in late summer and into autumn. There are also some very interesting foliage colours from silver-green through various shades of green to red, burgundy and almost black. As well, selections from a closely related genus that has good sized, bright yellow flowers are in the collection.

Earlier work (Slater et al. 2001) started to produce interspecific hybrids to combine characters and spread the flowering, and produced intergeneric hybrids, with the aim of introducing the bright yellow flower colour into cold tolerant forms.

Our success with producing hybrid seedlings between *Leptospermum* and *Neofabricia*, and the natural hybrids that occur between *Leptospermum* and *Kunzea* (Harris et al. 1992; Elliot and Jones 1993) indicate that other combinations are possible. This could introduce further desirable characters into *Leptospermum* cut flower forms, including true reds into flower colour, massed flower arrangement on the stem, and the presentation of attractive stamens in the flowers.

As well as selecting and breeding for longer vase life, other important cut flower characters include flower size and colour, flowering time and foliage form. There are a number of species of tea-trees that have flowers that are various shades of pink, and some that have foliage that is soft and includes various shades of greens and reds. Flowering time is not limited to spring; it ranges from August to April. Combining these characters should produce a range of hybrids with good colour and vase life that flower at various times.

Exciting opportunities now include using the superior forms within each species and combining their characters through a breeding program to obtain superior cut flower hybrids that can continuously supply cut flowers for the market. The monitoring and evaluation of the hybrid seedlings should provide attractive flowering characteristics on stems that have a good vase life.

Cut flower leptospermums are in demand on export markets, and the development of superior hybrids with good vase life and a range of colours can only increase this demand.

1.3. Postharvest

*Leptospermum* species, hybrids and cultivars vary in their postharvest behaviour and vase life (Slater et al. 2001). The end of vase life is caused by either the flowers drying out or petal drop. Flower drying is caused, at least in part, by limited water uptake by the stem and possibly by low rather than high humidity around the flowers (e.g. 50 to 60% relative humidity (RH)). Petal drop is increased by applied ethylene and possibly high humidity (e.g. 100% RH), but the control of petal drop is not understood.
2. Objectives

To produce superior *Leptospermum* hybrids that can continuously supply cut flowers for the market, through a breeding program using superior selections.

The objectives of the postharvest work were to develop improved methods to maintain quality during handling and marketing.
3. Methodology

3.1 Plant Cultivation

3.1.1. Plant collection

A collection of desirable *Leptospermum* species and cultivars was located at the Institute for Horticultural Development (IHD) Knoxfield and a field site at Longford. This collection contained 249 cultivars, representing 2 genera, and 45 species. Further cultivars and samples were obtained from commercial nurseries, botanical gardens, and by field trips to natural populations as necessary.

3.1.2. Plant propagation

3.1.2.1. Vegetative propagation

The plants were propagated using semi-hardened tip cuttings, dipped in Clonex®, purple gel (3g/l Indole-3-Butyric acid) and placed in 100mm Ritegrow black polypropylene squat pots containing Debc® professional propagating medium. The pots were then placed into mist beds, which were maintained with a minimal basal temperature of 25°C and a misting duration controlled by a Sage Horticultural, Sprinklermatic 303 with carbon block sensor or a balance arm sense unit. The mist beds were housed in a glasshouse with temperatures controlled within the ranges of 15-26°C. Sunlight levels were maintained between 180 and 460 µmol m⁻² s⁻¹ by an automatic screen on a 10 minute delay. The cuttings remained in the mist bed until they had a well-established root system, which ranged from 3-12 weeks depending on the selection. When necessary, cuttings were drenched monthly with Previcur® to control fungal problems and Gesapon® to control root eating insect larvae.

Once cuttings had produced roots, the plants were tubed and maintained in a glasshouse with minimal heating.

3.1.2.2. Seed propagation and seedling growth

The nuts were placed in paper bags until all seed was shed. Seeds were surface sterilised in 70% ethanol for 1 minute, followed by a wash in 1% sodium hypochlorite containing Tween 20 for 1 minute, followed by two washes of sterile distilled water. The seed or embryos when they could be distinguished were placed on agar plates of MS media under controlled conditions for germination. When the seedlings were at the 2-4 leaf pair stage, they were removed from the plates, potted into 5cm tubes and placed into mist beds for further growth. When the seedlings were 8 to 15cm tall they were repotted into 16cm native tubes (7cm square) and placed on benches in the glasshouse. When the hybrids were large enough they were planted into the field.

3.1.3. Nursery culture

The glasshouse was maintained above a minimum temperature of 15°C with good air movement. The plants were on open mesh benches and were watered with an automatic sprinkler system on each, or every alternate, day.

All plants were grown in potting media of 6mm pine bark, 10mm pine bark, Seymour grit and deep mined sand (8:6:1:1 v/v). The potting medium contained fertiliser consisting of 3-5 kg/m³ lime, 1 kg/m³ GU-49® (source of iron), 500g/m³ Micromax and 600 g/m³ I.B.D.U. (isobutylidene diurea). When potted, plants were top-dressed with 3-4 month Osmocote®. Plants were also fed weekly with the liquid fertiliser Vital® at the prescribed rates of 5ml/L.
Once established, plants were potted up into 150mm pots (native tubes) and moved into a shade house to harden off. As the plants grew they were planted out into the field sites.

3.1.4. Field sites

Trial field sites were established at IHD Knoxfield and Longford (East Gippsland, Victoria).

Site description - Knoxfield

Climate summary: The site experiences mild temperature conditions. The summers are warm with occasional hot days. There is an average of 7 days over 35°C p.a. The winters are cool, with 9-10 frosts per year, some as low as -3°C. The site experiences an average rainfall of 900mm per year, which occurs consistently throughout the year and has a peak in May and an increase in spring.

Soil: The soil is a grey clay loam, and was improved with the addition of sharp river sand and organic material. The pH of the soil is 7.0. There is no sub-surface problem layer in the root zone.

Beds: The plants were planted on raised beds, 20-40 cm high. The beds were located on a very slight (<1 in 10) north facing slope.

Planting design: The plants were planted in single rows and spaced 1m apart, with 1.5m between the rows.

Plantation management: The fields were fertilised regularly and irrigated as required. Weeds were controlled by wood chip mulch and hand weeding, along the rows and by herbicides between the rows. The plants were pruned when planted and protected by windbreaks.

Site description - Longford

Climate summary: The site experiences mild temperature conditions. The summers are warm with occasional hot days. There is an average of 6-7 days over 35°C p.a. The winters are cool, with a few frosts per year. Most are mild while some have been substantial and reach as low as –4°C. The site experiences an average rainfall of 650 mm per year, which occurs consistently throughout the year with an increase in late spring.

Soil: The soil is a sandy loam with a pH of 4.5.

Beds: Due to the good drainage the plants are not growing on raised beds.

Planting design: The plants are planted in single rows that are 3.5m apart. The plants were spaced 1m apart in earlier plantings, but due to space constraints the latter plantings of hybrid seedlings were spaced 0.3m apart along the rows.

Plantation management: The plants are fertilised periodically with Osmocote®. Weeds are controlled by woven weedmat around the base of the plant, mowing in between the rows, and herbicide along the edge of the weedmat. The plants were not pruned when planted and are not protected by windbreaks. The site is protected from the wind by its north-east aspect.

3.1.5. Pests and diseases

The overall cultivation conditions in the glasshouse, nursery and field areas were maintained as pest and disease free as possible, and the plants were only sprayed with fungicide and insecticide as required.

Unfamiliar pests or diseases and plants showing symptoms were sent to the Crop Health Service at IHD Knoxfield for identification.
3.2. Evaluation of *Leptospermum* for use as cut flowers

Data were collected on floral and vegetative characteristics when individual cultivars came into flower. All clones that flowered were measured for a range of characters. These included: plant height and form; flower size; colour; shape and distinctive features; time of flowering; length of the vegetative tip extension past the floral display; and leaf colour. Flower and foliage colour were compared against R.H.S. Colour Charts (The Royal Horticultural Society 1966) to determine colour.

The vase life of a cultivar was tested by selecting 5 stems of a harvestable quality. The stems were harvested and placed in water for transport to the laboratory. Transport lasted for less than 6 hours, and the material was then placed at 1°C overnight. The following morning the stems were placed into deionised water in individual test tubes (12 cm deep) and placed in a controlled atmosphere with a temperature of 21°C, relative humidity of approximately 60%, and a 12 hour light / 12 hour dark cycle. The stems were assessed on a daily basis until all stems were considered to be at the end of their vase life.

End of vase life was determined to be when the stem ceased to have a decorative appearance. This was determined through assessment of foliage condition, floral display, condition of the flowers and buds, if the buds opened and any cultivar specific traits. If over 50% of the open flowers were shrivelled or in decline then the stem was deemed unacceptable. Excessive (>50%) foliage, flower, petal or bract drop also resulted in the end of vase life for the stem. Other factors contributing to the end of vase life included: stem tip wilt, bud browning and aborting, and foliage colour deteriorating.

Cultivars were then compared to identify the best genetic material for further development.

3.3. *Leptospermum* breeding program

3.3.1. Reproductive biology

The timing of floral development of several *Leptospermum* species was established in earlier work by observation under a dissecting microscope to determine the developmental changes to the male (androecium) and female (gynoecium) parts with maturity. The period of stigmatic receptivity was determined by conducting controlled pollinations and histochemical tests. The period of time that the pollen was viable was determined by germinating pollen on agar slides.

3.3.2. Hybridisation program

3.3.2.1. Controlled pollinations

Plants that were to be used as female parents were identified as potted plants in the nursery at IHD or in the field at Longford or IHD. Flowers were emasculated and covered with bags to exclude insect pollinators. Flowers were later cross-pollinated and re-covered with the bag. The bag was later removed and the nuts were left to develop until they were mature. They were harvested prior to seed dispersal, or when the nuts had aged and the seeds were mature.

Crosses that were to be performed where flowering periods overlapped were carried out using fresh pollen. For hybridisations between species that did not flower concurrently, stored pollen was used. To store the pollen and maintain its viability, pollen was collected when the anthers had just started to split, by collecting the stamen. The stamens with pollen were placed in eppendorf tubes, which were then placed in a glass desiccator containing silica gel, overnight before freezing at –20°C.

3.4. Hybrid evaluation

Data on floral and vegetative characteristics were collected on the hybrids as they flowered in the field. This information included: plant form; flower size; colour; shape and distinctive features;
flowering date; the terminality or extent of the floral display; and foliage features. The hybrids were
categorised into hybrid styles.

The vase life of more attractive hybrids was tested by selecting 5 stems of harvestable quality. Stems
were selected with 10-20% of flowers open and the buds showing colour. The stems were harvested
and placed in water for transport to the laboratory. Transport lasted for less than 6 hours, and the
material was then placed at 1°C overnight. The following morning the stems were placed into
deionised water in individual test tubes and placed in a controlled environment as described in section
2.2. The number of open flowers, buds showing colour and younger buds were recorded to monitor
the continued development of the buds and flowers after harvest. The stems were assessed on a daily
basis until all stems were considered to be at the end of their vase life.

End of vase life was determined to be when the stem ceased to have a decorative appearance. This
was determined through assessment of foliage condition, floral display, condition of the flowers and
buds, if the buds opened and any hybrid group specific traits. If over 50% of the open flowers were
dropping petals, or shrivelled and unattractive then the stem was deemed unacceptable. Other factors
contributing to the end of vase life included: excessive (>50%) foliage or bract drop, stem tip wilt, bud
browning, and foliage colour deteriorating.

Flower size was measured after 7 days in the vase, and flower colour was compared against R.H.S.
Colour Charts (The Royal Horticultural Society 1966) to determine colour.

3.5. Postharvest

3.5.1. Export suitability

3.5.1.1. Simulated export

These experiments were conducted in October – December 2002. Flowers of several selected species,
hybrids and cultivars were cut from plants at Longford or Knoxfield and transported in water to the
laboratory within 5 hours or 20 minutes respectively. The plants used, the source of the flowers, stem
length, degree of flower opening at harvest and fungicide treatments are described in Table 3.1. Most
flowers were dipped in Scala® fungicide (pyrimethanil) 160 mg a.i./L after harvest.

The experimental unit was a test tube, which contained one or two stems. These were treated in blocks
(Table 3.1). Sometimes the blocks were based on the extent of flower opening at harvest, or the
position of the plants in the field. For pretreatment and vase life the tubes were placed in randomised
complete blocks within the cold room and vase life room respectively. For export each block was
packed in one carton. Treatments were randomised within the block.
Table 3.1. Details of flowers and methods used in the simulated export experiments

<table>
<thead>
<tr>
<th>Species/hybrid</th>
<th>Source</th>
<th>Stem length (cm)</th>
<th>Open flowers (%)</th>
<th>Fungicide treatment (Scala®)</th>
<th>Blocks (No.)</th>
<th>Stems per tube</th>
<th>End of vase life criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>L. morrisonii</em> ‘Burgundy’</td>
<td>Knox</td>
<td>30</td>
<td>20-40</td>
<td>Yes</td>
<td>7</td>
<td>2</td>
<td>Petals dry and closed (&gt;50%) Petal drop (&gt;50%)</td>
</tr>
<tr>
<td><em>L. morrisonii</em> ‘LMBLR1’</td>
<td>Knox</td>
<td>30</td>
<td>80</td>
<td>Yes</td>
<td>7</td>
<td>1</td>
<td>Petals dry and closed (&gt;50%)</td>
</tr>
<tr>
<td><em>L. obovatum</em></td>
<td>Knox</td>
<td>30</td>
<td>20-40</td>
<td>No</td>
<td>5</td>
<td>2</td>
<td>Petals dry and closed (&gt;50%) Petal drop (&gt;50%)</td>
</tr>
<tr>
<td><em>L. polygalifolium</em> ‘Bronze’</td>
<td>Knox</td>
<td>30</td>
<td>20</td>
<td>Yes</td>
<td>7</td>
<td>1</td>
<td>Petals dry and closed (&gt;50%)</td>
</tr>
<tr>
<td><em>L. ‘Ruffles’</em></td>
<td>Longford</td>
<td>25</td>
<td>0-60</td>
<td>No</td>
<td>9</td>
<td>1</td>
<td>Flowers dry and closed (&gt;50%) Petal drop (&gt;50%)</td>
</tr>
<tr>
<td><em>L. spectabile</em></td>
<td>Longford</td>
<td>20</td>
<td>80</td>
<td>Yes</td>
<td>7</td>
<td>1</td>
<td>Petals dry, dark and closed (&gt;50%)</td>
</tr>
<tr>
<td><em>L. turbinatum</em> ‘LTPR1’, ‘LTPR3’</td>
<td>Knox</td>
<td>30</td>
<td>20-70</td>
<td>No</td>
<td>7</td>
<td>1</td>
<td>Petal drop (&gt;50%) Flowers dry and closed (&gt;50%) Foliage dried, discoloured (&gt;50%) Foliage wilt (tip wilted below horizontal)</td>
</tr>
</tbody>
</table>

After harvest the stems were cut to length and held in test tubes of deionised (DI) water 12cm deep at 0°C overnight. After 16 hours one test tube from each block was placed into the vase life room. At the same time, the stems from another test tube within each block were packed into a carton for simulated export. Vase life was assessed by placing individual flowers in individual test tubes of DI water 12cm deep. The temperature was 20°C, RH 50-60% and a 12 hours light/12 hours dark cycle was used with cool white fluorescent lights delivering approximately 20 μmol/m²/s. Export simulation was achieved by packing stems in a small carton (50 x 20 x 15cm) which was filled with foliage of other *Leptospermum* species and tightly closed. These were then placed at 15°C for 3 days. After 3 days the flowers were removed from the cartons, the stems recut 2cm, and placed in individual test tubes of DI water in the vase life room.

The criteria used to determine the end of vase life are described (Table 3.1). Most species/hybrids had both a dominant and secondary cause of the end of vase life. The end of vase life for an individual stem was when any one of the listed criteria for that species was reached.
3.5.1.2. Export pretreatments

An experiment was conducted to investigate the effects of pretreatments before export. *L. obovatum* flowers were used as described in Table 3.1. They were given a series of pre-treatments and then simulated export prior to vase life assessment as described above (3.5.1.1.).

The design was a 2 x 2 factorial of pretreatments (2 temperatures x 2 humidities) + no treatment (immediate export) + a treatment where flowers were precooled in the carton.

The treatments were:

1. Pretreatment: Water, 0°C, low RH, (no cover over the flowers, RH 50%), for 16 hours. This is the standard pretreatment used in the above experiments (2.5.1.1.).
2. Pretreatment: Water, 0°C, high RH (polythene bag covering the flowers, RH approx 95%), for 16 hours.
4. Pretreatment: Water, 20°C, high RH, for 16 hours.
5. No treatment, immediate export – immediately packed into carton and transferred to 15°C.
6. Precooled in carton - packed into a carton and cooled at 0°C for 16 hours before export (i.e. no water between harvest and packing).

The design is: [(2 x 2) + 2] x 5 blocks x 2 stems per test tube. The same blocks were used during pretreatments, export and vase life. Treatments were randomised within the blocks. There was no treatment without export.

3.5.2. Water relations

3.5.2.1. Deep water - foliage

Deep water and increased water pressure have been shown to increase water uptake and water flow (respectively) in rose stems (Durkin 1979, Valle et al. 2001). The effects of shallow and deep water on vase life of *Leptospermum* foliage (no flowers) were examined using stems of *L. obovatum* and *L. polygalifolium ‘Bronze’*. The stems were cut at Knoxfield in March 2001 and were approximately 40cm long. Leaves were stripped from the bottom 25cm of the stems. Ten (10) stems were placed in either shallow (5cm) or deep (20cm) water. The 10 stems for each treatment were placed in a single container in the vase life room as described above. The end of vase life was usually when the soft tip growth wilted to below the horizontal, but in a few stems the tips did not wilt and vase life ended when >50% of the foliage had dried and discoloured. The treatments were not replicated.

3.5.2.2. Deep water – flowering L. spectabile

Flowering stems of *L. spectabile*, 25cm long, with 100% of flowers open, were cut at Knoxfield in November 2002. The experimental unit was an individual stem. Each stem was placed in a bottle with either shallow (5cm) or deep (20cm) water at 0°C for 18 hours. They were then transferred to test tubes with 12cm of water in the vase life room at 20°C. The end of vase life was when >50% of flowers had dried, closed or darkened. The stems were treated in blocks, 1 stem per block and 11 blocks, both in the 0°C room and the vase life room. Treatments were randomised within the block.

3.5.2.3. Recutting the stems - foliage

In most flowers, recutting the basal part of the stem under water restores water uptake when it has declined during postharvest handling or vase life (van Doorn 1997). Recutting stems of *L. rotundifolium ‘Lavender Queen’* after marketing increased vase life (Slater et al. 2001) and daily
recutting stems of *Thryptomene calycina* increased vase life (Jones *et al.* 1993). The effects of recutting the base of the stem daily on vase life of *Leptospermum* foliage (no flowers) were examined using stems of *L. obovatum* and *L. polygalifolium* ‘Bronze’. The stems were cut at Knoxfield in March 2001 and were approximately 40 cm long. 10 stems were placed in each of two containers with 12 cm of water, in the vase life room as described above. Each day one group of 10 stems had the bottom 1 cm of stem cut off under water. The end of vase life was when either the soft tip growth wilted to below the horizontal, or >50% of the foliage had dried and discoloured. The treatments were not replicated.

### 3.5.2.4. Photographs of the effects of treatments on water relations

Stems, 80 cm long, of *L. morrisonii* ‘ex Qld.’ foliage (no flowers) were cut at Knoxfield in February 2002. They were placed in a single layer on the lab bench at 20°C and 50-60% RH with gentle air movement over them for 1 hour. By that time the soft new growth had wilted and tips had bent more than 90° towards the stem base (below horizontal). Each of the following treatments was applied to 8 stems in one container:

1. Control, no recutting stems, shallow (65mm) DI water, room humidity (50-60% RH)
2. Recut the stem base 75mm in air
3. Recut the stem base 75mm under water
4. Deep water 21cm
5. High humidity (polythene bag placed over the stems, 95% RH)
6. Chlorine germicide (sodium dichloroisocyanurate, DICA, 80mg/L, 50mg/L available chlorine)
7. Citric acid 200mg/L
8. Commercial postharvest solution (Chrysal Professional #2)

The stems were held in the vase life room as described above for 3.5 days. Photographs were taken of representative stems of each treatment compared to the control.

### 3.5.3. Botrytis

#### 3.5.3.1. Observations of Botrytis infection

Flowers were taken from several *Leptospermum* species growing at Knoxfield and Longford. They were held in loosely closed polythene bags containing wet paper towel (1 per sample) at 20°C for 2 days then given to the Crop Health Services diagnostic service at Knoxfield to identify the fungi that were visible on the flowers.

#### 3.5.3.2. Postharvest fungicide treatment

An experiment was conducted to examine the effects of postharvest fungicide treatment on vase life and flower drop. Fungicide treatments may decrease *Botrytis* growth and hence any effects of *Botrytis* on the flowers. Fungicide treatments decreased flower drop in waxflower (Beasley and Joyce 2002). A selection of *L. rotundifolium* (‘LRBL1’) which often drops petal was used. Stems were picked at Knoxfield in November 2002, 30 cm in length and with 100% of flowers open. The experimental unit was an individual stem. They were dipped for 1 minute in either DI water or Scala® fungicide (pyrimethanil) 160mg/L a.i. They were then placed in test tubes with 12cm of DI water in the cold room at 0°C, with a polythene bag over the stems, for 16 hours. They were then transferred to the vase life room at 20°C. There were 7 blocks used in the cold room and vase life room, with 1 stem per block, and the treatments were randomised within each block. The end of vase life was when either >50% of the petals had dried and closed or >50% of the petals had dropped. Petal drop was estimated to the nearest 10%.
3.5.4. Cold storage

An experiment was carried out to investigate the effects of cold storage on a red hybrid *L. ‘Rudolph’* to see if the flowers could be cold stored for two or three weeks and then sold before Christmas. *L. ‘Rudolph’* is a hybrid between *L. morrisonii* (purple foliage selection) and *L. spectabile*. Stems were cut at Knoxfield on November 28, 2002.

The experimental unit was a test tube containing two stems. These were treated in 5 blocks based on the plant of origin, the extent of flower opening at harvest (20% to 50%) and stem length (20cm to 40cm). The tubes were placed in randomised complete blocks within the cold room for pretreatment and vase life room for vase life respectively. Each block was packed in one carton for cold storage. Treatments were randomised within each block. All stems were dipped for 1 minute in Scala® fungicide (pyrimethanil) 160mg/L a.i. The flower stems were held in test tubes with 12cm of DI water in the cold room at 0°C, for 16 hours. After 16 hours one test tube per block was placed into the vase life room as described above and the stems from the other test tube in each block was packed into a carton for cold storage. Storage was assessed by placing flowers in small cartons (50 x 20 x 15cm) with other *Leptospermum* foliage. The cartons were lined with thin polythene (garbage bag) and newspaper, they were completely filled and the newspaper and plastic wrapped tightly over the flowers before the carton lids were closed and taped down. These were then placed at 0°C for 2 weeks. Then the flowers were removed from the cartons, the stems recut 1cm, and placed in individual test tubes of DI water in the vase life room. The end of vase life was judged to occur when >50% of the flowers were dried and closed or when the tip growth wilted below the horizontal.

3.5.5. Statistical analysis

All measurements were analysed by analysis of variance using the Genstat 5 statistical package from Rothamsted Experimental Station, UK. Least Significant Differences (LSD) are expressed at the 5% level, unless otherwise stated.
4. Results

4.1. Identification of the superior forms of *Leptospermum* for use as cut flowers

The species and selections obtained in earlier work were characterised as they matured and flowered. Twenty-seven superior selections were identified from 10 species and 3 hybrids. The better species and cultivars and their characteristics are listed below in alphabetical order.

**Characteristics of the superior forms of the better species of *Leptospermum* for use as cut flowers**

*Leptospermum morrisonii*

**Characteristics**
- Medium-tall (2-3m) upright plants
- Foliage is green, or shades of red to black
- Leaves are narrow and lanceolate, but not prickly
- Start of flowering is in early-mid December
- Flowering lasts for 3-4 weeks
- Flowers arranged terminally on side shoots, not profuse and not terminal on upper shoots
- Medium (21-25mm) white flowers
- Flat petals that are round and touch
- Vase life of 11 days
- Buds open if showing colour
- Vase life ends due to petals dropping and/or drying

**Better selections or commercial cultivars**

* L. ‘Copper Glow’ (large white flowers 24mm, dark foliage, vase life 12 days)
* L. *morrisonii* ex Qld (large white flowers 26mm, green foliage)

*Leptospermum rotundifolium*

**Characteristics**
- Medium (1.5m) upright plants
- Leaves are stiff, short and fleshy, but not prickly
- Start of flowering is in mid October
- Flowering lasts for 3-4 weeks
- Flowers arranged terminally on short side shoots and along stems
- Medium- large (24-28mm) pink / mauve flowers
- Flat petals that are round and touch
- Vase life of 10-14 days
- Buds open if showing colour
- Vase life ends due to petal drop
**Better selections or commercial cultivars**

*L. rotundifolium* ‘Lavender Queen’ (25mm, flower colour, vase life)
Longford improved *L. rotundifolium* ‘Lavender Queen’ (28mm, flower colour, presentation)

**Leptospermum sericeum**

**Characteristics**
Medium (1.5m) round plants
- Foliage is silver green
- Leaves are short and robust, but not prickly
- Start of flowering is in late August to early September
- Flowering lasts for 3-4 weeks
- Flowers arranged terminally on short side shoots and along stems
- Medium- large (26-30mm) soft pastel pink flowers
- Flat petals that are round and touch
- Vase life of 11-12 days
- Buds open if showing colour
- Vase life ends due to petal drop

**Better selections or commercial cultivars**

*L. sericeum* ex Pomonal (silver foliage, pastel pink flowers, early flowering, upright)
*L. sericeum* ex WA (silver foliage, pastel pink flowers, 26-30mm, early flowering)

**Leptospermum spectabile**

**Characteristics**
Medium (1.5m) upright, narrow plants
- Leaves are narrow and lanceolate, but not prickly
- Start of flowering is early-mid November
- Flowering lasts for 3-4 weeks
- Flowers arranged terminally on short side shoots and along stems
- Flowers are not terminal, they are on short lateral shoots
- Medium- large (25-32mm) red / crimson flowers
- Flat petals that are round and touch
- Vase life of 8-10 days
- Buds open if showing colour
- Vase life ends due to petals shrivelling

**Better selections or commercial cultivars**

*L. spectabile* (dark red flowers, 25mm)
*L. spectabile* 967 (vibrant flower colour, flat petals, 29-32mm)
*L. spectabile* 899 (less vegetative tip, 30mm)
*L. spectabile* LT1 (vibrant red flowers)
*L. spectabile* LB2 (terminal and dark red flowers)
Leptospermum turbinatum

Characteristics
- Medium (1-2m) round plants
- Foliage is green, or shades of red to black
- Leaves are short and robust, but not prickly
- Start of flowering is in early-mid October
- Flowering lasts for 3-4 weeks
- Flowers arranged terminally on short side shoots and along stems
- Medium- large (28-31mm) white flowers
- Flat petals that are round and touch
- Vase life of 9-10 days
- Buds open if showing colour
- Vase life ends due to petals shrivelling and dropping

Better selections or commercial cultivars

*L. turbinatum* LTPR3 (large flat flowers, terminal)
*L. turbinatum* LTPR1 (large flat flowers, terminal)

Table 4.1. Characteristics of other priority species of *Leptospermum* for use as cut flowers

<table>
<thead>
<tr>
<th>Species</th>
<th>Characteristics</th>
</tr>
</thead>
</table>
| *L. brevipes* | • Flowers – small to medium, white, lateral along the stem to the tip,  
dense on the stem, Oct/Nov.  
• Stem – narrow, fine side branches  
• Plant - reasonable vigour, spreading habit  
• Vase life – 8 to 10 days  

**Better cultivars**

• *L. brevipes* (small 8mm, delicate mass flowering)

| *L. grandiflorum* | • Flowers –medium, white to pink, lateral along the stem, reasonable display, Jan/Feb.  
• Stem – narrow, fine side branches  
• Plant - reasonable vigour, spreading habit  
• Vase life – 9 days  

**Better cultivars**

• *L. grandiflorum* ‘Bicheno Pink’ (pink, medium flowers 24mm)
<table>
<thead>
<tr>
<th>Species</th>
<th>Characteristics</th>
</tr>
</thead>
</table>
| *L. lanigerum*  | • Flowers –medium, white, terminal on the stem, dense along the stem, Aug/Sept/Oct.  
• Stem – narrow, short side branches  
• Plant - good vigour, upright habit  
• Vase life – 6 days plus  
**Better cultivars**  
• LLLP2 (upright, vigour, flower density) |
| *L. macrocarpum* | • Flowers – large, various colours, lateral on the stem, can be dense on the stem, Oct/Nov.  
• Stem – upright or branching  
• Plant – slow to reasonable vigour, spreading habit  
• Vase life – 5 to 10 days  
**Better cultivars**  
• L. macrocarpum (pink)  
• LMP4 ‘Longford Pink’ (large flower 40mm, pink petals and sepals)  
• LMGG2 (large green flowers)  
• LMCBG191J (flower size 31mm) |
| *L. deuense*    | • Flowers –medium, white, Feb.  
• Stem – fine weeping branches  
• Plant - reasonable spreading habit |
| *L. petersonii* | • Flowers – small to medium, white, dense, Sept/Oct.  
• Stem – narrow, fine side branches  
• Plant - good vigour, spreading habit  
• Vase life – 4 to 11 days  
**Better cultivars**  
• *L. petersonii* ‘Longford’ (good vase life) |
| *L. polygalifolium* | • Flowers – small, white, lateral along the stem to the tip, dense on the stem, Sept/Oct.  
• Stem – branching and spreading  
• Plant - medium vigour, spreading habit  
• Vase life – 6 to 10 days |
| *L. laevigatum* | • Flowers –medium 19mm, white, lateral along the stem to the tip, reasonable display, Oct/Nov.  
• Stem – spreading branches  
• Plant - medium vigour, spreading habit  
• Vase life – 14 days |
### Table 4.2. Characteristics of other cultivars of *Leptospermum* for use as cut flowers

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Characteristics</th>
</tr>
</thead>
</table>
| *L. ‘Aphrodite’* | • Flowers – small to medium 19-22mm, red-pink, lateral along the stem to the tip, dense on the stem, Nov.  
|                | • Stem – upright, branching                                                      |
|                | • Plant - reasonable vigour, upright-spreading habit                             |
|                | • Vase life – 12 days                                                            |
| *L. ‘Merinda’  | • Flowers – small to medium 20mm, pink, lateral along the stem to the tip, dense on the stem, Oct/Nov.  
|                | • Stem – narrow, fine side branches                                              |
|                | • Plant - reasonable vigour, spreading habit                                     |
|                | • Vase life – 7 days                                                             |
| *L. ‘Rhiannon’ | • Flowers – medium to large 30mm, purple-pink, lateral along the stem, good display but low on the stem, Nov.  
|                | • Stem – upright, branching                                                      |
|                | • Plant - reasonable vigour, upright habit                                       |
|                | • Vase life – 9-11 days                                                          |
4.2. Leptospermum breeding program

In previous work the reproductive biology of *Leptospermum* was investigated to enable controlled pollinations to be conducted (Slater et al. 2001). These early controlled pollinations were undertaken using any cultivars that were in flower without the knowledge of which cultivars had the best cut flower characteristics. As the superior cut flower cultivars were identified they were included as parents in the breeding program with the aim of producing superior cut flower hybrids.


During this first flowering season the superior selections were used as parents in the breeding program. In total 646 interspecific hybrid pollinations were conducted that included 77 combinations using different parental cultivars. As well as the interspecific hybrid combinations, 44 intergeneric hybrid pollinations were conducted.

The interspecific breeding program was relatively successful with 87 nuts being harvested when they matured, while the intergeneric program was not successful with no nuts developing through to maturity. This lack of success meant that a number of combinations would need to be repeated after the reproductive biology of some of these cultivars was closely studied to determine if there were differences to the original cultivars studied.

4.2.2. Breeding program 2001 – 2002

During the second flowering season the superior selections were again used as parents in the breeding program. In total 658 interspecific hybrid pollinations were conducted that included 78 combinations using different parental cultivars. From these pollinations 201 nuts were harvested when they matured. This represented an improved success rate over the previous year’s results.

As well as the interspecific hybrid combinations, 312 intergeneric hybrid pollinations were conducted. The floral morphology and biology of species within the related genera was examined to facilitate their successful inclusion in the breeding program. The intergeneric program was successful with 46 nuts developed through to maturity.

4.2.3. Breeding program 2002 – 2003

During the third flowering season the superior selections were again used as the parents in the breeding program. In total 139 interspecific hybrid pollinations were conducted, including 18 combinations using different parental cultivars. During this season the breeding focused on late season flowering species, and one parent that we had been previously unsuccessful with. Further work on this species’ reproductive biology allowed us to include it in the program. 21 pollinations were conducted using late season parents and 71 pollinations were conducted using the previously unsuccessful parent.

As well as the interspecific hybrid combinations, 165 intergeneric hybrid pollinations were conducted. Eight nuts were harvested from the interspecific breeding program, while 20 nuts were harvested from the intergeneric program.

4.2.4. Hybrid seed germination and seedling production

From the interspecific hybrid pollinations 368 nuts were collected when the seed was mature. These nuts were derived from 107 different combinations of parents. The resulting seed, or embryos when they could be distinguished, were plated out and the hybrid seedlings were grown until they were a size that was suitable for transplanting into the field at Longford. During this work over 1800 seedlings were prepared for field planting.
From the intergeneric hybrid pollinations, 49 nuts were collected when the seed was mature. These nuts resulted from 21 different combinations of parents, and over 116 seedlings were prepared for field planting.

4.3. Hybrid evaluation

4.3.1. Field assessments

The hybrid seedlings were monitored at the Longford field site over the three flowering seasons of the project. Due to the juvenility period of the seedlings, which was not foreseen at the start of the project, none flowered in the first year after planting and few in the second year. Generally the plants needed to be at least 18 months in the field and over 50cm tall for flowering to occur. The flowering response desirable for cut flower use occurred in the third and fourth flowering season in the field.

During the first flowering season of the project, twenty hybrids flowered, but each only produced a few flowers. Two of the hybrids exhibited promise, as the flowers were very attractive.

During the second season, the hybrids growing in the field at Longford flowered more profusely and the flowering response was in proportion to the individual plant’s age and height. The oldest hybrids had been in the field for 2.5 years, were up to 1.5m tall, and exhibited strong flowering. On the other hand the younger plants were smaller and flowering was much less significant, (a few flowers per plant) if at all. A few of the hybrids showed promise for use as cut flowers, with good stem numbers and stem length. The flowers were very attractive (good colour, size and form) and were well distributed along the stem. The stems of some hybrids had acceptable vase life. Other plants exhibited characters that may make them useful as landscape plants.

During the 2002 season a more detailed appraisal of the hybrids was possible, although they were various ages (Table 4.3), and the assessment that could be conducted on them corresponded to the individual plant’s age and height. The oldest hybrids had been in the field since 1998, were up to 2m tall, and showed a strong flowering that could be assessed for vase life as well as the flower characters. Hybrid plants that had been in the ground since 2000 were a range of sizes and a number of these could also be assessed for the vase life of the stem, as well as flower size and colour. The younger plants (<1.5 years old) could only be assessed once they commence flowering, and of the 101 plants that were planted in 2001 only 11 flowered.

Table 4.3. No of hybrids in the field of various ages as shown by planting date

<table>
<thead>
<tr>
<th>Planting time</th>
<th>Number of hybrids at October 2002</th>
<th>Number of hybrids at June 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct-98</td>
<td>159</td>
<td>114</td>
</tr>
<tr>
<td>Jun-00</td>
<td>466</td>
<td>372</td>
</tr>
<tr>
<td>Oct-00</td>
<td>289</td>
<td>194</td>
</tr>
<tr>
<td>May-01</td>
<td>101</td>
<td>79</td>
</tr>
<tr>
<td>2002</td>
<td>291</td>
<td>709</td>
</tr>
<tr>
<td>2003</td>
<td>n/a</td>
<td>769</td>
</tr>
<tr>
<td>Total</td>
<td>1306</td>
<td>2237</td>
</tr>
</tbody>
</table>
During the 2002 flowering season field observations were conducted on the 1017 plants that were in the field. Of these 833 flowered and flowering times were noted and the flowering display and flowers were described. An extra 31 plants were also described, although they did not flower, as their plant structure was considered interesting for landscape use, due to their compact or weeping habit. The remaining 184 plants did not flower at all during the season, and no observations were taken.

Due to the on-going production of hybrid seedlings the age of the hybrids in the field varied as indicated by their planting dates (Table 4.3). A significant number of plants flowered in the 2002/2003 season and were suitable for primary assessment for their suitability for use as cut flowers. A number of plants that were considered unsuitable were consequently removed from the field site to allow new hybrids to be planted in their place in late 2002 and 2003.

4.3.2. Vase life assessments

Of the 833 hybrids that flowered during the 2002 flowering season, vase life was assessed (at least once) on 202 plants. A further 190 plants were also identified for vase life assessments, but these were not conducted due to harvest time, short stem length or low stem numbers.

Vase life was monitored for
- bud and flower opening after harvest
- vase life of each stem
- average vase life of 5 stems
- characteristics of end of vase life

Flowers being assessed for their vase life were also measured for their flower diameter and the flowers and floral display was described, while the colour was recorded by reference to RHS colour charts.

A number of the hybrid seedlings show promise for use as cut flowers, as they produce good stem numbers and stem length. The flowers are very attractive (colour, size & form) and are well distributed along the stem. The stems of some hybrids have a good vase life. Other plants are showing characters that may make them useful as landscape plants.

4.4. Hybrid Styles

Hybrid style No. 1 – Pale, ruffled petals

Characteristics
- Tall (2m) upright plants with, dark foliage
- Leaves are stiff, short and fleshy, but not prickly
- Start of flowering from mid October to mid November
- Flowering lasts for 6-8 weeks
- Flowers arranged terminally on short side shoots and along stems
- Large (25-30mm) pale flowers with pink / pale violet edges
- Flat or ruffled petals that are round; petals touch or overlap
- Vase life of consistently 11-12 days, good after simulated export
- Buds open if showing colour
- Vase life ends due to petals drying and dropping

Potential cultivar
- 1-4 cut flower
Hybrid style No. 2 – Long, pink and profuse

Characteristics
- Tall (2m) upright plants or short bushes, with bright green or darker foliage
- Leaves are small, narrow and soft
- Flowering starts in November
- Flowering lasts for 6-9 weeks
- Long stems with near terminal or terminal flowering
- Profuse flowering along stems and side branches, with flowers overlapping
- Medium sized (18-25mm) flowers
- Petals are pale pink to dark pink and flowers have a green nectary
- Nectary can have a red / pink rim
- Vase life of 11 – 12 days
- Buds open if showing colour
- Vase life ends due to petals shrivelling

Potential cultivars
1-4 cut flower

Hybrid style No. 3 - Purples

Characteristics
- Robust plants with thick stems and robust leaves
- Leaves are large and bright green
- Start of flowering varies from mid Oct to late November
- Flowering lasts for 6-9 weeks
- Flowers are clustered on short side shoots and along stems, and are near terminal to terminal
- Medium to large (25-30mm) flowers with a green nectary and yellow stamen
- Petals are pink to purple, round and touch, sepals are green
- Vase life of consistently 12-13 days
- Buds open if showing colour
- Vase life ends due to petals dropping

Potential cultivars
1-4 cut flower

Hybrid style No. 4 – Large with alternating colours

Characteristics
- Robust plants with large leaves
- Leaves are strong and thick
- Start of flowering is in November
- Flowering lasts for 4-6 weeks
- Flowering is generally not terminal
- Large to very large flowers (28-38mm) with petals and sepals a similar size and alternating, and long stamen
- Petals pale pink to dark crimson, sepals pale green
- Vase life of 9-13 days
- Buds open if showing colour
- Vase life ends due to petals shrivelling and drying

Potential cultivars
0-3 cut flower
Hybrid style No. 5 – Pink flowers on dark foliage, Christmas Characteristics
Tall upright plants with long stems and dark foliage
Leaves are large, dark purple and soft
Flowers are terminal on short side shoots along the stem, and are terminal on lateral shoots, but not the main upright stems
Start of flowering varies from late November to December
Medium to large (23-28mm) flowers
Petals are pale pink to red pink, round and overlap
Vase life of 12-24 days
Buds open if showing colour
Vase life ends due to petals shrivelling
Potential cultivars
1-5 cut flower

Hybrid style No. 6 – White flowers on dark foliage, Christmas Characteristics
Tall upright plants (2m) or shorter spreading plants (1.2m) with long stems and dark foliage
Leaves are small or large, dark purple and soft
Start of flowering is in December
Flowering lasts for 5-8 weeks
Flowers are profuse and terminal or near terminal
Small-medium flowers or medium-large flowers (20-23, 24-31mm)
Petals are white/cream, round and join / overlap, sepals are small, buds may be pale pink
Vase life of 15-16 days
Buds open if showing petal colour
Vase life ends due to petals shrivelling
Potential cultivars
1-2 cut flower

Hybrid style No. 7 – White flowers on green foliage, Christmas Characteristics
Tall upright plants with green foliage
Leaves are small and green, but not prickly
Start of flowering is in early December
Flowering lasts for 5-8 weeks
Flowers are profuse and terminal
Small to medium flowers (17-20mm)
Petals are white/cream-green
Vase life of 12-13 days
Buds open if showing colour
Vase life ends due to petals shrivelling and dropping
Potential cultivars
1-4 cut flower

Hybrid style No. 8 – pink flowers crowded along stem Characteristics
Plants have long stems with short leaves
Leaves are short and robust
Start of flowering is in October
Flowering lasts for 5-6 weeks
Profuse and terminal flowering with the flowers crowded along the stems
Small to medium flowers (23-27mm)
Petals are pale to strong pink
Vase life is short, 7-8 days
Buds open if showing colour
Vase life ends due to petals shrivelling

Potential cultivars
0-2 cut flower

Hybrid style No. 9 – white and red flowers crowded along stem

Characteristics
- Plant has weeping stems to 70 cm, with compact side branches
- Leaves are short and robust
- Starts flowering in mid October
- Flowering lasts for 5-6 weeks
- Profuse flowering
- Small to medium flowers
- Flowers have white petals and red sepals

Potential cultivars
1 landscape

Hybrid style No. 10 – robust pink flowers

Characteristics
- Plants are medium sized
- Leaves are small, unobtrusive to the display
- Start of flowering is in October
- Flowering lasts for 5-6 weeks
- Flowers are near terminal to terminal on stem and short side shoots
- Various medium sized flowers (25-29mm), petals are thick, pink and solid
- Vase life of 8-10 days
- Buds open if showing colour
- Vase life ends due to petals shrivelling

Potential cultivars
1-2 cut flower

Hybrid style No. 11 – robust peach coloured flowers

Characteristics
- Plants are medium sized
- Leaves are small, unobtrusive to the display
- Start of flowering is in October
- Flowering lasts for 5-6 weeks
Flowers are near terminal to terminal on stem and short side shoots.
Various medium sized flowers (17-31mm),
Petals are two toned, cream centre with pink edging providing a peach appearance
Vase life of 9-12 days
Buds open if showing colour
Vase life ends due to petals shrivelling

**Potential cultivars**

1-2 cut flower

**Hybrid style No. 12 – large pink petalled**

**Characteristics**

Robust plants with thick stems and long leaves
Leaves are large, green and soft
Start of flowering varies from mid to late October
Flowering lasts for 5-6 weeks
Flowers arranged on short side shoots and along stems, but not terminal
Medium to large pink flowers (25-30mm)
Petals are red pink and round with a short stem
Vase life of 8-10 days
Buds open if showing colour
Vase life ends due to petals shrivelling

**Potential cultivars**

0-1 cut flower

**Hybrid style No. 13 – short and squat**

**Characteristics**

Very short, compact plants
Leaves are small, green and soft
(Have not flowered to date)

**Potential cultivars**

1 landscape
4.4. Postharvest trials

4.4.1. Export suitability

4.4.1.1. Simulated export

Simulated export reduced the vase life of *L. morrisonii* ‘Burgundy’, *L. ‘Ruffles’* and *L. turbinatum*, but *L. morrisonii* ‘Burgundy’ and ‘Ruffles’ still had a life greater than 7 days. Export did not significantly reduce the vase life of *L. morrisonii* ‘LMBLR1’, *L. polygalifolium* ‘Bronze’, *L. spectabile* or *L. turbinatum* ‘LTPR3’, but these all had a short life of less than 6 days. *L. obovatum* has previously been shown to lose about a day’s vase life after export (Slater et al. 2001). *L. ‘Ruffles’* flowers, both fresh and exported, opened fully even when picked with only 0-10% of flowers open (Table 4.4).

Table 4.4. Effects of 3 days simulated export on subsequent vase life of *Leptospermum* cultivars.

<table>
<thead>
<tr>
<th>Species</th>
<th>Vase life, fresh (days)</th>
<th>Vase life, after export (days)</th>
<th>LSD ($P=0.05$)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>L. morrisonii</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Burgundy’</td>
<td>11.9</td>
<td>7.5</td>
<td>2.0</td>
<td>Some petal browning indicative of <em>Botrytis</em> infection.</td>
</tr>
<tr>
<td><em>L. obovatum</em></td>
<td></td>
<td>5.5</td>
<td></td>
<td>Data from the experiment reported in Table 3.5.</td>
</tr>
<tr>
<td><em>L. ‘Ruffles’</em></td>
<td>10.4</td>
<td>8.0</td>
<td>1.0</td>
<td>Slight petal drop during export. 90% of flowers opened, regardless of opening at harvest and regardless of treatments. Some petal browning indicative of <em>Botrytis</em> infection.</td>
</tr>
<tr>
<td><em>L. turbinatum</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘LTPR1’</td>
<td>7.7</td>
<td>5.6</td>
<td>1.4</td>
<td>Slight petal drop during export. Substantial petal browning associated with <em>Botrytis</em> infection. ANOVA showed a significant interaction between treatment and cultivar.</td>
</tr>
<tr>
<td>‘LTPR3’</td>
<td>5.0</td>
<td>5.7</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td><em>L. morrisonii</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘LMBLR1’</td>
<td>4.6</td>
<td>4.9</td>
<td>1.8</td>
<td>A single experiment was conducted with <em>L. morrisonii</em> ‘LMBLR1’, <em>L. polygalifolium</em> ‘Bronze’ and <em>L. spectabile</em>, ANOVA showed only a significant effect of species, no effect of export.</td>
</tr>
<tr>
<td><em>L. polygalifolium</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Bronze’</td>
<td>5.9</td>
<td>6.0</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td><em>L. spectabile</em></td>
<td></td>
<td>3.9</td>
<td>3.0</td>
<td></td>
</tr>
</tbody>
</table>
4.4.1.2. Export pretreatments

ANOVA showed two significant treatment effects. The overall factorial (water) pretreatment (mean 5.6) was significantly different to no pretreatment (immediate export, mean vase life 6.9) or to precooled in carton (7.4). The effect of RH within the factorial was significant, where high RH had a mean vase life of 5.1 days and low RH 6.1 days. There was no significant effect of temperature within the factorial (Table 4.5).

Table 4.5. The effects of pretreatments before export on subsequent vase life of L. obovatum.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Vase life (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Factorial (in water), 0°C, low RH</td>
<td>5.5</td>
</tr>
<tr>
<td>2. Factorial (in water), 0°C, high RH</td>
<td>5.0</td>
</tr>
<tr>
<td>3. Factorial (in water), 20°C, low RH</td>
<td>6.8</td>
</tr>
<tr>
<td>4. Factorial (in water), 20°C, high RH</td>
<td>5.1</td>
</tr>
<tr>
<td>5. No treatment, immediate export</td>
<td>6.9</td>
</tr>
<tr>
<td>6. Precooled in carton</td>
<td>7.4</td>
</tr>
<tr>
<td>LSD P=0.05</td>
<td>1.5</td>
</tr>
</tbody>
</table>

4.4.2. Water relations

4.4.2.1 Deep water – foliage.

The effect of continuous deep water on the foliage of these two species was quite dramatic (Table 4.6). Deep water treatment of *L. obovatum* reduced the number of stems showing tip wilting. This experiment was followed by a replicated experiment with foliage of *L. obovatum* by Williamson *et al.* (2002) (see Discussion 5.5 below).

Table 4.6. Effects of shallow and deep vase water on vase life of *Leptospermum* foliage.

<table>
<thead>
<tr>
<th>Flower</th>
<th>Vase life (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shallow water (5cm)</td>
</tr>
<tr>
<td><em>L. obovatum</em></td>
<td>3</td>
</tr>
<tr>
<td><em>L. polygalifolium</em> 'Bronze’</td>
<td>2</td>
</tr>
</tbody>
</table>

NB: Values are means of 10 stems. The treatments were not replicated so there is no statistical analysis. The results were reported, without the data, by Williamson *et al.* (2002) and are included here to present all our laboratory’s relevant data together.

4.4.2.2. Deep water – flowering *L. spectabile*

The effects of deep water to extend the life of *Leptospermum* foliage are marked, however we need to know whether such treatments improve flowering stems and whether short pretreatments that growers
and exporters could apply are likely to be effective. When flowering *L. spectabile* stems were given an overnight pretreatment in the cold room before vase life the effect on vase life was significant at \( P=0.065 \) (Table 4.7).

**Table 4.7. Effects of shallow and deep water pretreatment on subsequent vase life of *L. spectabile*.**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Vase life (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow water (5cm)</td>
<td>4.6</td>
</tr>
<tr>
<td>Deep water (20cm)</td>
<td>6.2</td>
</tr>
<tr>
<td>LSD ( P=0.05 )</td>
<td>1.8</td>
</tr>
</tbody>
</table>

### 4.4.2.3. Recutting the stem – foliage

The effect of continuous recutting of the stem on the foliage of these two species was quite dramatic (Table 4.8). In *L. obovatum*, recutting reduced the number of stems showing tip wilting. This experiment was followed by a replicated experiment with foliage by Williamson *et al.* (2002) (see Discussion 5.5 below).

**Table 4.8. Effects of recutting the base of the flowers stem by 1 cm daily on vase life of *Leptospermum* foliage.**

<table>
<thead>
<tr>
<th>Flower</th>
<th>Vase life (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Uncut</td>
</tr>
<tr>
<td><em>L. obovatum</em></td>
<td>8</td>
</tr>
<tr>
<td><em>L. polygalifolium ‘Bronze’</em></td>
<td>3</td>
</tr>
</tbody>
</table>

NB: Values are means of 10 stems. The treatments were not replicated so there is no statistical analysis. The results were reported, without the data, by Williamson *et al.* (2002) and are included here to present all of our laboratory’s relevant data together.
4.4.2.4. Photographs of the effects of treatments on water relations

Figure 1. Effect of recutting stems in air (right) compared to an uncut stem (left) on foliage wilting of *L. morrisonii* ‘ex Qld.’ after 3.5 days in the vase.

Figure 2. Effect of recutting stems in water (right) compared to an uncut stem (left) on foliage wilting of *L. morrisonii* ‘ex Qld.’ after 3.5 days in the vase.
Figure 3. Effect of deep water (21 cm, right) compared to shallow water (7 cm, left) on foliage wilting of *L. morrisonii* 'ex Qld.' after 3.5 days in the vase.

Figure 4. Effect of high RH (95%, right) compared to medium RH (50-60%, left) on foliage wilting of *L. morrisonii* 'ex Qld.' after 3.5 days in the vase.

Figure 5. Effect of chlorine germicide (right) compared to water (left) on foliage wilting of *L. morrisonii* 'ex Qld.' after 3.5 days in the vase.
The following treatments appeared to cause a strong recovery from wilting, so that no wilting was observed after 3.5 days in the vase:
- Recut stems in air
- Deep water
- High RH
- Commercial postharvest solution, Chrysal Professional

The following treatment appeared to cause a partial recovery from wilting:
- Recut stems in water

The following had little or no apparent effect:
- Citric acid
- Chlorine
4.4.3. Botrytis

4.4.3.1 Observations of Botrytis infection

*Botrytis cinerea* was positively identified on the two samples analysed (Table 4.9).

<table>
<thead>
<tr>
<th>Species</th>
<th>Fungi present</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>L. rotundifolium</em> ‘Lavender Queen’, Longford, 1999.</td>
<td><em>Botrytis cinerea</em> consistently isolated. <em>Alternaria</em> was also present (Slater et al. 2001).</td>
</tr>
<tr>
<td><em>L. turbinatum</em> ‘LTPR1’ and ‘LTPR3’, Knoxfield, 2002.</td>
<td><em>Botrytis cinerea</em> associated with wounds at the base of the petals. <em>Cladosporium</em> and <em>Penicillium</em> found on dead flower parts. Note these flowers were brown at the base of petals after a few days in the vase (Table 4.4).</td>
</tr>
</tbody>
</table>

4.4.3.2. Postharvest fungicide treatment

There was no significant effect of fungicide on vase life or petal drop (Table 4.10).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Vase life (days)</th>
<th>Petal drop, day 4 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>5.7</td>
<td>11</td>
</tr>
<tr>
<td>Fungicide dip</td>
<td>5.2</td>
<td>6</td>
</tr>
<tr>
<td>LSD <em>P</em>=0.05</td>
<td>1.8</td>
<td>15</td>
</tr>
</tbody>
</table>

4.4.4. Cold storage

Storage for 2 weeks did not significantly reduce the vase life of *L. ‘Rudolph’*, which was short (Table 4.11).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Vase life (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh</td>
<td>5.67</td>
</tr>
<tr>
<td>Stored</td>
<td>4.50</td>
</tr>
<tr>
<td>LSD <em>P</em>=0.05</td>
<td>1.24</td>
</tr>
</tbody>
</table>

NB: The vase life data are shown to 2 decimal places to show that the treatment effect was not significant at *P*=0.05.
### 4.4.5. Variability between replicate stems

During the analysis of these results it became clear that there was large variation in the vase life of replicate stems of the same species, within the same treatments (Table 4.12).

#### Table 4.12. Variation in vase life between replicate stems. All flowers are untreated controls, unless stated otherwise.

<table>
<thead>
<tr>
<th>Species</th>
<th>Vase life Min. – max. (days)</th>
<th>Replicate stems</th>
<th>Experiment</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>L. morrisonii</em> ‘Burgundy’</td>
<td>5-16 (mean 11.9)</td>
<td>14</td>
<td>Tables 3.1 and 4.4</td>
<td>The high variability may have occurred because stems came from several plants and there was variable stem size and flower opening. There were also different causes of the end of life i.e., drying, tip wilt and petal drop.</td>
</tr>
<tr>
<td><em>L. morrisonii</em> ‘LMBLR1’</td>
<td>3-6 (mean 4.6)</td>
<td>7</td>
<td>Tables 3.1 and 4.4</td>
<td>The low variability may be because there was only one cause of the end of vase life –drying and closing.</td>
</tr>
<tr>
<td><em>L. obovatum</em> Exported with no pretreatment</td>
<td>4-9 (mean 6.9)</td>
<td>10</td>
<td>Tables 3.1 and 4.4</td>
<td>Very uniform stems.</td>
</tr>
<tr>
<td><em>L. polygalifolium</em> ‘Bronze’</td>
<td>4-10 (mean 5.9)</td>
<td>7</td>
<td>Tables 3.1 and 4.4</td>
<td></td>
</tr>
<tr>
<td><em>L. rotundifolium</em> ‘LRBL1’</td>
<td>4-7 (mean 5.7)</td>
<td>7</td>
<td>Table 4.10</td>
<td></td>
</tr>
<tr>
<td>L. ‘Rudolph’</td>
<td>4-8 (mean 5.7)</td>
<td>12</td>
<td>Table 4.11</td>
<td></td>
</tr>
<tr>
<td>L. ‘Ruffles’</td>
<td>7-12 (mean 10.4)</td>
<td>9</td>
<td>Tables 3.1 and 4.4</td>
<td></td>
</tr>
<tr>
<td><em>L. spectabile</em></td>
<td>3-5 (mean 3.9)</td>
<td>7</td>
<td>Tables 3.1 and 4.4</td>
<td>The low variability may be because all the stems came from the one plant and there was only one cause of the end of vase life –drying and closing.</td>
</tr>
<tr>
<td>2-8 (mean 4.6)</td>
<td>11</td>
<td>Table 4.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>L. turbinatum</em> ‘LTPR1’, ‘LTPR3’</td>
<td>7-9 (mean 7.7)</td>
<td>7</td>
<td>Tables 3.1 and 4.4</td>
<td></td>
</tr>
<tr>
<td>4-8 (mean 5.0)</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. Discussion

The Australian cut flower export industry has expanded from approximately $5 million in 1984/85 to near $6.7 million in 2011/12. To ensure exports continue to increase it is necessary to improve the quality and continuity of supply of existing products and increase the available product range with high quality new flower crops. New cultivars of *Leptospermum* have a good capacity to be able to provide a range of high quality cut flower cultivars.

5.1. Superior forms of *Leptospermum* for use as cut flowers

The genus *Leptospermum* contains a diverse group of plants. There are a range of flower colours and sizes, and between August and March a member of the group will be in flower. These are important characters to develop this genus as a diverse floral crop, as it allows continual supply to the market, and it provides diversity within the crop.

The cut flower characteristics of a range of *Leptospermum* cultivars have been assessed to establish the better species and cultivars of *Leptospermum* for use as cut flowers. The species and selections were assessed and placed under cut flower selection pressures as they matured and flowered. Their postharvest performance has also been assessed and described. The better species and cultivars and their characteristics have been listed and described in section 3.1. The superior forms that were assessed have been identified and these species and cultivars should be sought out by wildflower growers to trial under their growing conditions.

In the process of assessing the performance of the cultivars we have described the plant structure, foliage type and colour, flowering time in Victoria, flowering duration, flower characteristics and postharvest behaviour. Whilst the flowering time for each species and cultivar can be quite short, especially for optimal harvest time, a range of species and cultivars have been identified that flower between late August and early January. This should enable growers to produce a range of cultivars and market *Leptospermum* over an extended season.

5.2. *Leptospermum* breeding

The breeding of *Leptospermum* has developed during this work and targeted superior cut flower cultivars for parents. This has been able to be done by the on-going identification of species and cultivars showing superior cut flower characteristics, and placing these cultivars into the breeding program with the aim to produce superior cut flower hybrids.

The breeding program was extensive with a total of 1443 interspecific hybrid pollinations conducted. In addition 521 intergeneric hybrid pollinations were performed with closely related species. During this work over 1800 interspecific hybrid seedlings from the earlier breeding work and this program were germinated and prepared for field planting. From the intergeneric hybrid pollinations, 116 seedlings were prepared for field planting. In total from this and the earlier work there are now over 2200 hybrids growing at the field site.

5.3. Hybrid evaluation

The hybrid seedlings have been monitored at the Longford field site over the three flowering seasons of the project. Due to the juvenility period of the seedlings, which was not foreseen at the start of the project, none flowered in the first year after planting and few in the second year. Generally the plants needed to be at least 18 months in the field and over 50 cm tall for flowering to occur. The flowering response desirable for cut flower use occurred in the third and fourth flowering season in the field.
During the first flowering season of the project 20 hybrids flowered from the previous breeding work, but only produced a few flowers per plant. During the second season, more hybrids flowered and the flowering response was in proportion to the individual plant’s age and height. During the third season a more detailed appraisal of the hybrids could be undertaken, although not a complete appraisal as with the on-going production of hybrid seedlings, the recently planted hybrids were not old enough to flower.

Of these hybrids that did flower, the flowering times were noted and the flowering display and flowers were described. Material was collected for postharvest assessment of the hybrid. The vase life was monitored and the postharvest behaviour described. All the hybrids that had an acceptable vase life, exhibited an ability for mature buds to continue to develop and open after harvest. This will enable these hybrids to be harvested when they are just starting to flower to maximise vase life.

**5.4. Hybrid Style Descriptions**

From the field and postharvest observations 13 different hybrid styles have been described. These styles can be easily distinguished on petal colour, size and other floral characters. The hybrid styles have been described in full, and a number of cut flower and landscape cultivars should be obtainable from each of the hybrid styles.

**5.5. Postharvest**

**5.5.1. Export suitability**

Those species/hybrids with long vase lives as fresh flowers (greater than 10 days) tend to retain good vase life (greater than 7 days) after export, even though they lose approximately 3 days life, the duration of export. Thus selection for long vase life should produce plants with adequate life after export. Most of our export experiments were with stems cut with more than 20% of flowers open. Stems picked earlier may not open as well if stressed by export, though the flowers of *L. ‘Ruffles’* opened fully even when picked with only 0–10% of flowers open. It would be wise to continue to assess elite selections and hybrids for their export performance.

The experiment with export pretreatments showed there was no significant benefit of pretreatment in water over either immediate packing and export, or immediate packing and precooling before export. In fact, the water treated flowers had shorter lives than those from the other two treatments. This is consistent with our previous results, with the same species (*L. obovatum*), where holding the stems out of water but in a closed polythene bag for 24 hours led to a greater subsequent vase life than for flowers kept in water at ambient RH for those 24 hours (Williamson *et al.* 2002). The result is different to what we reported with *L. rotundifolium* (‘Longford Improved’) where there was no difference in the effects of pretreatments with water (at 0°C or 20°C) and precooling dry in the carton before export (Slater *et al.* 2001). In the current experiment the flowers were not water stressed when they reached the laboratory. In commercial practice water stressed flowers may need hydration before export.

When flowers were pretreated in water, temperature (0°C or 20°C) had no significant effect, but low humidity, without covers over the flowers, led to a longer vase life after export than a high humidity with covers over the flowers. It is likely that water uptake at low RH would be higher than at high RH and this may improve later vase life. However this is contrary to the conclusion above that water uptake (before export) is not very important.

**5.5.2. Water relations**

Several treatments that are known to affect water relations in cut flowers improved vase life and overcame wilting in *Leptospermum*: deep water, recutting stems, high RH and a commercial postharvest solution.
The effect of deep water on vase life of *L. obovatum* foliage was confirmed in a replicated experiment in our laboratory. Vase life in shallow water (5cm) was 9 days and in deep water (23cm) it was 26 days (*P*=0.05) (Williamson *et al.* 2002). They also showed that the effect of deep water was probably not due to water moving in through the sides of the stems, as coating stems with petroleum jelly did not change the result. The water depth did not alter the concentration of bacteria in the water either. Other evidence shows that the effect is due to the hydrostatic pressure of the deep water. Water flow rate through isolated segments of rose stems increased with head pressure from 18 to 240cm (Durkin 1979).

If deep water treatment is to be of commercial use it must be effective on flowering stems, not just foliage, and it must be effective when applied as a short treatment, e.g. overnight after harvest. In the one experiment we conducted to test this, flowering *L. spectabile* stems were given an overnight pretreatment in the cold room before vase life. The effect was not significant at *P*=0.05 but it was at *P*=0.065. Preliminary, unreplicated experiments with flowering stems of *L. polygalifolium* and *L. turbinatum* indicated that continuous deep water, for 2 days and 3 days respectively, markedly delayed flower drying and closing (Figures 8 and 9). Further research and commercial trials are warranted.

The Society for American Florists’ manual (Nell and Reid, 2001), which was available after the experiments were conducted, recommends use of deep water (20-30cm) to “push water into flower stems, particularly to revive wilted flowers”. We’ve also learned of a waratah (*Telopea speciosissima*) grower who places the flowers in deep water after harvest to improve the subsequent quality of the flowers.

![Figure 8. *L. polygalifolium* after 3 days in shallow water (7cm, left) or deep water (30cm, right).](image)
Figure 9. *L. turbinatum* after 3 days in shallow water (7cm, left) or deep water (30cm, right).

The effect of recutting the stems on *L. polygalifolium* ‘Bronze’ foliage was also confirmed in a replicated experiment by Williamson et al. (2002). Vase life of uncut stems was 7.6 days and the life of those recut 1cm each day (under water) was 10.1 days ($P=0.05$). The effects of recutting stems in air, or under water, on vase life and flower opening were also shown in *L. rotundifolium* ‘Lavender Queen’ and there was no difference between cutting in air or water (Slater et al. 2001).

The Society for American Florists’ manual (Nell and Reid, 2001) does not recommend recutting under water for large commercial operations unless the equipment used ensures that each stem receives clear, clean water. Otherwise stems can easily be blocked by debris. The manual recommends using other strategies to improve water uptake: acidification, warm water, de-aerated water, ice-cold water, deep water, or pulsing with detergent.

The high RH treatment of *L. morrisonii* ‘ex Qld’ foliage reduced wilting to some extent (Figure 4.) and the same treatment also extended the vase life of the related *Thryptomene calycina* (Jones et al. 1993). However high humidity treatments before export led to lower vase life than the low humidity control (Table 4.13).

Chlorine germicide and citric acid had little or no effect on reducing wilting of *L. morrisonii* ‘ex Qld’ foliage, contrary to their effects in a wide range of flowers (Figures 5 and 6). Perhaps wilting of soft new growth is quite difficult to prevent. On the other hand the commercial postharvest solution strongly inhibited wilting; most similar products contain several compounds to improve water uptake (e.g. acid and germicide) and maintain water status and “nourishment” (e.g. sugar) of the foliage.

To understand the mechanisms affecting water uptake by *Leptospermum* stems, treatments were applied to remove compounds blocking the xylem (Williamson et al. 2002). These compounds were acetone (solvent), hypochlorite (oxidant) and potassium hydroxide (hydrolysing agent) and they had been shown to delay wilting of chrysanthemum (*Dendranthema grandiflora*) (van Doorn and Cruz 2000). They were applied for short times of 2, 5, or 15 minutes only. However these treatments did not increase the vase life of *L. obovatum* foliage and in some cases reduced it.
5.5.3. Botrytis

Botrytis cinerea was identified on the two samples that were thoroughly diagnosed. We suspect it is common, but this remains to be tested. In California, L. scoparium hybrids apparently drop petals in response to Botrytis growth, which particularly occurs after rain. There, fungicide sprays are applied in the field, particularly after rain, to prevent flower drop (K. Robb, University of California, San Diego, personal communication). This is probably worth testing here on susceptible species. Our single experiment with fully open flowers showed no effect of postharvest fungicide dips on flower drop. However it may have been too late to stop Botrytis action if it was there.

It seems reasonable to hypothesise that Botrytis acts in Leptospermum as it does in waxflower (Chamelaeucium uncinatum) where it induces ethylene production and consequently flower drop (Beasley and Joyce 2002). This can be tested and if it is the case, two approaches can be used to counter Botrytis. Field sprays and/or postharvest dips with fungicides could be tested. Anti-ethylene treatments such as silver thiosulphate (STS) and 1-methylcyclopropene (1-MCP) can be applied to see if the treatment stops petal drop as it does in waxflower. In our previous experiments, applied ethylene induced petal drop in two Leptospermum species. However STS or 1-MCP did not stop natural petal drop in L. rotundifolium ‘Lavender Queen’, L. scoparium and L. petersonii (Zieslin and Gottesman 1983, Macnish et al. 2000, Slater et al. 2001). These limited results suggest that ethylene may not be involved in natural petal drop, but this needs further research.

5.5.4. Cold storage

The results of our single storage experiment, with L. ‘Rudolph’, shows that cold storage can be used with no significant loss of vase life. L. ‘Rudolph’ is probably not the best hybrid/species to store as it showed signs of drying out even before storage, it had soft tip growth that wilted and a short vase life even for fresh flowers. Perhaps other varieties with longer inherent vase lives would be better to store, for example some produced by the current breeding program. Christmas is a difficult time to store flowers, as the flowers are likely to be water stressed and there may be soft tip growth that easily wilts.

5.5.5. Variability between replicate stems

Some of the variation in vase life is probably caused by stems coming from different plants (even though they are vegetatively propagated), from different stem sizes and different degrees of flower opening and from different causes of the end of vase life (e.g. drying versus petal drop) (Table 5.20). However, where these factors don’t vary, there are still sometimes large differences in vase life between replicate stems, e.g. on apparently identical stems cut from the same plant.

Some of new hybrid selections, described in Appendix 1, show considerable variability, with approximately 20% of them having the maximum vase life twice that of the minimum in any one assessment experiment. However, some selections, particularly the hybrid styles ‘ls x lr rhiannon’ and the ‘tb x lq ruffles’ groups, have consistently long vase lives (Section 3.3.3 and Appendix 1).

In riceflower (Ozothamnus diosmifolius) there is also considerable variation in vase life between replicate stems e.g. 7-15 days. Correlation between vase life and either stem diameter or stem length was investigated in O. ‘Cook’s Snow White’ from Helidon, Queensland, and no correlation was found (Beal et al. 1999).
5.5.6. Causes of the end of vase life

Some *Leptospermum* species and hybrids become unacceptable in the vase because they dry out: *L. morrisonii* ‘LMBLR1’, *L. obovatum*, *L. polygalifolium* ‘Bronze’, *L. ‘Rudolph’, L. scoparium* and *L. spectabile*.

Some species dry out and drop petals: *L. morrisonii* ‘Burgundy’, *L. rotundifolium* ‘Lavender Queen’ and ‘LRBL1’, *L. ‘Ruffles’* and *L. turbinatum* (‘LTPR1’, ‘LTPR3’). *L. ‘Ruffles’* suffered some petal drop during vase life and it’s interesting that this was not prevented by early picking, when only 0-10% of flowers were open.

Some species drop petals at high humidity (e.g. in a package) but dry out in a vase at room humidity: *L. ‘Aphrodite’, L. lanigerum, L. obovatum, L. scoparium* and the related *Thryptomene calycina*. *L. rotundifolium* ‘Lavender Queen’ appeared to dry out if the branches had been dry for some time after picking, but dropped petals if the branches had been supplied with water continuously (Slater et al. 2001).

Petal drop occurs in the field in susceptible species, so it is not just a postharvest phenomenon and may be either a natural aging process or the result of fungal infection. There may be some value in selecting for species that don't drop petals in the field.

Most of the new hybrid selections end their vase life by drying out (“shrivelling” and “closing”), for example: If x ls; flavescens (If x nm); Imb x ls; ls x lm alt; and ls x lr rhiannon. Some, particularly the ruffles group, have some petal drop as well as drying. The new hybrids also open well, even when picked with only 0-10% of flowers open.
6. Conclusion

This project has identified the superior species and cultivars of *Leptospermum* that can be used as cut flowers. The project has extended this series by using the superior selections as parents in a breeding program and producing a series of 13 hybrid styles that could continuously supply *Leptospermum* cut floral forms for the market. This work has also looked at the postharvest behaviour of these cut flower leptospermums to enable the development of superior hybrids with good vase life that should increase the demand for this cut flower.

The next steps required in the development of *Leptospermum* as a cut floral crop include:

- The commercial evaluation of cultivars that have shown promise in field and vase life evaluations
- The commercial evaluation of cultivars that have shown promise for use in market sectors other than the cut flower sector, such as flowering container plants or landscape plants
- The development of a commercialisation strategy for commercial cultivars
- The continued primary assessment of hybrids as they flower, and
- The communication of the results of this work through industry articles.
7. Implications and recommendations

Selection and breeding

A range of *Leptospermum* species and cultivars have been assessed against cut flower selection pressures including their flowering characteristics and postharvest performance. These cultivars have been listed and described in section 3.1. Wildflower growers interested in producing *Leptospermum* should seek out these superior forms to determine their performance under their growing conditions.

Whilst the flowering time for each species and cultivar can be quite short, especially for optimal harvest time, the range of species and cultivars flower between late August and early January. This range of flowering times will allow *Leptospermum* to be marketed over an extended season, and growers have the opportunity to supply the market over this extended season by growing a range of species and cultivars.

The breeding program has been extensive and a range of hybrids have flowered and been assessed. Thirteen different hybrid styles have been described. These styles can be easily distinguished on petal colour, size and other floral characters. The hybrids have interesting and attractive flower colours including various shades of pinks through to reds, bright white and pink flowers against dark foliage, and particularly interesting two tone flowers where the petals are pink and white, pink and cream, or where the pink/crimson petals and green sepals alternate. There are cultivars within most of the hybrid styles that have a good vase life of over 10 days, while one cultivar lasted an average of 18 and 24 days when tested on two occasions.

These hybrid styles still need to be assessed for the best commercial cultivars, although a number of cut flower and landscape cultivars should be obtainable from each of the styles. The best cultivars will be commercialised and made available when they are ready.

A large number of hybrids are too young at this stage and are yet to flower for the first time. As these are combinations of parents that have not flowered to date, further hybrid styles are likely to arise from these plants.

Postharvest

The best way to achieve good postharvest quality is to grow species, hybrids or selections that have an inherently good quality and vase life. Some of the species and hybrids identified and bred in this project provide excellent quality and vase lives greater than 10 days. It appears that if species/hybrids have a long vase life as freshly picked flowers (greater than 10 days) they will have an acceptable vase life after export (greater than 7 days), but will lose vase life approximately equal to the time spent in transport.

In all but the best species/hybrids, flower and foliage drying and petal drop after harvest are problems. Our results have shown some treatments that may help overcome drying out i.e. deep water, recutting stems and some postharvest solutions. These need further researching and commercial testing, on *Leptospermum* and other Australian native flowers. The control of petal drop needs further research, for example into the role of *Botrytis* and ethylene. The effects of anti-ethylene treatments (STS and 1-MCP) still warrant further investigation.

Our recommendations for postharvest handling are:

- to grow *Leptospermum* species/selections/hybrids with an inherently long vase life. These include the new hybrids bred in this project;
- cut stems when about 10-20% of buds are open, and other buds are showing petal colour;
- consider treating species that are prone to drying in a deep postharvest solution;
• consider treating species that are prone to petal drop with anti-ethylene compounds;
• use good practices of cooling and an effective postharvest solution;
• handle and sell the flowers quickly; and
• encourage the end user to recut the stems and hold them in a deep solution of flower preservative.

This project has built on the work and knowledge established in an earlier project, and has been able to identify a range of cultivars that should be grown, and establish a range of postharvest treatments that will address some of the postharvest issues with Leptospermum. However further work is still required in the following areas:

• Commercial evaluation of the new cultivars and hybrids.
• Commercial release of superior cultivars
• Continued assessment of the hybrids that have not flowered to date.
• Commercial trials of deep water, the best postharvest solutions and of recutting stems should be carried out with Leptospermum and other flowers that are prone to drying out.
• Continue to look for ways to overcome drying and petal drop, the roles of Botrytis and ethylene and the effects of anti-ethylene treatments.
• The dissemination of this work through talks, articles, papers, training courses.
References


Developing leptospermum for cut flowers

By Anthony T. Slater, John D. Faragher, Slobodan Vujovic, Fran Richardson, Geoff Kelly, Peter Franz and MaryAnne Blakemore

Pub. No. 13/102

This report describes the development of superior Leptospermum hybrids through a breeding program and the evaluation of post-harvest performance and techniques.

This report is targeted at wildflower growers interested in producing Leptospermum for cut flowers and similarly for growers looking to exploit the landscape potential of the species. These growers should seek out the superior forms to determine their performance under their growing conditions.

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