Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

VARIETY COMPARISON AND MODELLING FLOWERING OF *LIMONIUM PEREZII* (Stapf) Hubb. × *LIMONIUM SINUATUM* (L.) Mill. 'LSLP4'

A thesis presented in partial fulfilment of the requirements for the degree of

Masters in Horticultural Science

Massey University

Palmerston North

New Zealand

Jianyu Chen

2005

Abstract

A series of new inter-specific hybrids have been derived between *L. perezii* and *L. sinuatum*. One of the selections 'LSLP4' offers potential as a cut flower. Precise knowledge on quality, yield and timing of these selections, as well as scheduling 'LSLP4' accurately in commercial production were required. To address these needs, this project comprised both a variety trial and an experiment to model the time to flower.

Plants of 'LSLP4', 'LSLP5' (a sibling of 'LSLP4'), *L. perezii* and *L. sinuatum* derived from tissue culture were grown in a temperature-controlled (daily mean temperature around 20°C) greenhouse and long-day photoperiod. With the exception of the inferior wing characteristic, the yield, timing, and quality as well as the consistency of yield and quality of 'LSLP4' were intermediate or superior to *L. sinuatum* and *L. perezii*. The potential of 'LSLP5' as a cut flower could not be assessed due to its failure to flower during the variety trial.

To develop a predictive model for time to flower of 'LSLP4', 7 sequential plantings were conducted from autumn through to late spring, utilizing one of two light regimes (50% shaded and no-shade). This resulted in 11 treatments of average daily light integral (DLI). Duration from transplanting to first visible flower bud (DTV) was correlated with average DLI, with the response being saturated above 15 $mol{\cdot}m^{-2}{\cdot}d^{-1}$. This relationship between DTV and average DLI is the foundation of a 'pre-planting' predictive model for 'LSLP4'. DTV was also correlated with leaf number accumulation rate (LNAR) and ground cover index increase rate (GCIR). The

combination of average DLI and LNAR together as predictors of DTV improved the r^2 of the model over that using DLI alone from 88% to 92%, which subsequently formed the basis of a 'post-planting' predictive model. It was recommended that growers of 'LSLP4' for cut flowers use the 'pre-planting' model to schedule planting dates and predict flowering time according to historical DLI data. Once planting occurs, and actual DLI and LNAR are collected, the prediction of DTV can be refined by the post-planting model.

Acknowledgements

I sincerely thank my senior supervisor Dr. Keith Funnell for his excellent guidance, encouragement, infinite patience, and unconditional support throughout this study. Keith always enlightened and challenged my thoughts, and had an open-door policy for me. I would also like to express my appreciation of his dedication and time on reading and critically evaluating my thesis from very beginning pieces to final drafts.

My special gratitude also goes to my co-supervisor Mr Ed Morgan (Crop & Food Research Ltd.) for his invaluable advice and help whenever I needed it for my thesis. Ed spent lots of time discussing my results and his feedback on my thesis was also very important to complete this project.

I would like to thank the staff from Crop & Food Research Ltd., particularly Maaike Bendall, John Koolaard, and Duncan Hedderley for their invaluable statistical help in various stages of my thesis, and also Dr Ian Brooking for freely sharing his knowledge with us and thought provoking discussion. I also thank Crop & Food Research for the provision of plant materials for this research.

I am grateful to Prof. Ian Warrington for his helpful advice and discussion during different stages of this project. I thank all the staff members at the Institute of Natural Resources and the Plant Growth Unit, Massey University for their help in different ways, especially Prof. Qiao Wang for his moral support and guidance of my study and life in New Zealand. Massey Applied Science Scholarship Committee is very much thanked for providing various scholarships to me during these years.

My special appreciation is also extended to my lab mates and friends in New Zealand: Pyone for her kindness and care; Zhao for his help; Tuing for her friendship; Mya Mya for her warm hospitality and yummy foods, which satisfied my craving for my home cooking; Zheng, Ping, and Ming for the enjoyment of playing badminton; and Jenny and Graham Teahan family for their support and making me feel at home.

Some of my fellow mates in China, Ying Gao, Xiaomeng Sun and Jinxiang Xu have always been there for me during these years despite the distance. Their support, humour, and fun from chatting through the internet made my life never boring.

Finally, I owe so much to my parents and brother for their love and support while I was far away from them. Ba and Ma, thanks for asking that classic question every week (now I can finally answer: yes, I finished my thesis). My boyfriend, Dominic Teahan, thanks for being such a nice close friend, for all of your kind help in my study, for being with me in the computer lab until early morning, for all of your distraction, which made my life more enjoyable.

Table of Contents

List of Tables

List of Figures

List of Abbreviations and Units of Measurement

CDLI	cumulative daily light integral	$mol \cdot m^{-2}$
DLI	daily light integral	$mol \cdot m^{-2} \cdot d^{-1}$
DTFH	duration from transplanting to first harvest	days
DTH	duration from first visible flower bud to harvest	days
DTV	duration from transplanting to first visible flower bud	days
GCI	ground cover index	$cm^2 \cdot cm^{-2}$
GCIR	ground cover index increase rate	$cm^2 \cdot cm^{-2} \cdot d^{-1}$
GDD	growing degree days	°C·d
LNAR	leaf number accumulation rate	$leaves \cdot d^{-1}$
MLN	number of leaves below the first visible flower bud	leaves
NLN	number of leaves presented between transplanting and first visible flower bud	leaves
PRSS	predictive residual sum of squares	--
PTR	photothermal ratio	$mol \cdot m^{-2} \cdot °C^{-1} \cdot d^{-1}$
RD	rosette diameter	cm
SE	Standard error	--
T_a	daily mean temperature	°C
VIA	visual impact area	cm^2

Chapter 1 General Introduction

1.1 Overview of the New Zealand Cut Flower Industry

The New Zealand cut flower industry has developed well in the last two decades. Exports of cut flowers have increased from $8 million in 1985 to $48 million in 2002 (Kerr et al., 2002). Combined domestic and export earnings from cut flowers currently contribute approximately $125 million to the New Zealand economy, with "new" cut flower selections representing 22% of this value.

The floriculture industry in New Zealand has been successful in developing novel cut flowers for export, from species and cultivars of *Cymbidium* Swartz., *Zantedeschia* Spreng and *Sandersonia* Hook. These successes have encouraged the New Zealand cut flower industry to focus on developing new cut flower varieties so as to ensure survival in the international cut flower market.

Crop & Food Research Ltd. is one of New Zealand's Crown Research Institutes and has a programme that specializes in introducing and breeding novel cut flowers. They have successfully developed a series of inter-specific hybrids within the genus *Limonium*. One of the hybrids has been commercialized as 'Chorus Magenta', and exported from New Zealand as both planting material and flowers. With ongoing breeding, more new *Limonium* selections have been identified with potential as cut flower crops.

1.2 *Limonium* Species Grown as Cut Flower Crops

Limonium is a well-known genus in the international cut flower market, and was ranked 19th in cut flower sales through Dutch auctions in 1999 (VBN, 1999). The popularity of *Limonium* is not only because of their wide range of adaptation within tropical and temperate zones, but also their attractive florets and long lasting calyces. The flowers of most *Limonium* species can be air-dried, which further extends their use and marketing opportunities.

Several *Limonium* species are grown as cut flowers. The best known species are *L. sinuatum* and the free-flowering statice hybrids between *L. latifolium* (Sm.) Kuntze. and *L. bellidifolium* (Gouan) Dumort. (Armitage, 2003). As *Limonium* became popular in the international flower market, more species were selected as cut flowers, such as *L. perezii*, *L. tetragonum* (Thunb.) Bullock., *L. suworowii* (Reg.) Kuntze. and *L. perigrinum* (Bergius) R.A.

There are more than 150 species in the *Limonium* genus (Baker, 1948). These display a range of morphological characteristics, which provides many opportunities to develop new selections through inter-specific hybridisation (Burge et al., 1995). Breeding to incorporate desirable traits (e.g. long flower stem) from different *Limonium* species into new selections has been demonstrated. For example, 'Chorus Magenta' is a selection from crosses between *L. perigrinum* and *L. purpuratum* L. (Morgan et al., 2001). The long stem characteristic is an attribute from *L. purpuratum*, which is not grown commercially due to its less attractive inflorescence.

1.3 *Limonium* 'LSLP4' and 'LSLP5'

A series of inter-specific hybrids have been developed between *L. perezii* and *L. sinuatum* using embryo rescue techniques (Morgan et al., 2001; Morgan et al., 1998). The objective of this breeding was to produce new forms of *Limonium* which retain inflorescence characteristics from *L. perezii*, e.g. long and smooth stem (i.e. no wings or wing extensions) and a large panicle, but include the range of flower colours evident in *L. sinuatum*.

L. sinuatum is one of the most common *Limonium* species in the international cut flower market. It is usually grown as an annual. The inflorescence is particularly valued for the dense and bright colours from long lasting calyces. Breeding of *L. sinuatum* has provided numerous hybrids of various colours, ranging from the pure white 'Iceberg' through the clear pink 'Pacific Twilight' and the aptly named 'Sunset' mixtures, to deep blues and violets (Huxley et al., 1992). There are however some characteristics of *L. sinuatum* that reduce the ornamental value of cut stems. *L. sinuatum* has angular stems with 0.5-0.6 cm wings and 2-3 cm wing extensions. The wings and wing extensions easily become yellow in the vase shortening the vase life (Steinitz and Cohen, 1982). The stem length (40 cm) is shorter than some other species, e.g. *L. perezii* (60 to 90 cm), and the panicle is small (Armitage, 2003; Huxley et al., 1992). Thus, breeding aims for *L. sinuatum* are to increase stem length, reduce wings and wing extensions, and enlarge the panicle (Ed Morgan, per. comm.).

L. perezii is also grown as a commercial cut flower though only a few cultivars are available. 'Violet' was selected for its deep colour, earliness to flower and high production (Harada, 1992). 'Atlantis' has dark blue flowers and 60 to 90 cm stems (Armitage, 2003). This species is considered attractive with its long stem length, large panicle, and smooth stem without any wings and wing extensions, but the colour range in this species is limited. It is mainly blue. Therefore, one of the breeding aims for this species is to broaden the colour range (Ed Morgan, per. comm.).

The initial inter-specific hybrids between *L. perezii* and *L. sinuatum* were sterile and the fertility was restored by doubling chromosome numbers of the hybrids (Morgan et al., 2001). A blue tetraploid was back-crossed to *L perezii* to produce a range of back-cross selections designated as 'LSLP1' to 'LSLP7'. 'LSLP4' was the first of these selections to produce flowers. 'LSLP5' was the last (Ed Morgan, per. comm.).

Preliminary visual observation by the breeder has identified that these selections, in particular 'LSLP4' (Fig. 1-1), included some improved characteristics from its parents and might have potential as a commercial cut flower. For example, the inflorescence of 'LSLP4' retained the form of *L. perezii,* i.e. larger panicle and longer stem length, while the wings and wing extensions were considered less frequent than in *L. sinuatum* (Ed Morgan, per. comm.). When the flowers within the inflorescence of 'LSLP4' reach maturity, the funnel-like calyces open acropetally and expose a white corolla. The corolla abscises 2-3 days after anthesis while the calyces remain open, a feature that also occurs in both *L. sinuatum* and *L. perezii*. The calyx colour of 'LSLP4' is deep purple-blue, and was different to the blue of *L. perezii* (Ed Morgan, per. comm.). The preceding information was only based on visual observation. Therefore, a more detailed and accurate study was required to further quantify the morphological characteristics of 'LSLP4' through variety trials. Furthermore, to replace or supplement existing species or cultivars for horticultural use, new selections should display a number of features including: early flowering after planting, compactness of flowering over time, high flower yield, and consistent quality of product (Funnell et al., 2003). To date no evaluation of the selections of *L. sinuatum* and *L. perezii* through variety trials has been carried out and, therefore, this forms the basis of the research reported in Chapter 2.

Fig. 1-1. Inflorescence of *Limonium* 'LSLP4' showing stem length, leaf, and panicle (left) as well as close-up of flowers (right).

The commercial introduction of any new cultivars of cut flowers not only requires the validation from variety trials that their quality, yield and timing are similar or superior to that of the industry standard cultivars, but also need to provide growers with the knowledge that allows growing and scheduling of the new cultivars accurately. No research has been published investigating the response of 'LSLP4' to light intensity, temperature, and photoperiod. Hence no data was available to develop a model for flowering prediction and scheduling plantings. This therefore forms the foundation of the research reported in Chapter 3.

1.4 Goals and aims of this study

The goals of this research were to provide horticulturists with some useful information for selecting *Limonium* selections, and also some crop scheduling strategies of 'LSLP4'. Within these goals the aims were:

1. To compare the quality, yield and timing of 'LSLP4'and 'LSLP5' to the industry standards of *L. sinuatum* and *L. perezii* through a variety trial
2. To develop and validate a model to predict time to flower of 'LSLP4'