Factors Influencing Flowering in *Metrosideros excelsus* (pohutukawa)©

J. Clemens, P.E. Jameson, L. Sreekantan, and R.E. Henriod
Institute of Molecular BioSciences, Massey University, Private Bag 11 222, Palmerston North

Shoot growth and development in mature trees of *Metrosideros excelsus* (pohutukawa) were monitored over 2 to 3 years, and responses to temperature and daylength in container-grown plants of the same species studied under experimental conditions. Marked differences in the degree of flowering in a tree in 2 successive years resulted from differences in the number of overwintering, resting buds that could potentially form flowers. Heavy flowering in one season resulted in a scarcity of overwintering buds capable of flowering the following year. Cool temperatures following floral initiation were required to permit normal floral development in greenhouse experiments. The proportion of buds that became floral following a relatively mild winter in 1998 and a winter with more typical temperatures in 1999 was 20% and >50%, respectively.

INTRODUCTION

We have completed a number of projects on flowering of *Metrosideros*, including *M. excelsus* (pohutukawa), the New Zealand Christmas tree (Clemens et al., 1995; 1999; 2000; Henriod et al., 2000; Sun et al., 2000). The purpose of much of this work was to understand the temperature and daylength signals that control flowering in pot plants, and the life of the individual flowers on the plant or when cut. Further to our preliminary study (Clemens et al., 1998), we have been able to complete a picture of the flowering behaviour of mature plants growing in the field. Specifically, we wanted to know the reason or reasons why pohutukawa flowering can vary from year to year and why there are good and bad flowering years for these majestic trees that line the coasts of North Island New Zealand.

Theories have been advanced for this variation. Kleinpaste (1999) suggested that the weather might have an effect on flowering, with drier rather than wetter conditions favouring good flowering. As others have commented, he also notes a lot of variation between trees in a stand, some being “covered” in flower buds while others have very few. Godley (1987) made similar observations, and suggested a comprehensive monitoring programme of pohutukawa buds be undertaken.

The Project Crimson Trust, which promotes research and oversees revegetation with pohutukawa (and related *Metrosideros*) in New Zealand, recently released a bibliographical database on pohutukawa (Smith, 1999). The bibliography contains a wealth of information, yet surprisingly few reference relating directly to flowering behaviour. However, one entry notes that “large amounts of vegetative growth this year indicates that flowering should be heavier next year” (Simpson, 1997).

MATERIALS AND METHODS

Shoot growth and flowering in pohutukawa plants growing in Palmerston North were monitored as earlier described (Clemens et al., 1998), the observation period being extended for a second year. Details of experiments on the environmental control of flowering in container-grown pohutukawa plants have been reported elsewhere (Henriod et al., 2000).

RESULTS AND DISCUSSION

Typically, as nonflowering pohutukawa shoots elongate in spring, the tips of the shoots fall away before the leaves can expand. What remains are short shoots, at the tip of each of which is a pair of opposite buds in the leaf axils of the last pair of leaves. These buds do not grow out during the rest of the growing season, but overwinter as resting buds before breaking the following spring. When they break the following spring, they will be either floral (and go on to flower at Christmas time), or they will be nonflowering, vegetative shoots. The latter go through the same cycle again over the following 12 months, their axillary bud pairs again having a chance to become floral or to remain vegetative.

Between spring and early autumn, a resting bud is made up only of several pairs of bud scales protecting the apical meristem, the growing point. At this stage there is no way to differentiate microscopically between a bud that is going to be floral in spring, and one that is going to be vegetative. However, during late autumn one of two things happens at a tiny scale within the bud that determines which buds are the likely to produce flowers next summer.

The pohutukawa “flower” is actually an elaborate structure in which there are typically several tiers of three-flowered cymules opposite each on a short flowering shoot. Each group of three flowers is protected in the bud by a scale. The cymules form in the axils of these scales. However, the apical meristem at the tip of the shoot remains vegetative in the bud and can produce leaves if conditions are favourable. From late autumn until winter, either the apical meristem starts to produce new leaves and three-flowered cymules are not initiated in the scale axils, or cymules are initiated and develop in the scale axils at the expense of the apical meristem. The contrasting fates of the overwintering buds have been captured by carefully sectioning buds and examining them microscopically (Clemens et al., 2000).

The balance between cymule development in the bud scales, and leaf growth at the apical meristem lays the foundation for how well a pohutukawa tree is going to flower the following summer. In our study, the trees showed varying degrees of flowering each season. Some had an approximately equal balance between vegetative shoots and flowers from year to year. However, we also observed cases where almost all the overwintering buds were floral, and the trees were a mass of red flowers in summer. When this occurred, there was very poor flowering in spring of the following year.

A pohutukawa tree that flowers exceptionally heavily in summer has produced very few vegetative shoots in spring. It, therefore, has very few shoots bearing the pairs of overwintering buds at their tips that would be needed to initiate flowers during winter. The result is an “on” year, followed by an “off” year (which, in turn, could be followed by another “on” year). Incidentally, each pohutukawa flower head (each with its several cymules) conceals the vegetative growing point at its tip. This can produce a leafy shoot in the autumn or winter after flowering. Some of these leafy shoots arising from the tops of the flowers can also produce flowers the following spring, although not at an intensity comparable with that of shoots that did not flower the previous summer.

Pohutukawa would appear to have an alternate or biennial pattern of flowering. Alternate bearing is common in fruit and nut trees, e.g., in apple (Stephan et al., 1999), although such behaviour is usually ascribed to the hormonal inhibition of floral development in potentially floral buds. In pohutukawa, the cyclical flowering pattern is probably due to a lack of potential flower buds during autumn. A similar explanation was suggested for variation in flowering in avocado (Salazar-García et al., 1998). Our results are consistent with the observation made by Simpson (1997) that heavy vegetative growth one spring can be followed by heavy flowering the next.

This would explain why there are alternate cycles of flowering in heavily flowering pohutukawa trees. As we found, some trees have the ability to flower more moderately from year to year, probably as a result of floral development taking place in different parts of the canopy each year. However, it may be only as a result of particularly favourable weather conditions (or other site factors) that several trees will flower heavily in a given season. Observation of flowering during 1998 and 1999 suggest that cool winter temperatures foster floral development. Following the mild 1998 winter relatively few resting buds became floral and went on to flower normally (20% of potential flower buds). In the following year when temperatures were more typical, over 50% of potential floral buds produced flowers. Our greenhouse and controlled-environment work confirmed the importance of cool temperatures during winter for floral development to progress satisfactorily beyond floral initiation (Henriod et al., 2000).

In conclusion, the observations we have been able to make over 2 to 3 years indicate that flowering in pohutukawa in any given year depends on how much flowering occurred the previous summer, and probably on winter temperatures. Difficulties of trying to explain why some trees flower well and others do not include genetic variation from tree-to-tree, variation in soil type, aspect and moisture availability where trees are growing within a site, and the lack of accurate flowering records to match meteorological information from different sites. We plan to carry out pohutukawa plantings at several contrasting observation sites during spring 2001, enlisting the help of local monitoring teams. We will then be able to test our conclusions as these plants mature.

Acknowledgements. This work was supported by the Native Ornamental Plants Programme of the Public Good Science Fund through a sub-contract to the New Zealand Institute for Crop & Food Research (Contract C02626). Thanks are expressed to the Agricultural and Marketing Research and Development Trust, and the Massey University Research Fund for additional support.

LITERATURE CITED

Clemens, J., R.E. Henriod, D.G. Bailey, and **P.E. Jameson**. 1999. Vegetative phase change in *Metrosideros*. Shoot and root restriction. Plant Growth Regulation 28:207-214.

Clemens, J., P.E. Jameson, P. Bannister, and **R.P. Pharis**. 1995. Gibberellins and bud break, vegetative shoot growth and flowering in *Metrosideros collina* cv. Tahiti. Plant Growth Regulation 16:161-171.

Clemens, J., P.E. Jameson, and **R.E. Henriod**. 1998. Hastening and controlling flowering in *Metrosideros*. Comb. Proc. Intl. Plant Prop. Soc. 48:80-83.

Clemens, J., L. Sreekantan, R.E. Henriod, and **P.E. Jameson**. 2000. Floral development in pohutukawa. J. Royal N. Z. Institute of Hort. (in press).

Godley, E. 1987. The Christmas tree. N.Z. Gardener.

Henriod, R.E., P.E. Jameson, and **J. Clemens**. 2000. Effects of photoperiod, temperature and bud size on flowering in *Metrosideros excelsa* (Myrtaceae). J. Hort. Sci. Biotech. 75:55-61.

Kleinpaste, R. 1999. Will they or won't they? In true colours, spring edition. Newsletter of the Project Crimson Trust.

Salazar-García, S., E.M. Lord, and **C.J. Lovatt**. 1998. Inflorescence and flower development of the 'Hass' avocado (*Persea americana* Mill.) during "on" and "off" crop years. J. Amer. Soc. Hort. Sci. 123:537-544.

Simpson, P. 1997. Natural pohutukawa in Taranaki. Conservation advisory science notes No.150. Department of Conservation, Wellington.

Smith, S. 1999. First bibliography of pohutukawa and rata. [http://www.projectcrimson.org.nz/biblio_search.html].

Stephan, M., F. Bangerth, and **G. Schneider**. 1999. Quantification of endogenous gibberellins in exudates from fruits of *Malus domestica*. Plant Growth Regulation 28:55-58.

Sun, J., P.E. Jameson, and **J. Clemens**. 2000. Stamen abscission and water balance in *Metrosideros* flowers. Physiol. Plant. 110:271-278.

Spinifex Research Project. A Collaborative Research Project Between Naturally Native New Zealand Plants Ltd and New Zealand Forest Research Institute©

Mark A. Dean
Naturally Native New Zealand Plants Ltd, 30 Gammon Mill Rd, RD 3, Tauranga.

INTRODUCTION

In 1996 Naturally Native New Zealand Plants Ltd. was approached by Natural Logic, an ecological consultancy company operating in the field of revegetation planting, to research the growing of spinifex [*Spinifex sericeus* (syn. *S. hirsutus*)] for planting on coastal dunes in Northland. This company required these plants to restore degraded coastal sand dunes in a rather difficult exposed site and could not find a source for the plants anywhere.

Spinifex along with pingao (*Desmoschoenus spiralis*), had long been recognised as an important indigenous sand binding species. In 1911 Leonard Cockayne the eminent botanist, had noted that these species, along with *Euphorbia glauca* were the most prevalent sand-binding species occurring on the fore dunes throughout most of New Zealand. It also occurs naturally on the eastern coast of Australia where it is a dominant sand dune species.

However, even as late as 1996, little was known as to how to propagate spinifex in sufficient quantities required to make it a viable option to use in sand dune restoration. Some nurseries, notably the Whakatane District Council Nursery and Christchurch City Council Nursery, had been experimenting with propagating spinifex with mixed results and the numbers of plants available were minimal. Cutting propagation had been tried and proved to be very costly and damage to