materials, and disruption to our production patterns are all taken into consideration the cost has actually been quite considerable. Forest Research has estimated it to be in the vicinity of $40,000. The whole research process has been really practically orientated, largely because of the people involved including both scientists and the nursery staff and the fact that there was a practical goal set at the outset.

We have, by being involved, found a small area of specialisation for our company. We are committed to being a key producer of plants for dune restoration — not just spinifex, and this will require even more research in the future. However we recognise that the market for such plants is limited, as at this stage only councils are purchasing them.

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# Focus on New Zealand Flax: *Phormium* Production in 2000©

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## INTRODUCTION

This paper is a combination of 3 years intensive research on *Phormium* J.R. Forst. & G. Forst. for a Bachelor of Science in Crop Technology and Management at Writtle College, United Kingdom and a passion on my part for a truly amazing New Zealand native, making its mark around the world on our modern global landscapes.

My first encounter with *Phormium* was at Lees and Company, a specialist grower of container nursery stock to the landscaping industry in the United Kingdom. In the early 1980s, the plants arrived in large boxes from South Africa rapped in nappies. Later that same season, smaller plants wrapped in bundles of 25 in brown paper and sphagnum moss arrived from New Zealand. An air of mystique shrouded these plants and like any keen plantsperson I started thinking. What conditions would these plants grow under? What feed makes them thrive? How hardy are they and how do you propagate them? This search inevitably led me here to New Zealand, and 3 years on I'm still searching and learning. I'd like to share with you some of my research and key findings.

## KNOWING YOUR CROP

The key to success in any crop is knowing and understanding your crop and knowing what your market requires now and most importantly in the future. To assess this I carried out a survey of the top 40 suppliers, producers, and retailers of *Phormium* in the U.K., U.S.A., France, Japan, South Africa, and New Zealand.

The survey acted as a primary source of information to review current market trends, forecast possible future trends, and give a detailed review of current production techniques. Of the 40 companies surveyed 29 responded (72.5% response rate). As a general summary, the survey highlighted the market in all of its aspects which is currently expanding. This expansion far outweighs current production, therefore, leaving the market with tremendous scope for further production to satisfy a growing consumer demand.

Producers are at the mercy of the plants, however, to reproduce it in sufficient numbers. This being such a long-term process, with cultivars producing between 2 to 4 divisions a year, growers need a large volume of stock plants to satisfy demand. For the future, producers must develop successful new or improved propagation methods.

The world market requires from new breeding programs improved frost tolerance and dwarfer cultivars. This would make *Phormium* more attractive to people with small gardens as well as making them adaptable to a more diverse range of growing conditions. The survey also suggests there is a limited amount of specialist information available, especially on commercial production, which can lead to husbandry problems.

## PLANT PROPAGATION AND FUTURE PRODUCTION

The striking foliage and form of *Phormium* has become increasingly popular with landscape architects and gardeners alike. The single biggest problem facing commercial producers is the long time periods required to build up sufficient plant numbers for commercial release. However, large numbers of *P. tenax*, *P. cookianum*, and *P. tenax* Purpureum Group can be easily raised from seed in a single growing season, currently, the variegated cultivars have remained impossible to increase rapidly by micropropagation. Growers have had to continue to rely on slower production methods of traditional division to build up plant numbers. Generally speaking plants produce between 2 and 4 divisions per season. Considering this, a new variegated cultivar, from selection to final marketing can take between 8 to 15 years depending on how well the cultivar reproduces (Jones, 1998).

**Seed.** Commercially, seed is the most economic method of bulking up *Phormium tenax*, *P. cookianum*, and *P. tenax* Purpureum Group. Seed is best sown fresh and usually germinates within 4 weeks. As with all forms of sexual reproduction the resulting seedlings vary slightly in colour and form from the parent plants, unlike asexual propagation, such as division, where the offspring more closely resemble the parent plant.

*Phormium* seed can be cool-moist stratified for commercial production. This has two significant benefits to the grower. It allows the seed to be stored up to 5 months from harvest and therefore facilitates a more convenient planting date and secondly often results in an increased and more uniform germination rate (Metcalf, 1997).

Seed is soaked overnight, the water is then drained and the seeds are mixed with 3 to 4 times their own volume in moist peat, and placed in a sealed plastic bag. This is then left at room temperature for 3 to 4 days to enable the seeds to take up as much moisture as possible. This maximises the effectiveness of the chilling period. The bags of seed are then refrigerated at $3^{o}$C for 4 to12 weeks. Each week the bags are shaken to keep the seeds well aerated and moistened as necessary. Seeds commercially treated with cool-moist stratification as stated above for up to 5 months readily germinated and grew away within 12 days of planting (Metcalf, 1997)

**Division.** Historically, *Phormium* plants were field produced with the fans lined out at 0.6- to 1-m spacing and left to reproduce for 4 years before being lifted for division. Apart form the sheer physical effort of digging up and dividing the young fans from these large plants, *Phormium* was regarded as relatively easy to propagate. It is, as with many genera, interesting to note that as the plants age they loose vigour and generally are slower to bulk up and harder to establish after division. Many foliage growers and some wholesale nurseries, especially in the U.S.A, still practice the traditional methods of field production and divide as necessary on the 4-year cycle.

Metcalf (1997) advises that after the individual fans have been removed from the parent plant, the leaves on each division should be cut well back, 40 to 60 cm on larger cultivar or 30 to 50 cm on smaller cultivars. If the leaves are not cut back they wilt quite severely and can affect the well being of the new division. In container production a height of 20 cm has been shown to give a much better re-establishment percentage.

It is also interesting to note that Cheeck (1979) states “that during their first year after division the new plants grow fairly slowly as the plants seem to need to develop a new root system prior to growing away”. Lamb et al. (1995) state “after division the old roots die away before new ones emerge from the base plate” which further substantiates this point. This is a serious problem for commercial producers as it has the potential to dramatically increase commercial crop production times. Cheeck (1979) also comments on the weakness of many of the highly variegated cultivars “as one may expect, the cultivars with the most variegation and therefore the least chlorophyll are also particularly slow to make new growth”. Many current producers in the market survey echoed this point.

With the plants being relatively slow to re-establish, under poor husbandry this allows optimum conditions for pest and disease attack. *Phormium* are particularly prone to fungal attack and root rots, especially under excessively wet and airless conditions. Therefore it is essential for the producer to take an active role in monitoring plants after planting and apply an all-purpose fungal drench within 7 days of planting to reduce the impact of any attack.

**The Future and Micropropagation?** The future for *Phormium* propagation in many current producers' opinions lies in increasing the number of divisions each plant is capable of producing. Many growers have talked about their particular view on the benefits of high nitrogen, phosphorus, and potassium fertiliser, and that in certain years plants tend to produce high numbers of divisions leading to the possibility of cyclic reproduction patterns. Growers also state that plants seem to produce a high number of small divisions some years with other cultivars producing one large central fan and two 10- to 15-cm divisions. In my opinion this is a key area of research, which requires in-depth scientific investigation as it holds the key to unlocking the reproductive potential of the genus.

Looking to science is often the answer to commercial problems of poor propagation. Micropropagation has been a commercial alternative for bulking rare and unusual cultivar of plants for commercial growers for over 20 years. A number of micropropagation laboratories have experimented with bulking up *Phormium* cultivars. Lamb et al. (1995) state the prospects are now looking good for propagating *Phormium* cultivars by tissue culture. The method chosen today would probably be in vitro propagation of plants by the proliferation of axillary buds. This method involves culturing the buds on a cytokinin medium. During this process the main buds, as well as the meristematic patches of tissue, are stimulated to develop into shoots giving rise to a shoot cluster. The base of the shoot cluster is subdivided and new shoots are obtained by the outgrowth of axillary buds on the stem. In grass species the production of numerous shoots by axillary buds is called tillering (Lamb et al., 1995).

Commercial *Phormium* producers are however still very skeptical about the benefits of micropropagation to produce numerous new *Phormium* plants for the expanding market. Several nurseries in the past have attempted to propagate some of the highly popular and slow-to-bulk-up cultivars by tissue culture. All the nurseries to date have had little success. Monrovia Nurseries in Azusa, California, attempted to propagate the deep maroon and scarlet-leafed cultivar *Phormium* 'Dazzler' by tissue culture. In the process the red variegation, as has often proved the case with tissue cultured *Phormium* plants was lost. In this case however the subsequent mutated plants where deemed worthy of introduction as a new cultivar and were named *Phormium* 'Monrovia Red' in honour of their technological producer (San Marcos, 1998).

Current thinking suggests the reasons why micropropagation has proved unsuccessful in the past is the fact that the resulting plants from tissue culture were produced from adventitious shoots from cells of pith, leaves, roots, or even undifferentiated callus and not directly derived from meristematic tissue. Lamb et al. (1995) states this type of micropropagation is not always desirable, as in some species it can give rise to plants which are not true to type, for example when the plant to be propagated is a chimera, consisting of several different layers of cells, resulting in unique variegation as is the case with *Phormium*. The resulting plants will not be true to type as the plants obtained from culture will be formed from a single rather than a multiple layer of cells and the variegation will therefore be lost.

**Mechanically Enduced Division.** This is a technique which has the potential to stimulate reproductive rates in *Phormium*. In this technique the crown of the plant is removed just above the base plate, removing all the apical dominance and in theory stimulating all the axillary buds in the base plate to grow away. It is important the horizontal cut is a centimetre above the base plate and goes through without damaging the buds, otherwise you'll limit the number of new divisions. As with traditional division as the plants reach the 10- to 15-cm stage they can be removed with a sharp knife and rooted up in sterile propagation trays of propagation pumice with a bottom heat of 18 to 20$^{o}$C and watered by mist once per day. *Phormium* produces new roots from their crown or base plate. This is the area in the plant where auxin, the plant growth regulator responsible for root initiation, naturally occurs. Under optimum conditions the young divisions with no roots will root up well in 4 to 6 weeks.

## A REVIEW OF CURRENT PRODUCTION TECHNIQUES

In their natural environment *Phormium* plants can tolerate temperatures as low as –8°C and will thrive in wet or swamp conditions but will also do well in dry, exposed conditions (Fisher, 1994). However to obtain optimum growth in a commercial situation, producers need to be somewhat more specific with their production regimes.

Export *Phormium* plants and cut foliage are generally sold by height, with each fan producing between 1 to 6 new leaves in ideal conditions. In basic terms, if the conditions are unfavourable, the plants will take longer to reach a marketable size. This is a considerable drawback to today's cost-conscious producers. To obtain optimum growing conditions it is therefore helpful to look at the plants ideal natural habitat. Both species grow in very open, exposed areas in the loose free-draining, nutrient-rich, volcanic soil endemic to New Zealand. In cultivation it is therefore beneficial to the grower to reproduce a similar growing environment in their nurseries.

An ideal root environment should also mimic the plants natural environment. Good container-grown plant should be provided with an open potting mix with an air-filled porosity (AFP) of 20% to 25%. This could be achieved using a mix of peat and coarse pumice (1 : 2, v/v). Pumice can also be used in a finer grade for propagation of unrooted *Phormium* crowns. This media provides an ideal growing environment for the young *Phormium* plants, keeping moisture available to the plants without them constantly sitting in water and also allowing good air flow around the roots. This reduces the opportunity for fungal attack particularly in the form of root rots, which are one of the major contributing factors to plant loss in the early stages of container production.

As the plants grow naturally in very open areas they are used to good air movement and relatively low humidity. As soon as the plants are subjected to poor air movement and high humidity (above 70%) problems occur. This is often the case in current nurseries where young *Phormium* plants are planted into large pots in poorly draining, nutrient rich media, and then forced in poorly ventilated polytunnels. This scenario is currently one of the biggest killers of *Phormium* plants in nurseries worldwide as under these conditions the plants are prone to fungal attack, especially basal rots.

Producers would benefit greatly from looking at the plant's origins, and replicating them as much as possible in their nurseries. Two major steps which would dramatically reduce loss rates, which some producers have quoted as being in excess of 40% would be, firstly improving the airflow in the production areas. This would help lower humidity producing much stronger plants thereby improving their survival rates. Secondly by providing the plants with an open media with an AFP of at least 20%, improving drainage, and helping to prevent the conditions of water logging which are ideal for fungal attack.

## CONCLUSION

A better understanding of the plant's requirements, and methods of commercial propagation plus the consumer desire for improved frost hardiness, disease resistance, and more colourful dwarf varieties, offer great potential for *Phormium* in the worldwide horticultural industry. This dynamic foliage plant has a number of possibilities for creative breeders, growers, retailers, and landscapers in the future.

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# Forum: Are Stock Beds Being Abused?©

**Discussion led by Nichola Rochester**

## THE IMPORTANCE OF STOCK BEDS

The range of stock bed types currently in use is broad. Stock beds can be maintained in the open ground, in containers, or current production could be a “stock bed”. Using a show of hands it was determined that 37% have stock beds that provide less than 50% of total production, 63% have stock beds that provide more than 50% of total production, and 17% have stock beds that provide more than 90% of total production. This result showed that taking your own cuttings and the use of on nursery stock plants was significant. A written plan to manage your cutting production and stock beds is an important tool, which many are utilising. The reasons for this dependence on your own stock plants included convenience, flexibility, timing, availability of uncommon taxa, greater certainty about being true to type, reliability, and perceived cost savings. Those that had decreased their stock beds gave reasons of lack of nursery space, time, and cost in maintaining stock beds, improved overall cost control, and management. The impact of future changes to the tax laws concerning asset valuation of nursery stock could also have a large effect on stock beds. A suggestion that liner nurseries could offer a true-to-type guarantee for their product was received by many with interest.

## STOCK PLANTS AND STOCK BEDS

An alternative to stock beds and retaining the ability to take cuttings is the use of production stock on hand as stock plants. Plants in general production have the advantage of high nutrient status, juvenility, and continued turnover. Problems with these stock plants include lower volumes, more limited range of taxa, and the requirement for good planning. The taking of cuttings may be dictated by when plants are timed for sale. Some plants are not suited to containers and the use of production stock plants is not an option. Stock beds have the advantages of high volume cutting production and planning needs to be less precise. Stock beds can be