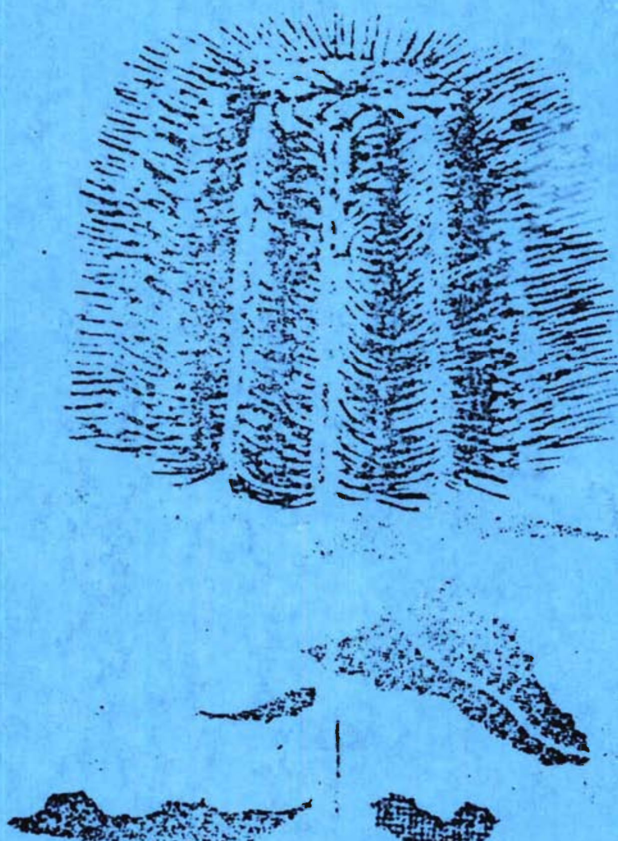
INTERNATIONAL PROTEA ASSOCIATION

SIXTH BIENNIAL CONFERENCE

Perth, Western Australia
22-27 September 1991



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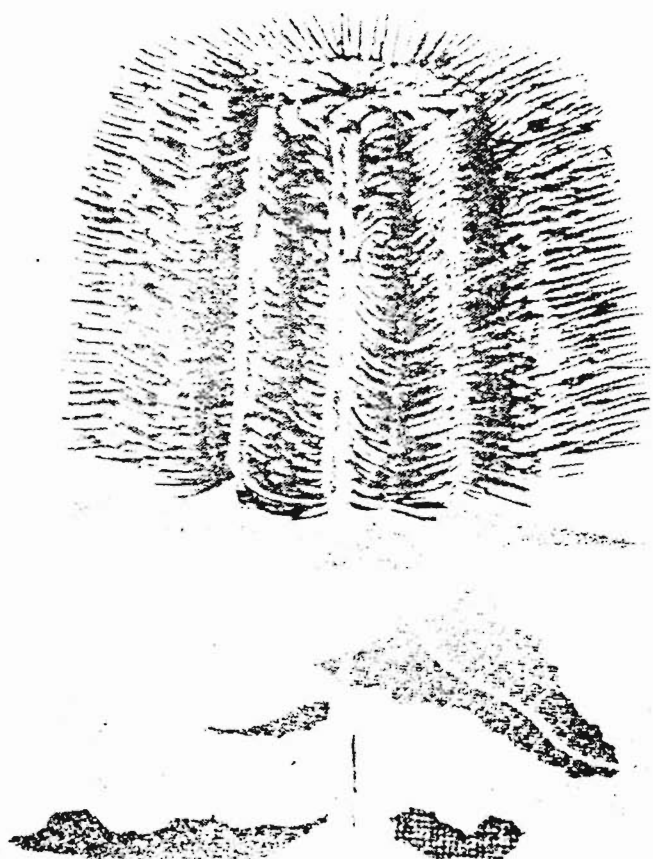

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International Protea Association

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This volume is a pre-Conference publication of the papers to be given at the Conference.

Only papers or abstracts received in time for publication are contained in this volume. They have been published in the form in which they were received and no editing has been carried out.

The Organising Committee is grateful to the authors who made this volume possible by meeting the required schedules so that the volume could be presented to the delegates at the Conference.

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PREFACE

"No man is an island" and no one in the Protea Industry can strive to achieve the highest standards without the benefit of others in the field. This benefit comes in many forms including embracing the latest research, planting new varieties and simply communicating with others in the industry worldwide.

Hence the importance of the Biennial Meetings of the International Protea Association.

This book of Proceedings includes as many papers as possible from the outstanding array of international and local speakers who have been assembled in Perth, Western Australia for the Sixth International Protea Association Conference.

This is the 10th Anniversary of the founding of the IPA and the Programme content is illustrative of how far this relatively new industry has progressed in these 10 years.

Growers need the continued networking of all those in the Protea and Allied Industries to assist them to produce a top quality product that will keep pace with developments in the world Floriculture Industry. Growers need all the assistance they can get to enable them to compete in the tough international arena and to expand their market share.

This Conference goes some way towards achieving these goals.

I would like to pay tribute to my colleagues on the Organising Committee for the Sixth Conference: Kingsley Dixon, Mark Webb, Bob Harington, Gordon Davies and Rose Dower.

They have put much time and effort into ensuring that this Conference is both rewarding and enjoyable.

This Book of Proceedings is a reference book which will prove its worth for many years to come.

I wish all Protea growers success and a sense of satisfaction from their efforts.

With kind regards,

Maggie Edmonds

Maggie Edmonds

President, IPA

AUGUST 1991

CONFERENCE ADMINISTRATION

IPA PRESIDENT AND CHAIRPERSON

Maggie Edmonds

COMMITTEE MEMBERS

Gordon Davies

Kingsley Dixon

Rose Dower

Bob Harington

Mark Webb

Conference Organisers

Promaco Conventions Pty Ltd

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GROWING TO PACKAGING

PROLOGUE TO PROFIT.

By Jack Harre'

Ladies and gentlemen,

The Concise Oxford Dictionary definition of "prologue" is:-
a preliminary speech, poem, or any act or event serving as an introduction. This paper is not an act, event or poem but it is an introduction to the Profitable Production Of Proteas at the basic level, the level I believe this industry must come to grips with before it can make the progress that it must. What I am gong to tell you is not based on theory or crystal ball gazing. It is pure fact based on my observations of where the protea industry is to-day and what it must do to become a vital and profitable part of the international floricultural trade.

In the last two years I have seen protea growing in California, El Salvador, Hawaii, Tasmania, Western Australia, Zimbabwe and of course New Zealand. In the past few years I have also seen them in the Eastern Australia States and South Africa and I have been to Canada, Western, Central and Eastern United States and Europe looking at the markets where these flowers are sold.

In the course of these visits I have seen many hundreds of thousands of proteaceae plants, spoken to hundreds of growers and interviewed a number of persons involved in the international floricultural wholesale and retail industries.

These contacts have repeatedly revealed two problems affecting to-days proteaceae industry and these are:-

i. A miss-match of the product being produced to market demand.

ii. A miss-match of plant variety/variant/clone to the climate where they are being grown.

Whether or not these miss-matches do occur and the magnitude of them if they do occur is almost always the governing factor of whether a grower makes a profit or not.

It is how to identify these miss-matches that is the basis of my "Prologue To Profit".

Later to-day in the happy hour after the formal part of the day is over I will be presenting the sequel to this prologue entitled "Profit From Proteas". In this I will tell and show you how to identify and rectify your problems so you can make your plantations more profitable.

Proteas first showed up in the flower markets of Europe as a flower that was ~wild picked~ in South Africa and sold as a seasonal ~African Wild Flower~ at very low values and consequently low returns to the farmers in South Africa.

In the last twelve to fifteen years there has been widespread development of ~cultivate plantations~ in a number of zones around the world with most of these being based on seedling stock. It is my analysis after seeing many of these that because so many plantations are composed of non-descript seedling stock or poorly selected cutting grown plants and not planted with selected clonal material or even at a basic level of seedlings of defined variants of varieties, that although we are now in our second decade of trading, little progress has been made in developing proteas away from being a wild flower and transposing them into the realms of being a reliable high profile floricultural product which can compete for and increase its share in to-days discerning and highly competitive international markets.

Proteas are to-day still virtually where they were twelve to fifteen years ago. They are still a flower that is regarded with deep suspicion by much of the floricultural trade because of their highly variable quality and supply pattern.

There is absolutely no doubt in my mind that the sub-standard material from these random seedling based plantations is having a depressing effect on the image and values of proteas in the international market place. The product from these plantations falls a long way short in the quality that the high priced markets demand not to mention the productivity needed by growers to survive. Compared to what selected clones can achieve they are poor performers and the profit margin from many of to-days plantations is marginal to survival.

Proteas are capable of much greater things than what has been achieved to-date.

It is a fact in this business of flower production that you will reap what you sow. If you plant rubbish you will harvest rubbish and it is a fact of life that there is very little difference in the quality of a flower that is harvested wild in South Africa to that of a semi tamed flower harvested from a random seedling or a cutting grown plant of poor genetic characteristics growing in a plantation in some other country except that the plantation flower has cost you a lot of energy and money to produce it.

Who ever heard of a commercial crop of roses, carnations chrysanthemums, orchids or almost any other flower being grown from seed that has been collected at random in the wild? These crops are all grown from carefully selected stock which is matched to the climate in which it is to be grown and the product is matched to the market in which it is to be sold.

I ask you. Why aren't proteas?

After seeing tens of thousands of plants and viewing film of some that I have not visited it is my assessment that to-day no more than 15% of the plants in the plantations of some zones around the world are capable of producing a crop which is totally acceptable to the consumers and at the same time be viable for the owners to grow.

This assessment would put California's estimated 400 odd acres at 60 effective acres, Australia's 2000 odd acres at 300 effective acres, and Zimbabwe 600 acres at around 90 effective acres. With South Africa it is difficult to calculate the situation as much of its crop is traditionally grown for and targeted into the low priced mass markets of Europe against a low production costing.

There are two exceptions to this 15% level and these are Hawaii and New Zealand. In both of these zones attention has already been paid to clonal selection. The Hawaiian plantations with their significant plantings of improved leucospermums would now probably exceed 70% effective while in New Zealand, although the total area planted in proteaceae has declined from an estimated 500 acres in the early 80's to about 100 acres to-day, this smaller acreage is about 80% effective.

Ladies and gentlemen, there is a lesson for all of us to learn from the very significant decline that occurred in the New Zealand plantings. It has happened for two reasons and I am going to highlight the reasons of this piece of recent history to you, not because I am a New Zealander and was involved in it but because I know that many of you here and many growers around the world will be able to relate to what happened in New Zealand in the mid-1980,s. I know from my extensive exposure with growers around the world, that many of them are now finding themselves in exactly the same situation as those growers in New Zealand did in the mid 1980's.

Firstly, the New Zealand leucadendron Safari Sunset crop which was a major part of the early 1980,s acreage planted, was found to be non-viable in many provincial areas owing to a high degree of fungal invasion and frost damage. Both of these problems were associated with unsuitable climatic conditions for that particular clone in those particular production areas.

When these problems were coupled to the reality of high transport costs to international markets for a product which was principally on stream for harvesting during the low market demand period (April to August; the northern hemisphere summer) and a very small domestic market (which can be flooded with a few hundred stems a week into any one market), it has resulted in the fact that this clone is now only grown in a few specific provincial areas where fungal and frost problems are not so acute and the crop either matures before or can be held until after the low demand/price period in the northern hemisphere. To-day this product is mostly grown in areas where it can be held for late harvest when the bracts have changed from their none too popular reddish brown beer bottle colour to the very popular rainbow yellow/red/bronze colouring. This change of colour can result in the price paid to the grower trebling with these late harvests in comparison to the low demand and priced April to August sales.

The second reason for a fall off in New Zealand acreage is because growers of the garden variety type of proteas (the seedlings and the cutting grown plants of poor genetic characteristics), quickly fell by the wayside when they were presented with zero and minus returns on cartons of flowers which they had submitted for export but which were only fit for the garbage bin on arrival at the international markets.

At its peak of area planted in the mid 80's, New Zealand was also only 15% effective, and in actual fact New Zealand has already done what most other zones are going to be faced with; that is: get rid of the non viable plants and plantations.

In those early years of development New Zealand growers experienced all the classic problems that many international protea growers are now experiencing and these were:-

* without any prior experience in the production or marketing of the crop it planted a mono crop which just happened to be Safari Sunset;

* it planted big numbers of Safari Sunset which in many provincial areas were miss-matched to the prevailing climate

* because in many provincial areas Safari Sunset produces the bulk of its crop during the low market demand period of the year it was therefore also seasonally miss-matched to the seasonal market demand

* because the product was the wrong colour at the wrong time of year for the New Zealand target markets it was also miss-matched to those markets during it's main season of availability because of its colour

* because it was on stream during the low demand and therefore low priced periods, the value of the product was often only equivelent to or less than the freight cost to the international markets

* there was a very small domestic market to absorb the volume of product that could not be viably exported.

With the other proteaceae varieties of poor genetic origin it was found that:-

* much of it went black in transit

* it was inconsistent in quality, style and colour and was therefore down graded by the high priced markets

* because of the blacking and inconsistent quality the value received was too low to support the harvest, packing and transport costs.

Have any of you people here ever experienced any of these problems? If you have and you want to continue to grow proteas and make a profit, then you are going to have to do something about it the same as those in New Zealand did. If you haven't experienced any of these things it is a miracle.

Ladies and gentlemen if you are to progress from the position of where you are to-day, that of being the growers of a semi-tamed wild flower, and you are to move into the realms of being the producers of a high profile exotic floricultural product, you must, both as an industry and as individuals do something about the quality and supply pattern of your production.

To improve your level of production you must identify and select the best plant material that is now in your plantations or available to you, You must then propagate it and populate your plantations with those elite clones and then from those plantations efficiently and consistently produce a high quality end product. If you don't you will remain in that semi wild flower slot forever with returns that are marginal to survival.

So we can define what must be done I must now briefly turn your attention back to the cultivated plantations that have been established around the world in the last twelve to fifteen years and analiyse what is being produced from them.

We know that most of these contain a very high percentage of plants that are from a seed base. I am not completely against seed based plantations, they do have their place in supplying the less sophisticated lower priced markets provided your production cost structure is matched to those lower returns. It must also be conceded that it is from these seedling plantations where we will get our new cultivars from to upgrade our vegetatively based plantations. However what I do say to you here and now, is that at this time, there are sufficient unidentified promising plants of every variety that I can think of that are out there in these seedling based plantations to keep this industry going with new cultivars for a long time. Growers in every production zone around the world have valuable plants in their seedling plantations that are there just waiting to be identified.

Admittedly there are some plantations which have been established with seedling plants of certain specific variants of some varieties that are currently producing a more or less acceptable commercial crop for specific slot markets such as the less discerning local domestic areas of trade or in the case of some varieties for some international markets but it is a fact of life that as each year passes and the market becomes more selective in what it will accept and as the economics of production continues to tighten, it will become more and more difficult to sell the product at all from many seedling or poorly selected vegetatively based plantations and for the grower to make a profit.

You may ask, what is the matter with flowers from these plants? Well my answer to you is that you should go and have a look for yourself at the quality of the flowers in the up-market areas of trade where you are hoping to and need to sell your product for you to remain viable. All other flowers in these markets from alstromeria to zanderdeicias are perfect in every sense every time, many of yours are not.

In the past ten years a lot of expense and dialogue as been expended by various protea grower organizations on ~The Marketing Of Proteas~. In fact, this subject has often dominated the thinking of those persons organising conferences. Ladies and gentlemen, in my book many of you don't yet have a product that you can market, all that you have is a conglomerate of herbage you can sometimes sell.

What does your target market, the fashion and top shelf areas of the market place think of our product? Well if you ask them the answer is not too much a lot of the time.

Why? You may ask.

Because in general terms your flowers when compared to other flowers such as roses, carnations, chrysanthemums, and orchids, is too inconsistent in quality, form, colour and season of supply, everything that the consumer evaluates and measures when setting a price they are prepared to pay for a product.

I understand that as an exercise at the 1989 IPA conference in San Diego, cartons of proteaceae product were sent from various production areas around the world and opened in front of the delegates. I also understand that there were a few red faces around when those cartons were opened, and this ladies and gentlemen is what your customers, the end consumers, the person who you are expecting to pay you money for your flowers could be faced with when they receive a consignment from you. Would you buy flowers that were less than perfect and pay big money for them. I think not!!!

To achieve success there are two aspects of our industry we must consider and work on. Each one is inter-related to the other and they both relate to the miss-match of product to market demand and the miss-match of plants to climate that I mentioned at the beginning of this paper.

First there is the consumer demands, that is the physical properties and make up of the flower as presented to the consumer which include such things as vase life, stem length, colour and so on, all those things that are measured visually.

Secondly there are the needs of the producer which cover the health and productivity and therefore profitability of the plant that is going to produce that perfect flower for the consumer.

As I will be referring back to these summaries a number of times in my papers I have made arrangements for you to have them in a printed form so you can refer back to them, not only while you are here at this conference but for the rest of your days as a grower, for if you don't heed what is contained in the consumer and the producer parameters, then in the long term I believe you won't succeed.

In the remainder of the time left to me now I am going to outline to you the reasons for setting these parameters and this-afternoon I am going to demonstrate to you how to identify and select those plants that match these parameters.

The consumer parameters come first because as I said a few minutes ago, they are buying, they are paying, they must be satisfied. Remember, no sale - no profit.

What constitutes the level of perfection a flower must achieve in the consumers eyes? Remember they are only interested in the flower and not the problems you the grower may have to overcome to produce what they want. Those are your problems and are covered in the producer parameters.

There are four things that a florist, commercial flower arranger or end user demand of the flowers. These demands are more or less universal at the fashion and top shelf level of trade, which are the ones under consideration here, they are:-

THE CONSUMER PARAMETERS
These are in order of importance:-

* a satisfactory vase life.
* a near straight stem.
* a stem length that is as long as possible, ie. not less than 45cm. for flowers and 65cm. for foliage. This will vary a little between markets.
* a flower/foliage must have a shape, form and colour which is visually appealing and be acceptable within seasonal, fashion or ethnic demands.

Having defined these parameters it is now necessary to determine what levels of each one is acceptable to the consumer bearing in mind that the level of quality demanded by the consumer decreases as you come down the price scale and when you get to the mass market price, (such as in the European street vendor range) the above criteria are not of any great consequence provided the price is acceptable to the buyer. However the price being offered for mass market material is not usually acceptable to the producers of cultivated proteas.

If we look at the consumer demands in order of importance, we see that a satisfactory vase life to the final end user, that is the condition of the flower at the point of presentation and its subsequent time span of usefulness is number one to them. Because it is the number one point to them I am going to investigate it in some depth here because if you don't get this right in your production the rest doesn't matter much anyway because you just won't have a market. If your flowers are a degenerated mess on arrival at the wholesalers he won't accept them, if they are less than perfect at the final point of sale, the consumer either won't buy them or alternatively will not pay the price you need.

Ladies and gentlemen, you as growers have no choice. You must aim to present a perfect flower to the consumer every time or your returns will be down graded.

The period of vase life required by the consumer can vary depending on the end use. For instance if the flowers are purchased for use in the home the buyer would expect a minimum of a week or ten days vase life where-as if the flowers were being used for a wedding, anniversary etc. then, provided they were perfect on that day, most buyers would be reasonably satisfied but note the point that the flowers must be perfect for that day.

For general consumer acceptance we should aim for always presenting at the point of sale a perfect flower that has an absolute minimum of one week and preferably two weeks vase life. Most flower dealers would be apprehensive of handling any product that was not perfect or near perfect at the point of sale and that in addition it would not give satisfaction to their clients for at least a week after it left their premises.

In the flowers life-span that I am discussing here, we must also include in this parameter not only the expected vase life but also the ability of a flower to travel from your plantation to the wholesalers or retailers premises and then still be up to these standards when they are finally sold to the end consumer.

Many of you are producing flowers that need stay fresh in a carton for at least three days and often up to five days and then still give a satisfactory vase life to the end consumer. This can add up to a period of two weeks or more from your bushes to the consumers dust bin. It's a long time to stay fresh and bright.

It is a proven fact that many flowers can give a satisfactory static vase life, that is they are O.K. in a vase life test when they are harvested and put straight into water, but when they are harvested, put through a standard pack house procedure and then put into carton for the three day trip to their destination, they may either degenerate during transit or very soon after they are re-exposed to the air and they are then unacceptable to the consumer.

One of the principal areas of investigation of plants I have carried out over the past twelve years is the ability of the flowers from any particular clone to sustain the terrors of international travel and then still give satisfaction to the consumer. In my selection programmes I have had to discard many clones that have been satisfactory for twelve to fifteen days in a static vase life test but were repeatedly a degenerated mess after three days in a carton or soon after.

Ladies and gentlemen, for the past 12 years my philosophy has been;-

IF IT WON'T TRAVEL DON'T PLANT IT

In 1979 I was in Europe, full of hope and a mass of dash looking at the possibilities of our N.Z. protea products in the Dutch markets. I had arranged for a carton of flowers and foliage to arrive at a certain wholesalers in Alsemeer on the day of my visit there. I was going to show these Dutchies just what proteas were all about.

I picked up a knife and cut the ties on my box of flowers, opened the lid and behold, inside was an assortment of flowers and foliage in various stages of decomposition probably pretty similar to that which was in those cartons in San Diego a couple of years ago.

However the most important thing to me that day was the fact that there were three flowers each of seven different clones of p neriifolia which had been harvested from my bushes back home in N.Z. Of those seven clones, one was in perfect condition, just as if they had been picked from their parent bush. Two others were near perfect and I was proud to own them. Of the remaining four, two were of a standard similar to what the street vendors were selling in Europe and I was not quite sure whether they were semi-dried flowers or semi-dead flowers. The remaining two were garbage.

I was shattered but there was a lesson to be learnt from this and this was that some plants have the genetic characteristics to produce a flower that will survive travel and some don't. This observation that day set the level of all my future selection programmes. If it wont travel it is no use growing it.

In the light of this, if we take p. neriifolia as a bench mark which are after all the most traded flower of the protea group, I have identified by research that on an average in my climatic location, the flowers of only one in fifteen seedlings plants will sustain travel and then consistently give a satisfactory vase life.

Further to that you will find that only about one in fifty seedlings (that is one in three of those that will travel) will also produce what the ~top-shelf~ market terms an acceptable flower in stem length, form, shape and colour.

As we progress through our investigations into what an average seedling plant can produce as a salable flower, we find that only one in five hundred plants do everything right, that is - the flower travels well and then gives a satisfactory vase life, has an acceptable stem length, colour and form, that it can produce a crop at the optimum time of the year to command top dollars in the markets that are accessible to you and finally it is a plant that is long lived, resistant to your local strains of fungi, nematodes, insects, sunlight and frosts and so on, and finally that the plant you are choosing as the basis of your production is capable of producing a bountiful crop every year under your management.

And this brings us to the production side of things. To be a viable prospect for you the producer to consider even growing, a plant must measure up to the following specifications and these I call the producer parameters.

THE PRODUCER PARAMETERS.

Those which concern all growers are:-

* all of those factors as set out for the consumer, ie. stem length, colour, form etc.

Plus the following:-

* resistance to leaf blacking during and after transport.
* resistance to fungal invasion above the ground
* resistance to fungal invasion below the ground
* resistance to by-passing of flower heads.

* productivity per unit.
* season of harvest in relation to accessible market demand.

Those that are additional to the above and are specific to particular climates, locations or management regimes are:-

* tolerance to sub-zero temperatures.
* tolerance to high temp/low humidity.
* tolerance to high light levels.
* resistance to nematode invasion.

Ladies and gentlemen.
You can see that by the time a plant and its product have been evaluated for all these things that many fall by the way-side because they just do not measure up to these parameters.

If you doubt me on these figures then I urge you, that when you get home you go out into your plantation of seedling proteas, or perhaps some of your vegetatively propagated plants, and look at them really critically and compare their performance and their product against what I have outlined to you in the past fifteen minutes and when you take into account all of these points you will begin to come to terms with the immensity of what you must do to become a professional and profitable grower of proteas. I know that at this moment that at least some of you will be focusing your thoughts on a very few individual plants in your plantations that do most of these things right and that the percentages I have quoted you on this are not far out.

It is up to you to research your own production base and evaluate your successes and failures and if you feel that there is room for improvement in the quality of the product you produce and/or the economics of your production, then I suggest you take time to listen to the second paper on this subject later to-day. In it I will demonstrate how to go about your own evaluation and selection programmes of matching your flowers and plants that produce those flowers to the parameters I have outlined to you. You will then be able to identify those plants that are there in your own plantations. In many cases the best stock for your climate and market is there right now awaiting you. Let me show you how to identify it.

For those of you who do not choose to select your own superior clones or perhaps do not already have a plantation of seedlings to select from and therefore must purchase your plants, the paper this afternoon will also be of value to you, as it will outline also what you must seek in the stock you choose to plant and show you how to investigate the characteristics of the plants that are available to you.

Ladies and gentlemen, it is over to you.

ESTABLISHING & MANAGING A SMALL PROTEA PLANTATION IN AUSTRALIA

DAVID MATHEWS
PROTEAFLORA ENTERPRISES PTY. LTD.
MELBOURNE, AUSTRALIA

This paper covers aspects of setting up a Protea plantation, plantation management and flower harvesting for a small viable production site (approximately 4-10 Ha) in Australia.

SETTING UP

Protea growing like any other production of goods and services needs to be customer oriented if it is to flourish. All aspects of growing must take account of market requirements. So before we begin the first steps of setting up our new plantation (or expanding an existing site) we need to understand our customers needs.

The Market

1. Local or overseas.
2. Colour preferences.
3. Time of peak demands.
4. Capacity.
5. Quality perceptions and requirements.
6. Packaging preferences.

The Site.

The site provides the growing opportunities and sets the limits to what can be grown. In an ideal situation the site will be selected to grow the species required by the market. Economic factors will influence the location of growing and favour sites close to the market.

Desirable Site Characteristics

1. Drainage suitable: Soil drainage to 60cm. Slope drainage to avoid rising water table (particularly where soils are shallow).
2. Soil: well drained and pH5 to pH 6 for most species.
3. Nutrients: Low levels of phosphorus. Below 15ppm is usually suggested. Low-moderate levels of nitrogen and potash and desirable.
4. Water: a source of clean irrigation water low in salts is essential in most situations, for most species.
5. Frost: There is a wide tolerance variation between species but a frost free site is preferable. Most species tolerate light frosts to - 3°C.
6. Access to Markets/Proximity to transport: Freight can be a major cost and significantly effect returns.
7. Humidity: Air movement is essential.
8. Wind: moderate wind but not extreme.
9. Disease: Check for Armillaria, Phytophthora and Nematodes.
10. Shade/Sun: All day sunshine is preferred by most species. Late afternoon shade is tolerated.

Species Selection.

There are three factors to be considered when selecting species:-

Market requirements
Growing conditions
Management constraints

Each of these factors is equally important and whether they are fixed or variable will depend on each situation.

Market Requirements. Understand the requirements of the market you will be supplying. e.g. Europe take few flowers between June & September, local florists prefer a wide range of material, special days, occasions require more flowers e.g. red flowers are in demand during December, etc. Clonal selections have more predictable performance characteristics.

Growing Conditions. Aim to grow species that will thrive on your site. If you have any particular features try to take advantage of these e.g. late/early flowering.

TABLE 1: SPECIES, SOIL AND FROST TOLERANCE

	HEAVY SOIL	ALKALINE SOIL	SANDY SOIL	FROST
Protea	cynaroides repens neriifolia Frosted Fire	obtusifolia repens (m) neriifolia (m)	'Pink Ice' repens	'Pink Ice' repens (winter) magnifica
Leucadendron	laureolum orientale salignum Silvan Red Red Devil Safari Sunset	coniferum Silvan Red (m) laureolum uliginosum	most species	laureolum Silvan Red salignum Red Devil Safari Sunset
Leucospermum		patersonii	cordifolium most species	reflexum
Banksia		prionotes ashbyii most species (m)	most species	burdettii

(m) = moderate tolerance

Management Constraints. Select species with flowering times that fit into your work program or labour availability.

TABLE 2:FLOWERING TIMES (Average times, Victoria, Australia).

MONTH	SPECIES
January:	Banksias baxteri, speciosa, burdettii Protea aristata and repens.
February:	Banksias baxteri, speciosa, burdettii, prionotes, victoriae. Protea repens, Lcd. 'Red Devil'.
March:	P. repens, P. cynaroides, P. neriifolia, P. 'Pink Ice', Lcd. 'Silvan Red', B. prionotes, 'Red Devil'
April:	As for March plus P. longifolia, P. obtusifolia, Lcd. salignum, Lcd. tinctum
May:	As for March and April plus B. hookeriana, B. menziesii.
June:	P. neriifolia, P. 'Pink Ice', Lcd. laureolum, Lcd. macowanii, Lcd. 'Silvan Red', B. hookeriana, B. menziesii.
July:	As for June
August:	P. neriifolia, P. 'Pink Icè', Lcd. comosum, Lcd. daphnoides, Lcd. salicifolium, Lcd. 'Silvan Red', B. coccinea, B. hookeriana, B. menziesii
September:	P. compacta, P. magnifica, P. neriifolia, P. obtusifolia, P. scolymocephala, Lcd. comosum, Lcd. coniferum, Lcd. daphnoides, Lcd. eucalyptifolium, Lcd. gandogeri, Lcd macowanii(f), Lcd. orientale, Lcd. salicifolium, T. speciossisima, D. formosa, D. polycephala, B. ashbyii, B. coccinea, B. hookeriana
October:	As for September plus P. cynaroides, P. eximia, P. grandiceps, Lcd. conicum, Lcd. discolor, Lcd. platyspermum, Lcd rubrum, Lcd. tinctum, Lcd uliginosum, Lsp. cordifolium, Lsp lineare, Lsp. reflexum, Lsp. 'Firewheel', B. grandis
November:	As for October plus Lcd. floridum, Lsp. tottum, B. speciosa
December:	**P. eximia, P. grandiceps, P. magnifica, Lcd. conicum(f), Lcd discolor(f), Lcd coniferum (f), Lcd orientale(f), Lsp. cordifolium, Lsp. lineare, Lsp reflexum Lsp tottum, Lsp. 'Firewheel', Lsp vestitum, B. ashbyii, B. grandis, B. occidentalis, B. speciosa.**

Preparation prior to planting

Design. Prepare a general plan for your whole plantation and then work out whether you develop in stages or complete it with one planting. This plan should include:-

- row layout
- traffic flows and roads
- packing shed
- irrigation (consult an expert in this field)
- fencing
- drainage patterns (storm water)
- hygiene controls

Site Preparation. Correct preparation before planting will save time and money in the long term. The following sequence is suggested:-

(1) Peg out planting rows and access roads
(2) Rip planting rows (if necessary)
(3) Cultivate planting rows
(4) Mound (if necessary)
(5) Add humus (if necessary)
(6) Install main water lines
(7) Construct access roads (if needed)
(8) Lay weed mat
(9) Lay drip irrigation

Plant Selection. In general, selected stock grown from cuttings is preferable to seed-grown material. Where species have been hybridised to give further improvement, these hybrids may be preferred (if suitable for your location).

Planting. Autumn planting is preferred in winter rainfall areas so that the root system establishes during winter. Where frost is a problem Spring planting may be advisable.

Steps to follow:-
- distribute plants along rows
- cut weed mat
- dig hole
- remove plant from pot
- place in ground (pot soil at ground level)
- replace weed mat, use gravel to hold it down
- water in as soon as practicable (within the day)

(approx planting rate - 250-300 per person per day (150mm pots).

Follow up Maintenance

Clear a narrow strip of weeds next to the weed mat using herbicide.
Slash between rows.
Irrigate as required. Depends on rainfall, temperature and soil type.

PLANTATION MANAGEMENT

Once the selections and layout decisions have been made then the methods of plantation management become critical.

Important factors in a plantation management programme are:

- Pest Control
- Disease Control
- Irrigation
- Nutrition
- Pruning
- Weed Control

Pests

Pests are those animals which damage the flower crop by reducing the number or quality of saleable blooms. Common pests are spiders, caterpillars and scale. Identify which pests you are dealing with before selecting and applying any treatments.

Spiders. Spiders are generally unacceptable to florists and certainly must not be present in export shipments. Spiders do assist in controlling the level of scale in the plantation so care does need to be taken in managing the spider population. Spray Ambush 4-6 weeks prior to picking a crop and immediately prior to picking OR treat flowers after picking - dipping or gas.

Caterpillars. These grubs damage the growing tips of Leucadendron and occasionally cause leaf damage on Protea, Banksia and Waratah.

Control:- DIPEL, applied at the stage when caterpillar eggs are hatching (monitor weekly).

- AMBUSH, applied during the growing season every 4-6 weeks (October-March).

- CARBRYL, applied during growing season every 1-2 weeks.

Scale. Scale is particularly serious where import requirements are stringent. Scale must be prevented in the plantation as it is not viable to remove it by post harvest treatments.

Prevention measures include pruning and thinning, and weed management which allow air movement through the plant minimising scale growth. Spiders are scale predators so high spider populations will also limit scale.

Eradication measures include:
Malathion - sprayed April/May and October/November when the scale are in their juvenile or crawler stage.
White Oil - sprayed during the cooler months on mature scale.
Supracide.

Disease Control

Disease identification can require expert analysis. In each State the Department of Agriculture can provide this service. The following may be helpful in identifying and treating problems. The controls are measures we have seen used successfully, they are NOT recommendations.

Root Fungi.

Phytophthora cinnamomi (P.C.)

Symptoms - plant becomes slightly yellow due to water stress. P.C. is a water-borne fungus that attacks the fibrous root system of a plant.

Control - "Ridomil 50G" spread at a rate of 10g/bush, Aliette sprayed at a rate of 3.75g/litre, twice/year (or may be used as a drench).

Armillaria

Symptoms - very similar to P.C. It can be distinguished by white mycelium under the bark at ground level. The fungus lives on old buried pieces of root.

Control - only possible method is to remove all old infected roots and fumigate ground.

Nematodes

Symptoms - gradual yellowing of leaves. Mainly occurs in light sandy soil.

Control - Nemacur or fumigation.

Leaf and Stem Fungi.

Botrytis

Symptoms - mainly affects Leucospermum. Leaves turn grey on the tips, then gradually shrivel.

Control - Rovral 1g/litre

Colletotrichum

Symptoms - affects only Proteas. New soft growth turns black.

Control - Octave 2g/1.

Drechslera

Symptoms - affects Leucospermum. Leaves develop red/brown streak, gradually curl and then shrivel up. It spreads into the stem and the plant collapses.

Control - Rovral 2g/litre or Octave 2g/litre.

Scab Disease

Symptoms - corky stem and raised brown spots on the leaves.

Control - Octave 2g/litre, immediately after wet weather, every 2 weeks.

Leaf Spotting (bacterial). Only significant on two species. It mainly occurs in the summer.

P. cynaroides - the leaves develop brown indentations with a watery or red halo.

P. magnifica - the spots appear as brown indentations with a red halo.

Control - Copper oxychloride at a rate of 3.5g/l.
Maximum twice per year.

Leaf Spotting (non-bacterial). Spotting can be fungal. These spots have raised red scabs. This damages the appearance of the cut flower. Treat with Benlate to prevent spread to new growth. (P. cynaroides and P. magnifica).

Spotting may also be caused by chewing insect pests - treat with Ambush.

Irrigation

Irrigation is essential to most Protea plantations. Where rainfall is over 1100mm per year irrigation may be needed only to establish the plants and supplement during very dry periods. In areas where rainfall is below 1100mm per year irrigation will play an important role in producing top quality blooms.

The quantity of water required will depend on soil types, age of plants, evaporation rates, and species planted. It is therefore not possible to give a general water requirement. It should be noted that P. cynaroides and Serruria florida have higher than average water needs.

Water quality is important. Irrigation water should be low in salt, free of phytophthora and must not have particles large enough to block the outlets.

Selection, design and layout can be advised by companies selling and specialising in irrigation equipment.

Nutrition

Proteas have a very efficient root feeder system and therefore require lower than average level of nitrogen (N) and potash (K) and much lower levels of phosphorus (P).

Before planting it is necessary to test soil nutrient levels particularly phosphorus. It is unusual to require additional nutrients at the planting stage but there may be excess phosphorus in areas which have received regular applications of superphosphate.

Established plantations may require additional nutrients, particularly those in the poorer sandy soils. A general fertiliser, low in phosphorus is usually recommended but each soil type and species will have specific requirements. The quantity and frequency of applications will need to be worked out, probably by trial and error. Fertilisers should be applied in spring and early summer.

Pruning

Pruning is essential for successful commercial Protea cultivation. Pruning is undertaken for the following reasons:-

To clear the area around the base of the plant which improves weed and pest control measures.

To establish a strong framework.

To limit the height of the plant for ease of picking and minimising wind damage.

To control flower stem length.

To increase productive life of the bush.

To thin bushes giving better pest and disease control.

To influence flowering times and flowering patterns.

Weed Control

Each region and soil type has its own weed problems and so this discussion must necessarily be generalised.

There are three major techniques of weed control.

- Mulch
- Pre-emergent herbicide (germination suppressant)
- Herbicide (weed killer)

Mulch - a number of options are available.

Weedmat - woven plastic mat allows air and water to pass through but prevents weeds. Manufacturers claim about 5 years life. This is a very economical method which would appear to be effective.

Straw - excellent mulch, some problems with weed growth from seeds in straw. Effective when used with pre-emergent. Requires frequent replacement, more costly than weed mat.

Other organic mulches eg. leaves, newspaper, chips (bark or wood).

Pre-emergent herbicides - we have used Casoron G. (in granular form) which, applied at the correct rate is effective. There is a range of pre-emergent herbicides available and it is essential that you select the right one for the weed to be controlled. At the same time test to see that it has no adverse effect on the Proteas.

Herbicides some common ones used by Protea growers include: -

Roundup - kills most weeds (and Proteas too if it gets on the leaves!). Systemic.

Triquat - knock down spray, kills annuals without a persistent root system.

Equipment for Plantation Management

The major activities in a plantation are initial planting, pruning, flower picking, grass cutting and spraying. The following (or similar) equipment is essential to carrying out these tasks efficiently.

Tractor. A smaller tractor, approx. 20-25 H.P. gives sufficient power and allows closer row spacing. Use 4WD on steeper properties.

Spray equipment. Either linked to tractor or tow behind. Those units attached to the tractor are more manoeuvrable. The trailer units will carry more spray liquid for a given size tractor so there is less time used in refilling. This is an advantage in larger plantations.

Slasher. Larger ride on unit or tractor attachment.

Secateurs. Sharp and of good quality.

FLOWER HANDLING

The handling methods outlined are those required of growers supplying flowers to Proteaflora. Each market will have its particular requirements but those listed are generally applicable.

Research into post harvest handling of Protea is in its infancy and treatments and techniques will change as more is learnt.

Harvesting

When are Flowers Ready to Cut?

Genus Leucadendron. The Leucadendron has both a female and a male flower occurring on separate bushes. The female flower develops into a cone which contains seed.

The flowers (both male and female) are surrounded by leaves (bracts) which colour and take on the appearance of 'petals'.

The male flower is made up of a pollen bearing centre which "breaks open" starting from the base of the pollen centre and it continues until it is covered with pollen. The time to pick this is just before or just after the pollen presenters begin to break open. No more than 25% should be open, otherwise the life of the cut flower is considerably shortened.

The female flower is different. It is a seed bearing cone which develops over a period of two or three months and can be picked at any stage during this period. Some are beautiful as the leaves surrounding the flower become coloured.
eg. laureolum
'Silvan Red'
salignum
floridum

Others are more useful when the seed cones have developed.
L. salicifolium after 3 months
L. conicum and macowanii after 2-4 months (the cones are red)
L. galpinii after 4 months (the cones are silver).

In some species the bracts change colour a number of times. eg. tinctum, orientale and 'Silvan Red'. They are useful at each of the stages of colour change.

Leucadendron also offer a wide range of types of foliage. The foliage of many species can be used at any time of the year for 'fill' or 'background' by florists. Ensure that growth tips are not soft, as this wilts soon after picking.

Examples of foliage are:
L. salicifolium for large fine leafed branches
L. galpinii for mauve/grey foliage
L. platyspermum for yellow green foliage
L. conicum for a grey/green/pink foliage
L. argenteum for large silver foliage
L. xanthoconus and L. uliginosum for silver foliage

Genus Protea. Proteas are picked, with some exceptions, when they are just about to open. This we will call the 'soft-tipped' stage, when the bracts still cohere but have loosened.

* For protea neriifolia, repens, Pink Ice, longifolia, the bracts should be just beginning to part.
* Protea grandiceps and magnifica should be picked just before or just as the bracts begin to reveal the flower mass which they surround.
* The broad-leafed protea cynaroides which flowers in summer should be left until the first few florets on the outer ring of the flower mass begin to part.
* Protea aurea, lacticolor and mundii should be picked in pencil form (in bud) when the top of the pencil is showing colour and loosening.

Leucospermum. The pincushions are picked as their styles begin to open. The aim is to maximise colour, facilitate packing and achieve longest vase life. To achieve this most are picked when about 50% of the styles are open. Styles usually open first on the north facing side.

TABLE 3: PERCENTAGE OF STYLES OPEN FOR PICKING

SPECIES	EARLIEST PICKED AT THIS STAGE FOR EXPORT AND PACKAGING	LATEST
Lsp. cordifolium	15%	80%
Lsp. vestitum	40%	90%
Lsp. firewheel/ Caroline	70%	100%

Banksias. Banksias are ready for picking when the first few rows of styles have uncurled. Dryandra are similar. There should be no more than 30% open.

Telopea. These are similar to Leucospermum but they are ready when between 2% and 50% of the styles are uncurled. Pick as early as possible for export.

The minimum frequency of picking would be twice a week, irrespective of size of plantation. In the hot months, November to March, it may be necessary to increase this to three times a week. This will depend on weather conditions, and species being picked. The number of blooms to be picked will determine the labour force needed. Pick repens daily.

Factors affecting the life of cut flowers

Protea flowers last very well and are readily transported. This is one of their major advantages when compared with other flowers. This great advantage should not be taken for granted and it is important to understand the factors that do affect vase life so that Proteas gain their maximum advantage on the flower markets.

The genus Protea presents the greatest challenge - in particular, leaf blackening will occur on many species if handled incorrectly.

Tips for improving vase life include:-

1. Selection of good genetic material when planting.
2. Cooling at high humidity.
3. Use of an appropriate pulsing solution.
4. Time out of water/pulsing solution.
5. A sharp, clean cut when picking, and stripping of bottom leaves.
6. Clean water.
7. A cool room with lighting
8. Clean buckets/containers
9. Packing and cool rooms free of ethylene gas.
10. Dry packing of all Protea except Leucospermum.
11. Time held before despatch minimised.
12. Care in general handling.

With the exception of material selection, these factors are equally the responsibility of grower, wholesaler and florist. In the U.S.A. this joint responsibility has been promoted under the slogan "The Chain of Life".

Selection of Material. Selection programmes are being undertaken to find plants/flowers with desirable vase life characteristics, particularly P. compacta, neriifolia and repens with long lasting leaves. Proteaflora has released Pink Ice and selections of neriifolia with better vase life.

Cooling at High Humidity. Cool rooms should be kept between 1°-4°C and a humidity of at least 80%.

Preservative Solutions. There are many theories and formulations. At present we add 10 grams of granulated swimming pool chlorine to 100 litres of rainwater.

Flowers should be held in solution for at least 6 hours before despatch.

N.B. Buckets should be about 1/3rd full and topped up regularly, especially in summer. Preservative should be discarded after one use.

Time out of Water. Stems dry after cutting making it more difficult to absorb water. Ideally stems should be placed directly in water when cut or recut if out of water for more than about one hour.

Cutting and Stripping. Stems should be cut cleanly, with a minimum of stem crushing. Use a very sharp pair of secateurs with a scissor-cutting action.

Leaves should be stripped cleanly from bottom 1/3 to 1/2 of stem. (in particular Proteas). Leaves should not contact water in the bucket as this promotes leaf blackening, bacteria build up and reduces flower life. It is often not necessary to strip the leaves of Leucadendron.

Clean Water. Total Dissolved Salts should be very low and water should be clean. Rainwater is preferable.

Cool room Lighting. Fluorescent lighting has been found to slow down leaf blackening. Further experiments are being conducted in this area with good results.

Clean buckets/containers. Use a chlorine based cleaner eg. White King, Sodium Hypochlorite to rinse buckets after each use.

Ethylene Gas. Specific research on Proteas is currently being undertaken. Avoid storage with fruit and vegetables and do not keep dry and fresh flowers together. Keep packing shed clean of old stripped leaves etc.

Dry Packing. Genus Protea leaves blacken more rapidly if packed wet. For Leucadendron, Banksia and Telopea it is less of a problem, although mould can occur if packed wet. Leucospermum are preferably packed slightly moist.

Time held before Despatch. The grower should hold the flowers for no more than 24 hours (less in summer if there is no coolstore). The earlier that the flower is delivered to the final purchaser the longer the vase life.

General Handling. All Proteas do bruise if handled roughly. When delivering flowers to the next point of sale, either in buckets, hobby bins or boxes, care should be taken to pack firmly but not to squash flowers together. If too loose, the flowers can damage each other as they are too free to move in the container. If too tight, leaves and flower heads can be crushed. If packed in boxes, place layers of absorbent paper between layers of flowers to avoid stems damaging flower heads in a lower layer and to minimise moisture.

Grading and Standards

In the flowers that we handle, we are aiming to:-

* offer a consistent product
* ensure flowers have a satisfactory vase life
* provide flowers with those characteristics required by the buyer

These aims influence our guidelines on grading and standards on quality.

It is the growers' responsibility to grade their flowers. This will involve sorting out those that are unacceptable and the remainder into the required grades.

General Guidelines on Grading

Key factors in grading include the following (in order of importance):-

* Quality of flower head and leaves;
* Stem length;
* Degree of bend in flower head and stem;
* Degree of openness of flower.

Flower head Quality. Flower heads should be unblemished on the top 1/3 of the bloom and be cleaned of cobwebs, spiders etc. Leaves should be healthy, not spotted, yellow or eaten. Only unblemished, well developed flower heads can be eligible for 'choice' grade.

Stem Length. Stem lengths are standardised by wholesalers to aid handling procedures. Minimum stem lengths are set to reduce damage to flowers during handling, particularly in buckets, hobby bins etc. They also relate to the aesthetics of the ratio of flower head size to the stem length.

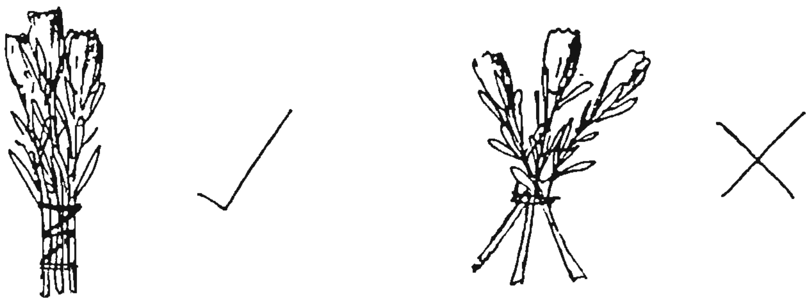
The table below sets out minimum stem lengths for Proteaflora's flower purchases of CHOICE and STANDARD blooms. In a CHOICE grade, with a longer stem, more flexibility is available to the florist in using the flower. Note, however that in the grading, a long flower stem is one factor only in determining whether a flower is Choice quality. A maximum length of 1000mm is suggested - beyond this the flowers are difficult to handle.

Bend in flower head/stem. Where the angle of the flower head is more than about 30°, the risks of damage during handling are greater. They do not present well in a bunch, nor do they pack well singly in a box. Ultimately they restrict the use to which a florist can put the flower in an arrangement.

Degree of openness. Section 1 sets out when flowers are ready to pick. If flowers are harvested later than suggested in these guidelines the end result is that of a flower with little vase life for the final purchaser to enjoy and a flower that is more easily damaged through normal handling procedures. Risk of damage to varieties such as P. repens or Lsp. cordifolium increases substantially the more open the flower.

Bunching

Protea and Banksia. For Protea and Banksia flowers, where bunching is required (see Table 4), bunches should be secured as shown - banding starts from where the leaves have been stripped to, to the base of the stems. This ensures the bunching process will not damage the leaves and that the bunch is 'stable' and will not spray apart.



Proteas for export usually are not bunched.

Leucadendron. Leucadendron may be bunched as for Proteas and Banksias making sure that the resulting bunch is 'stable' and will not spray apart when handled.

Number of stems per bunch. Table 4 (below) sets out numbers of stems per bunch for Protea and Banksia.

For Leucadendron the number of stems per bunch for single stemmed flowers has also been specified. For Leucadendron multiflora and multicones, the number of stems/bunch will need to vary to give an average sized bunch. The number of stems/bunch is a rough guide only, due to the variability in width of stems, bushiness of foliage and length of stems being produced by different bushes of one variety. An average bunch diameter of 45 to 55mm is suggested.

TABLE 4: GUIDELINES ON GRADING STEM LENGTH AND BUNCHING

VARIETY	UNIT	MINIMUM LENGTH INCLUDING FLOWERING HEAD (mm)		
Protea		CH		STD
P. coronata	5/bunch or STEM	600mm		400+
P. cynaroides	stem	650		450
P. 'Frosted Fire'	5/bunch or STEM	600		400
P. grandiceps	stem	600		400
P. lacticolor	5/bunch or STEM	600		350
P. longifolia	stem	600		400
P. magnifica	stem	650		450
P. minor	5/bunch or STEM	500		250
P. neriifolia	5/bunch or STEM	600		400
P. obtusifolia	5/bunch	600		350
P. 'Pink Ice'	5/bunch or STEM	600		400
P. punctata	5/bunch or STEM	600		350
P. repens	5/bunch or STEM	600		400
P. scolymocephala				200
P. speciosa	stem	600		400
Banksia				
B. burdettii	stem	600		400
B. baxteri	stem	600		400
B. coccinea	stem	550		3[illegible]
B. grandis	stem	750		550
B. hookerana	stem	600		400
B. menziesii	stem	500		350
B. prionotes	stem	650		450
B. speciosa	stem	650		450
B. victoriae	stem	600		400
Leucospermum				
Lsp. cordifolium	5/bunch or STEM	600	500	400
Lsp. 'Firewheel'	5/bunch or STEM	600	500	400
Lsp. lineare	5/bunch or STEM	600	500	400
Lsp. reflexum	5/bunch or STEM	600	500	400
Lsp. tottum	5/bunch or STEM	600	500	400
Lsp. vestitum	5/bunch or STEM	600	500	400

TABLE 4: GUIDELINES ON GRADING STEM LENGTH AND BUNCHING (CONT'D)

VARIETY	UNIT	MINIMUM LENGTH INCLUDING FLOWER HEAD (mm)					
Leucadendron	(number)			CH		STD	
Lcd. comosum					–	350	
Lcd. conicum					–	350	
Lcd. coniferum					–	400	
Lcd. daphnoides	10/bunch				450	350	
Lcd. discolor	10/bunch			500	400	300	*
Lcd. eucalyptifolium						400	
Lcd. floridum						350	
Lcd. gandogeri	10/bunch	800	700	600	500	400	*
Lcd. laureolum	10/bunch	800+	700	600	500	400	*
Lcd. macowanii					500	400	
Lcd. orientale	10 or 5				500	350	
Lcd. platyspermum					–	350	
Lcd. 'Red Gem'	10/bunch		700	600	500	400	
Lcd. salicifolium						400	
Lcd. 'Safari S/set'	10/bunch	800	700	600	500	400	*
Lcd. 'Silvan Red'	10/bunch	800	700	600	500	400	*
Lcd. tinctum						350	
Lcd. uliginosum						350	
Lcd. strobilinum						350	
Other Lcd. foliage						400	

* Bunched to actual length, all stems the same.

Grading

Genus Protea.

Choice: Stems must be between 600mm and 1000mm. Flower head should be unblemished, clear colour and an appropriate size for the species. Leaves near perfect.

Standard: Stems must be 350mm, or 400mm minimum (depending on species and flowerhead size (see Table 4) - Flowers should be free of major blemishes. Leaves: Some blemishes are permitted. Smaller head sizes accepted.

Genus Leucadendron

Lcd. multiflora and multicone would be in stem lengths 400mm+.
Lcd. foliage, stem lengths 400mm+.
Foliage should be healthy, not spotted or eaten.

Leucadendron flowerheads. There is great variation between male and female flowers. There is also great variation in size of flowers between male and female flowers, eg. for Lcd. laureolum, the male flower generally being classed as standard. Some species grow multiple heads as well as single heads. For Lcd. discolor male, which does this, each stem would be judged on its overall merits.

Stem lengths should be not less than 350mm or 400mm - see Table 4. Flowers should be near perfect.

Silvan Red, gandogeri and laureolum are graded into set stem lengths. Note that superior flower heads are expected with the longer stem lengths. For these flowers the specified length is the exact length required. Measure overall length, top to bottom.

Genus Leucospermum.

All should have:-

- * Flowerheads near perfect.
- * Flowerheads at not more than 45° to stem.
- * Stem length 400mm or more.

Choice: Flowerhead at not more than 15° to stem. Stems 600mm or more.

Standard: Stem 300mm+ Flowerheads 15-45°.
Measure stem length from base of flowerhead.

Packing & Transport

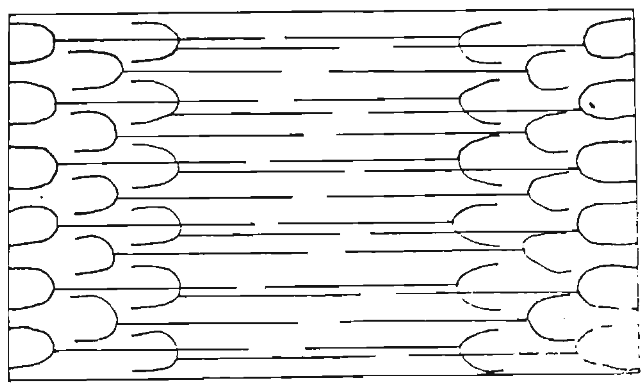
Cartons. This section is applicable where flowers are carried over longer distances and require packing in cartons.

Proteas are packaged dry. i.e. No water on leaves because this can hasten the blackening of the leaves. Do not use newsprint paper with cream Proteas. Use an absorbent paper with all proteas.

Leucadendrons, Banksias and Dryandras are packed dry. Use an absorbent paper.

Leucospermums are sprayed with water and enclosed in polythene sheeting.

The Leucospermum flowers are packed with their heads in rows as follows: -



The box is packed tight and the plastic sheeting is wrapped over the flowers to hold in moisture.

Transport to the Wholesaler. Ideally this would be by refrigerated transport. Alternatively by the quickest and coolest method available. Obviously this would apply to the warmer months in particular.

Planning the Packing Shed

The layout is important as it can save hours of labour. Shed should be located centrally to the plantation. For operations of 2-4 hectares the following layout could serve quite well. Shed 60′ x 20′ x 10′ high (approx.). The height allows extra storage. Size depends on maximum volume to be handled at any one time and storage time.

The shed should be insulated and/or shaded by tall shrubs or trees. Windows for adequate light and ventilation should be provided above the benches. Do not use skylights as these allow too much heat into the shed. The floor can become wet therefore use cement slab or suitable timber.

There are two distinct functions in the packing shed - (1) cleaning flowers immediately after picking and (2) packing the flowers for transport and sale. It is ideal to separate these two functions.

After flowers have been cleaned they are placed in water for at least 6 hours. Depending on the market they may either be cooled to 3°C or fumigated at 22°C. After this the flowers are ready for packing. If flowers are packed warm (ex fumigation) forced air cooling is necessary to rapidly cool the flowers in their boxes.

CONCLUSION

The methods of plantation management adopted on a given site in a particular country will vary greatly but in every case they should be dictated by market requirements and the economics of production.

This paper has emphasised the importance of understanding the market as an integral part of any Protea flower production programme.

IRRIGATION OF PROTEAS.

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INTRODUCTION

The information on the irrigation requirements of proteas is not only incomplete as has been highlighted by Nichols (1985) and Webb and Pegrum (1991) but also contradictory as seen by comparing the work of Furuta (1983) and Nichols (1985).

In Western Australia, a range of alternative irrigation techniques and scheduling regimes are employed with proteas. It is difficult to determine which is the most appropriate because there is little information upon which to base that assessment. However with a very basic understanding of the plant's physiology, and the conditions under which they occur naturally, it is possible to draw a few conclusions which should help design a suitable irrigation system and scheduling package.

The final implementation of the package will however depend upon many factors including the area in which the plants are to be grown, the species, soil types and water quality.

IRRIGATION

The irrigation of any crop can be considered in two parts, the system or equipment, and the scheduling or management. These two components are not mutually exclusive, but for the purpose of this exercise we can consider them in isolation.

As an aid in designing a system and management package, information on the plants' natural environment and water use patterns should be examined. This will assist in designing a package which will best suit the plants needs.

Water use by Proteas as indicated by their natural environment.

In South Africa, proteas grow on a range of soils which are usually coarse grained, acidic, and nutrient poor. (Ben-Jaacov, 1986). In Western Australia, banksias prefer deep,well drained, slightly acidic sands. (Webb and Pegrum, 1991).

However Leucospermum cordifolium, and Protea neriifolia can tolerate fairly alkaline soils, while Protea obtusifolia grows naturally in alkaline soils, (Furuta, 1983). Protea cyprinids, grow naturally in heavy soils, (Furuta, 1983).

Although proteas occur naturally under conditions of low soil fertility, Nichols (1985), cautions against drawing the conclusion that they do not respond to fertilisers.

The same could be true of the fact that they occur naturally on coarse sandy soils with low water holding capacities. While many growers consider that their proteas do not require irrigation, especially after the first or second summer, this is not necessarily the case.

<u>The significance of proteoid roots.</u>

Lamont (1986), reported on the significance of proteoid roots to different protea species. Every member of the commercially grown Leucadendron, Leucospermum, Mimetes, Protea, Serruria, Banksia, Dryandra, Grevillea, Isopogon and Telopea genera examined had proteoid roots.

Proteoid roots are dense clusters of hairy rootlets which form a mat two to five centimeters thick at or near the soil surface. Although they are found under the canopy, especially in the presence of good layers of mulch, they can cover an area six times that of the mature canopy (Lamont, 1986).

Hanekom et.al.(1973) reported that there were two periods of active growth of these proteoid roots, immediately preceding the bud differentiation, and bud development stages. These periods of active growth of the proteoid roots coincided with periods of rapid nutrient uptake.

Ben-Jaacov (1986), however reported that there was no relationship between these proteoid roots and shoot growth in nutrient solutions. This finding is supported by Lamont (1986), who reported that high levels of nutrients in potting mixes will suppress the development of proteoid roots.

It appears therefore that the proteoid roots play an important role in nutrient and probably water uptake under conditions of low nutrient or water availability. Their presence probably reflects an adaptation to the natural conditions under which many proteas developed.

The literature seems to suggest that the importance of proteoid roots will be diminished under conditions where nutrients and water are readily available. Lamont (1986), however concludes that conditions such as minimal root disturbance, use of mulches, careful use of phosphate fertilisers, and careful management of soil water levels to prevent high concentrations of nutrients from occurring, should promote the growth of proteoid roots, and enhance the performance of the plants.

Irrigation Systems for Proteas.

The first decision to be made when designing an irrigation system for proteas is the type of system to use. Furuta, (1983) recommended that proteas should not receive overhead watering. Therefore either trickle or microsprinklers are suitable.

The final choice between microsprinklers and trickle depends upon factors such as the soil, the cost, the area which must be wet, the quantity of water to be applied, and the water quality.

The poor lateral spread of water from trickle irrigation emitters, on the sandy soils of the Swan Coastal Plain near Perth, tends to limit the usefulness of that system. However the price of microsprinklers is about double that of trickle, and growers who only wish to irrigate for a the first couple of years may feel that the price is not justified.

Other design criteria such as filters, orifice sizes and pipe sizes depend upon the local climatic conditions and water quality. There are a number of areas where expensive pretreatment systems and filters will be needed if trickle is to be employed.

The ultimate choice will depend upon the grower's requirements. These can be determined in consultation with a competent irrigation designer. Remember it is worth employing and paying a professional designer who will ensure that you get a reliable workable system. There are numerous cases of growers who tried to set up their irrigation systems "on-the-cheap", only to find that short cuts usually don't pay.

Irrigation Scheduling for Proteas.

There is little information available on the quantity of water required by proteas. Furuta (1983), quotes rates from about one to 35 litres per week, for proteas in Southern California. Webb and Pegrum (1991), suggest that regular watering is required to establish banksias in Western Australia, but the value of watering plants over three or four years of age is unclear.

While Furuta (1983), recommended regular watering to maintain soil moisture, Nichols (1985), warns of the problems of diseases such as Phytophthora spp., if heavier soils are kept too moist.

The conclusions of Lamont (1986), suggest that the natural advantages accruing from the proteoid roots may be lost if the soil is kept wet. Infrequent watering, either deliberately, or due to equipment failure, may result in the production of proteoid roots being interfered with, and the benefits of them being lost.

It is possible that a choice has to be made between encouraging the surface feeding proteoid roots or the deeper ones. The irrigation systems and scheduling packages will differ depending upon the choice.

The grower's role is to interpret the varying pieces of information and design an irrigation scheduling package which suits the particular conditions.

Good soil moisture conditions, (i.e. around field capacity) should be maintained during the periods of active growth (floral initiation and development). This varies between species and regions. Banksia baxteri and B. menziesii initiate flowers in W.A. between September and December, while B. hookeriana initiates flowers between December and March (Rohl L.J. and Fuss A.M. pers. comm.). It is essential that growers are aware of these critical periods for their species and regions.

It is possible that the high numbers of aborted flowers on some non-irrigated banksias in W.A. (Webb M. pers. comm.) may be due to moisture stress. On similar soils, the abortion rate of avocado flowers and fruit was significantly reduced when the irrigation management was improved (Luke, 1991).

Improving the water management, by maintaining soil moisture within a desired range, is a relatively simple matter using a soil moisture sensor. One of the most common of these is the tensiometer. Full details on installation and operation of tensiometers are available from the manufacturers or the Department of Agriculture.

When using a tensiometers it is important to know which readings on the dial are critical for the plant/soil combination. These critical or trigger points at which the plants start to suffer from water stress can be determined either from experimental work, or in the field, by the grower. It is important however to determine at which level of stress plants yields decline significantly. Indeed some stress may be necessary to initiate flowering, or to prevent excessive vegetative growth.

Tensiometers should be set up in nests, with one in the active root zone, and one set below the active roots. This will enable the depth of watering to be determined and provide an indication as to the amount of water being wasted. The actual depths used will depend upon whether management practises aimed at promoting protea roots are in place.

As a starting point the guidelines in Table 1 could be used as the trigger points for irrigation when using tensiometers. These rates should replace the amount of water the plants are using, without putting them under too much water stress. Individual growers are strongly recommended to carry out trials to determine whether these rates produce maximum economic results.

Table 1. First guess trigger points for using with tensiometers as the scheduling guide for proteas.

Soil Type	Tensiometer Reading (Centibars)
Light (Sands, Sandy Loams)	15 - 20
Medium (Loams)	20 - 25
Heavy (Clays)	30 - 35

The frequency of watering is then determined by the rate at which the plants draw the water available to them.

CONCLUSIONS

Clearly there has been little work into the irrigation requirements of proteas. A number of suggestions have been made as to the most appropriate type of irrigation, and scheduling of the watering programme.

A considerable amount of further work is required to determine the economically optimum levels of irrigation. That will require the development of a better understanding of the relationship between proteas and their environment, especially the interaction between protea roots, nutritional levels, and the depth/frequency of irrigation.

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BIOGRAPHICAL PROFILE

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Mr Luke worked as an Irrigation Extension Officer specialising in irrigation design and management in the S.W. of W.A. between 1971 and 1979. He then held a position with the British Commonweath Secretariat as an Expert Advisor on Irrigation and Water Conservation in the West indies between 1979 and 1982.

In 1982 Mr Luke returned to W.A. and has been involved in several positions leading to his present one as Senior Research Officer and Manager of the Irrigation Section of the W.A. Department of Agriculture. He has experience with many different crops including grapes, avocados, carnations, bananas, mangoes, and vegetables.

GROWING PROTEAS ON A LIVING VOLCANO
ISLAND OF HAWAII

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The Hawaiian Islands are perhaps the most isolated lands found on our planet. Isolated, that is, from major land masses. This has played a major role in the evolution of plants and animals as well as the ultimate discovery and settlement by the Polynesians. Most of the archipelago's sixteen hundred mile length is composed of small islands and reefs. The higher islands are found at the southeastern end, with the Island of Hawaii the youngest and most eastern. Maui is to the north and west of Hawaii Island.

It is hypothesized that these islands were formed over a period of about 25 million years with the Island of Hawaii being less than a million years old. The accepted theory today is that these volcanic islands formed over a thin area in the earth's crust called a "hot spot". That hot spot is now beneath Hawaii Island, at latitude 19 degrees north and longitude 155 degrees west, and is producing new land each day from the fiery Kilauea Volcano. There are actually three active volcanos on our Island, dominating much of its 4,000 square miles with tortured lava beds. These extend from sea level to almost 14,000 feet. Where moisture and temperatures are ideal, forests of treefern and Meterosideros quickly cover the landscape. Where it is too cool or dry, only lichens grow. The west side of the Island has substantial lava lands formed as recently as 1950. It is this side that has become home to a number of proteaceous plants and other Australian natives as well.

Initial research by Dr. Philip Parvin and commercial plantings during the last 25 years were carried out on Maui, primarily in the Kula area, at about 3,000 feet elevation. Briefly, the climate there is cool and dry (20 to 30 inches of precipitation) with much of the rain occurring in our winter from November through March. Kula is on the western slopes of Haleakala volcano, where the soils are fairly well developed and well drained.

A similar area on Hawaii Island is found in Waimea at 2,000 to 3,000 feet. This area also became popular for planting Proteas. Our young Protea industry grew at these two locations despite many obstacles. Nematodes and diseases plagued most farmers, but over time these challenges have at least been managed.

Land prices have also escalated over the years. With land prices running above one hundred thousand dollars per acre in Kula and

Waimea, a number of new growers began to look at less expensive lands on the Island of Hawaii. These "lava lands" were priced as little as $5,000 per acre but were without soil. Some of the lava flows are less than 50 years old, but these areas were also free of most diseases, insects, nematodes and even weeds. A whole new set of challenges needed to be explored on the lava lands, and that is where we are today.

To understand why this particular side of the island is well suited for Banksias, Leucospermums, Grevilleas, Macadamias and others, it is important to note how the well drained lavas interact with temperature, moisture, and rainfall distribution. Most of the Hawaiian chain is influenced by moisture laden tradewinds blowing from the northeast. The windward east side of the high islands receive 50 to 600 inches of rain per year with a tendency to be wettest from November through April. The leeward side of the high islands except Hawaii generally receive 10 to 30 inches also during that period. However, because Hawaii (also known as the Orchid Island) has such a large mountain mass, the leeward side tends to have a dry period from December through February. Convectional rains occur during the rest of the year and usually fall in the afternoon. This type of rainfall, little influenced by the tradewinds, may range from 10 to 80 inches per year, depending on elevation. Highest rainfall is found in a belt from 1,000 to 3,500 feet, and tends to get dryer as one descends or ascends from the rainiest area. Toward the north side of this rain belt is Hualalai Volcano. This area is generally older than the south end of the island, the last flow being in 1801. To the south end is Ka'u, a very young part of the Island with almost no soil. The terrain is mostly a'a and pahoehoe lava with sparsely growing Meterisideros and other native dryland plants.

Temperatures vary tremendously. It might be 80 degrees on any given day at sea level, 70 degrees at 4,000 feet, and 60 degrees at 6,000 feet. That same night, the temperature at sea level could be 75 degrees. At 4,000 feet the temperature might fall to 50 degrees and at 6,000 feet almost down to frost. Because of all these microclimates, there is a great opportunity to grow almost any kind of plant. The problem is to figure out what will grow where, and then hope the volcano cooperates.

Protea farms have clustered in three main areas. Waimea--older volcanic soils, Kona--young lavas and Ka'u--very young lavas. The latter two areas are also planted to Macadamia and contain substantial forests of naturalized Grevillea robusta.

Because our Islands are isolated, we have very few endemic pests of Proteas. Unfortunately, along with plants, we have inadvertently introduced plant parasitic nematodes and diseases such as Phytophthora root rot, Colletotrichum, Drechslera blight, Elsinoe disease and Botrytis, just to mention a few. Thus growers make every effort to start their farms in areas as free of pests as possible. They focus on growing types that are adapted to the environment and try to be as sanitary in their practices as possible.

They tend to use chemicals such as fungicides and nematicides where necessary, but are looking for non-chemical approaches to pest control. Damaging insects have not been a major problem in the past, but regulations limiting shipments, of flowers to the mainland United States and other countries, require the flowers to be absolutely insect free.

Some of the major limitations to the industry include a very limited labor supply. With minimum wage soon to be over $5.00 per hour in Hawaii and the attraction to more lucrative work, the typical Protea farm is family operated. Expanding to large farms requiring large numbers of hired labor is difficult.

It is hard to say what the future will bring for the Protea industry in Hawaii, but it will most definitely be tied to our visitor industry. More than 6,000,000 visitors come to our Islands each year. Many have never seen King or Queen Proteas, Pincushions or Banksias. When they see them in spectacular flower arrangements at their hotel or in a garden setting, they are awe struck. Returning home, they ask their local florist for these magnificent flowers, thus creating the market demand for "Hawaiian" Proteas.

Hawaii Island has long been known as the Volcano Island, and the Orchid Island, but with more and more Proteas being used locally and shipped to the mainland U.S., our Island may one day be known more for its Proteas than its orchids. Perhaps it is appropriate that an island permeated with legends of gods, goddesses and demigods has become the home of a family of plants whose name is associated with the Greek God Proteus, who was able to change into many shapes and forms. Living and farming on the Island of Volcanos, one is constantly aware of nature's continuous and often violent changes.

We, of Hawaii, thank you for your hospitality and look forward to your visit so that we may share our Island Aloha with you.

Biographical Profile

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Undergraduate degree in Tropical Agricultune

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Present Employment:

Agricultural Extension Agent for the Island of Hawaii working with ornamental horticulture including turf since 1973.

1968-1973 worked with C. Brewer Ltd. (primarily a producer of cane sugar) as diversified crop horticulturist.

1961-68 worked as Agricultural Extension Agent in Palm Beach County, Florida.

THE TASMANIAN WARATAH (TELEOPEA TRUNCATA) AND ITS SELECTION FOR COMMERCIALISATION

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Waratah is the common term used to describe the small endemic genus _Teleopea_, a member of the Proteacea family. This genera includes four species: _T. speciosissima_ (Sm.) R.Br., _T. truncata_ (Labill.) R.Br., _T. oreades_ F. Muell. and _T. monqaensis_ Cheel. To date the most commercialised and most researched of this genera is _T. speciosissima_ or the New South Wales Waratah.

In the past five years I have studied both _Teleopea speciosissima_ and _T. truncata_ (Tasmanian waratah). The two major aims have been to study the effects of altitude on their flowering times and growth and the selection of the Tasmanian Waratah for the cut flower market. The work has involved the propagation and care of both potted and field planted waratahs.

The Tasmanian waratah (_T. truncata_) is endemic to Tasmania and this paper will discuss aspects of propagation, cultivation and progress towards its commercialisation.

This waratah has a smaller more compact bloom than the NSW waratah adding versatility to its use in flower arrangements and its stem lightness reduces freight costs. Its flowering time is later, commonly around late October to early December - closer to the lucrative Christmas market.

It is also a variation on a theme, being similar to the NSW waratah, but lacking the large bracts and having a flatter raceme. It may eventually be marketed under another name or it may be hybridised with one of the other waratah species - its development is at the embryonic stage.

DISTRIBUTION

The Tasmanian waratah is an evergreen shrub/tree usually growing one to three metres tall in the wild, there are, however, some specimens up to eight metres. The bush size and shape varies from small stunted bushes ranging through straggly shrubs to small trees. The plant is widely distributed over the high rainfall mountainous regions of Tasmania. It is frequently associated with Nothofagus cunninghamii (Southern Myrtle Beech), Drimys lanceolata (Native Pepper) and Phyllocladus aspleniifolius (Celery Top Pine). Areas regenerating after logging or fire damage often initially have waratah as the dominant species due to their ability to promote growth from their lignotuber.

SELECTION CRITERIA FOR CUT FLOWERS

Selections to date have been made from naturally occurring waratah stands and have been based on flower form and colour, vigour and leaf shape. It has become evident that other aspects to consider are flowering time, the tendency for the growth of new shoots through the flowers and vase life.

Leaf shape varies from obovate to oblanceolate with apex acute, with tip serrate or blunt toothed, to apex rounded and there is also a wide range in size. A variegated leaf form has been found.

Flower form varies in the number of florets per flower head or raceme. This can range from eight to in excess of thirty. The symmetry can also vary considerably, with some blooms appearing malformed whilst others are well formed and symmetrical.

Flower colour is most commonly red, with tones of orange-red to deep red. There are yellow forms but sightings are rare. There is an old report of a yellow form with a pink centre but unfortunately the bush's whereabouts were not recorded and no specimens are known today.

In summary, the selections to date have been for a deep red flower colour with a symmetrical flower head of approximately thirty florets. Any plants showing peculiarities, particularly of potential commercial value, are recorded, and where possible, cuttings or seeds collected to establish a germplasm collection.

PROPAGATION

Vegetative propagation using semihardwood stem cuttings has been the main method for bulking up the selected plants. Two systems can be used: leaf bud cuttings or stem cuttings. For stem cuttings all but the top one to two leaves are removed; the leaf tips are not cut.

Leaf bud cuttings are useful when there is a limited amount of plant material available, however stem cuttings are easier to prepare and if there is sufficient material it is the preferred method.

The cuttings are dipped in benomyl fungicide, drained and the bases dipped in 2000 ppm indole butyric acid for five seconds. They are then placed in a peat:perlite mix in a heated (22°C) misting bed. The growing mix is pressed firmly around the cutting. After 10 weeks (undisturbed) the cuttings are checked and if the root growth is sufficient they are potted. Care must be taken not to over pot. Cuttings with small root growth should be returned to the misting bed for a few more weeks. If no roots are present and the cutting is still intact the base can be recut and retreated with the hormone dip and returned to the misting bed.

The strike rate using this method is variable depending on the quality, treatment of the material and the time of year the cutting is taken. The post flowering surge of vegetative growth provides the best cutting material. The regrowth growing through old flower heads also provides good propagation material. It is possible to have a strike rate of 80%, however, for T. truncata 40% would be the average strike rate.

Seed propagation is a good method of obtaining a large number of plant stock, however there will be variability in the form of the bush and flower. It will be a minimum of three years before the plants will flower to allow the commercial selections to be made.

Seedlings have the following advantages; they establish better than cuttings, are cheap to produce, and there is that opportunity to find that extra special plant.

It is important to use fresh seed since the viability will slowly decrease up to six months and then rapidly thereafter. Prior to planting it is beneficial to dust seeds with a combination of the fungicides thiram and benomyl. Good results have been found using a peat:perlite "plug tray" system or rockwool propagation blocks. Both systems avoid transplant shock. The trays can be watered and placed in large plastic bags to minimise the chance of drying out. The bags need to be supported so as not to rest on the newly germinated seedlings and it is also necessary to occasionally aerate the bag. A germination rate of 80-90% is not uncommon. Once the seeds have germinated they can easily be potted into "slim-line" pots (5x5x12.5 cm deep).

Watering of the seedlings is crucial in the first six months and daily watering, provided the pots are off the ground either on gravel or on a wire bench, has resulted in an improved growth rate.

CULTIVATION

Getting the cuttings to strike is the easy part. Care of the potted plant stock in the first 18 months is thwarted by many problems and unsolved deaths. A 30% stock loss is common.

The waratah has a shallow root system with a deeper "tap" root. In its natural habitat the shrubs often occur as an understorey plant with a lot of bush leaf litter protecting the surface roots. The potted plant responds well to regular watering and also to mulching; the surface roots should not be permitted to dry out. However, the pots must be well drained. Problems are more likely to occur through insufficient watering rather than overwatering unless the roots have been damaged in some way.

The use of a slow release low phosphorus fertiliser with added iron has given good results.

Several different potting mixes have been investigated. A peat:sand:loam mix (1:1:1); composted pinebark; soil from beneath established waratah (native); combinations of peat:sand:loam and native soil. The best growth rate and least deaths occurred with the peat:sand:loam mix and the next best response was with the composted pine bark mix. The pure native soil resulted in the most deaths.

A preliminary trial has indicated that waratahs benefit from shading in the first 18 months of growth ; the healthiest plants were produced in a shaded environment.

Field Trial Plot Construction and Selection Four trial plots have been fenced in the North East of Tasmania in the Scottsdale district.

		Altitude (m)
1.	Maryvale Flats, Tonganah	50
2.	"Sunnyside", Branxholm	200
3.	"Gum Flat", Trenah	400
4.	Gray's Hill, Branxholm	580

Trial plot selection was based on the following criteria:

A. The climate was known to support native stands of Tasmanian waratahs.
B. The soil had good drainage and a pH range of 5-6.
C. A topography that allows 4 sites to be selected within the range of 50-600.
D. Private property to enable suitable overseeing of the equipment and plants.

These sites were selected to test the effect of altitude on flowering time and growth of the New South Wales and Tasmanian waratahs. Unfortunately due to herbicide drift from a neighbouring paddock the 50 m plot was abandoned.

The plots were constructed using vermin-proofed fencing. Windbreak cloth was erected to protect the plants from prevailing winds.

Prior to planting the rows were sprayed with Roundup (R). Planting began in April 1989. Replants have been necessary since a 30% death rate in the field is not uncommon.

At planting a slow release fertiliser tablet (Agriform (R)) - 20:4.3:4) was used as a source of nutrients. Rows were mulched with pinebark to aid moisture retention and weed control.

The planting density was 1.5 m within the row and 3 m between the rows. Row orientation was East-West.

All plots have a microirrigation system with 4 l/h drippers and an irrigation header tank. The plants were irrigated in the period immediately after planting. It appears even in these high rainfall areas summer irrigation is necessary if the plants are to survive.

Four Easidata environmental recording system sensors have been purchased to record the climatic conditions at the selected sites. These solar powered sensors record humidity and soil and air temperature. The data is collected monthly using a Toshiba 1200 F portable computer.

Rainfall is recorded using a standard rain gauge.

Selected Tasmania waratah clones and seedling material have been planted at these sites and their growth, flowering time and quality will be compared with New South Wales waratahs.

PESTS AND DISEASES

Disease problems have been numerous, although it has not been possible to positively identify them as the primary cause. Many problems have been attributed to that frustrating term "physiological disorders". One symptom which has caused particular concern is an ink black discolouration of the leaf axil, leaf main vein, and sometimes a discrete banding of the stem. No fungus has been consistently isolated and it may be a physiological response to a variety of disorders. Some of the fungi isolated from both the New South Wales and the Tasmanian waratahs have been: Cylindrocarpon sp., Cylindrocladium sp., Phythophthora sp., Gliocladium sp., Fusarium sp., Cladosporium sp., Phoma sp., Phyllosticta sp. and Colletotrichum sp.

Pests that have caused damage include Looper caterpillars (Family Noctuidae) [control: carbaryl]; Two-spotted mite (Tetranychus urticae) [control:predatory mites(Typhlodromus occidentalis)].

A pest of major concern in nursery plants is the European strawberry weevil (Otiorrhyncus sulcatus). The larvae destroy the roots and lignotuber of the plants in spring and autumn. This pest was controlled by drenching the pots with nematodes (Heterorhabditis sp.) and this has reduced the number of plant losses.

POST HARVEST TRIALS

Trials conducted in 1985 on the post harvest handling of Tasmanian waratah indicated that the vase life was 6.5 days at 21°C for blooms harvested at maturity stage 3 (0-2 styles reflexed, 80-100% perianths split). The end of vase life was taken as the point where a minimum of 10% petal necrosis had occurred. The blooms used in this experiment were from unpruned, rarely harvested, well established trees, and the flower stems were short and woody. This vase life indicated the need for careful post harvest care and correct harvest maturity. The experiment has since been repeated using flower stems of young wood but the results have yet to be analysed. There was no increase in vase life due to the floral preservative, Chrysal(R); however it did increase the rate of flower development when the blooms were harvested at the earlier maturities, thereby extending the period where the bloom would be attractive to the public.

This series of experiments brought out several important points:

(1) Seedling material is highly variable in post harvest

behaviour and response to treatment.

(2) The tendency for flowers to produce vegetative shoots through the flower head is a bush related phenomena which should be avoided in the selection process.

(3) There is the possibility of selecting for bushes that yield longer lasting blooms.

CONCLUSION

Like many of the Proteacea family, the Tasmanian waratah is a frustrating plant to work with.

There are opportunities in hybridising with other Telopea species as well as selecting from its own genetic pool.

The beauty and potential of this plant as a cultivated ornamental is a driving force for us to continue to gather knowledge and understanding of its growth requirements.

BIOGRAPHICAL PROFILE

Susan Alexander is currently employed as a Horticulturist (Floriculture and Nursery) by the Department of Primary Industry, Tasmania. She commenced work for the Department in 1984.

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POST-HARVEST TREATMENT AND DISINSECTATION OF *PROTEA* CUT FLOWERS

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Introduction

Protea cut flowers harvested in South Africa are subjected to phytosanitation post-harvest treatments to meet with phytosanitary requirements, and to prolong the shelf-life of blooms. International phytosanitary requirements require flowers to be free of insects and fungal infections. Three main groups of insects cause phytosanitary problems on proteas, namely (a) borers tunnelling into buds/stems; (b) leaf miners and leaf feeders, which scar leaves; and (c) insects which visit flowers to feed on pollen and nectar.

The presence of fungal infections on leaves and stems is not aesthetically acceptable, and can lead to the rejection of plant material by quality inspectors. Pre-harvest, harvest and post-harvest treatments are required to avoid these problems.

Pre-harvest treatment

Preventative treatment in orchards is required if high quality cut flowers are to be produced. Insect pests such as leaf feeders can be controlled with an intensive spray-programme. Orchard sanitation is of value in controlling borers. Fungal diseases also require controlling with an intensive spray programme.

Spray programmes used in South Africa are presented in Tables 1 and 2. A more complete spray programme including comments on the application of insecticides has been compiled (Wright 1991). Such spray programmes contribute to the phytosanitary acceptability of flowers, but further measures are often needed.

Harvest treatment

If *Protea* flowers are harvested in the "soft-bud" stage, few insects are present, and the shelf-life of the blooms is increased. At the "soft-bud" stage, anthesis has not yet occurred, so there is little to attract insects. Picking of flowers at the "soft-bud" stage requires careful training of the pickers, as there are large variations between cultivars/species. Flowers picked too early will not open. At the picking stage, careful inspection for the presence of borers and diseases is required.

Table 1: Insecticides for use on Proteaceae

Pest	Leaf feeders Insecticides	Conc./ 100ℓ water	Application
Leaf miners	Dichlorvos ec.	100 mℓ	Apply when growth cycle commences. Repeat every six weeks.
Weevils Caterpillars Locusts	Deltamethrin ec. or Dichlorvos ec.	10 mℓ 100 mℓ	Every six weeks and alternate.
Scale insects	Chlorpyrifos ec. Prothiofos ec. Mineral oil	100 mℓ 50 mℓ 5 000 mℓ	Only if pest is present. (Two or three applications needed)
Mealybugs	Chlorpyrifos ec.	100 mℓ	Only if present.
Pine emperor moth larvae	*Bacillus thuringiens* var. *kurstaki*	450 g	Only if present.
	Borers		
Black moth (larvae)	Dimethoate ec.	120 mℓ	Apply to growth points and buds.
Other borers	Sanitation	-	Remove all infected plant material, un-harvested flowers and seed heads.

Table 2: Fungicides for use on Proteaceae (Compiled by M.D. Saunderson)

Spray a combination of the following every 2-3 weeks when flushes are forming and once a month thereafter:
Two of : Prochloraz/Captab/Mancozeb
plus: Chlorothalonil or Iprodione
plus: Benomyl (not more than three times per annum)
Apply as specified on container.
A general spray programme should be followed during the "flushes" or periods of growth and flower formation with the intention of keeping young tissue free of infection by pathogens. The programme will be effective against all leaf spot diseases and shoot and flower diseases.

Post-harvest treatment

Various options exist for the post-harvest treatment of Protea flowers. The internationally prescribed treatment, viz. fumigation with methylbromide, is unsuitable for use on proteas, as leaves go brown when treated. Various alternatives have been investigated in South Africa. Controlled atmosphere treatment i.e. 2° C; 20% CO_2; 2% O_2 (Seaton & Joyce 1988), did not give acceptable results. Only 91% insect mortality was achieved after 10 days of this treatment. Controlled atmospheres do, however, have some potential as they appear to improve the lasting ability of some *Leucospermum* and *Leucadendron* cultivars.

Alternative fumigation methods have been tested (Wright & Coetzee in prep). *Protea neriifloria* and *Protea laurifolia* inflorescences were subjected to fumigation in a chamber (3.8 x 3.5 x 2.6 m) at an ambient temperature of 10°C or higher. An exposure period of 16 hours was used.

No treatment gave 100% insect mortality (Table 3) but if used in conjunction with pre-harvest spraying, less insects would have been present and acceptable results could have been achieved.

Table 3: Results of various fumigation treatments tested on *Protea* cut flowers to effectuate disinsectation. (Exposure time: 16 hours)

Treatment	Concentration	% Mortality
Mg	2.65 g.m-3	95.5
Mg + deltamethrin ec.	2.65 $g.m^{-3}$ + 1 % (v/v)	97.4
Al + dichlorvos ec.	2.65 $g.m^{-3}$ + 1 % (v/v)	97.9
Dichlorvos ec.	1. % (v/v)	92.5
Dichlorvos aerosol	9.3 %	91.6
Control	-	4.1

Mg = Magnesium phosphide gas   Al = Aluminium phosphide gas

After fumigation, the temperature of the flowers must be reduced to 2°-5°C, and maintained. A drastic drop in cut flower quality is often found after the packed blooms leave the producer. By placing a data logger in a box of flowers sent to Europe, a curve of the temperature changes was recorded. As seen in Figure 1, these fluctuations are large. To ensure the bloom quality and shelf-life, the flowers must be stored and transported at a constant temperature of 2°-5°C.

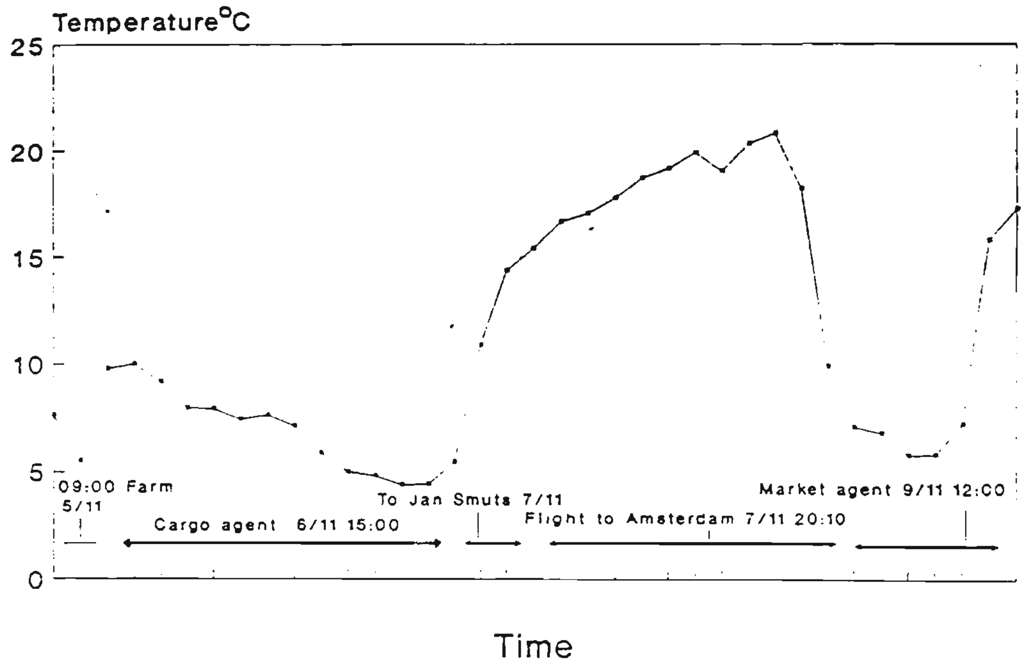

Figure 1. Temperatures recorded in a box of cut flowers in transit from Cape Town (5 November) to Amsterdam (9 November). The greatest increase in temperature occurred between Jan Smuts airport and Amsterdam

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REVIEW OF FIELD AND POSTHARVEST CONTROL OF INSECTS IN PROTEACEAE

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Introduction

The importance of insect problems as barriers to the development of Proteacea as a viable export industry has been recognized for at least 20 years (Myburgh and Rust, 1971). In 1988, 12% of *Leucadendron* spp., 57% of *Leucospermum* spp. and 59% of *Protea* spp. did not pass quarantine inspection on arrival in Japan due to the presence of insects (Anon 1988). For flowers to enter these countries in top quality, free from blemishes or damage and without insects, effective field and postharvest insect control measures are of utmost importance. This paper reviews insects occurring in Proteacea in Australia and overseas and methods for their control.

Insect Pests and Field Control

In a survey (1988) of Australian Proteaceae cut flower exports Seaton (unpubl.) found that a wide variety of insects and spiders were present in flowers before export from Australia: Insects found were thrips, beetles, aphids, caterpillars, mealy bugs, scale, ants, true bugs and weevils (Table 1).

The family proteaceae is primarily a southern hemisphere plant, with greatest diversity being in south-western and eastern Australia and South Africa (Morley and Toelken, 1988). A great diversity of insect pests have evolved with to feed on these plants, consequently the greatest number of species of insects attacking proteaceae will also be at these centres of diversity. These centres will be *Proteas* grown in South Africa and *Banksias* grown in south western Australia. Proteas or Banksias grown as exotics in a similar, but foreign environment will be expected to have a more restricted insect population.

Insects Attacking Banksias and Waratahs in Australia. Many insects attack Banksias in the wild (Woods, 1988). A major insect pest are gall forming eriophyid mites and cecidomyiid flies. Scale insects and leaf miners and termites also occur. However these insects are not a problem in plantations.

A survey by Scott (1982) of Banksias growing near Perth found moth larvae and weevil larvae damaged the flower spikes and seed heads. The most widespread insect was the Banksia moth larvae (*Arotrophora arcuatalis* (Lepidoptera: Tortricidae). This species occurs throughout Banksias in Australia (Zamnut and Hood 1986, Wallace and O'Dowd 1989). In Western Australia *Arotrophora* moth is a major pest of *B. prionotes* (summer flowering) and less so of B. hookeriana (winter flowering) (Woods and Rohl, unpubl.). Damage occurs from the larvae feeding from within the flower spike causing a malformation of the Banksia inflorescence.

Biological control of Arotrophora by the Triogramma carverae egg parasite together with Bacillus thuringiersis gave incomplete control whereas fortnightly application of alphamethrin gave effective control (Woods and Rohl, unpubl.).

A serious pest of Telopea speciosissima is the protea bud borer, (xyloryctid moth larvare) (Mullins 1987). No other pest problems of Waratahs have been reported.

Insects Attacking Proteas (Protea, Leucadendron, Leucospermum and Serruria) in South Africa and Australia.

In 1986 Coetzee (unpubl.) listed 233 species of anthropods in proteaceae in South Africa. The insect fauna of Protea repens growing in its natural environment was studied by Gess (1968), Myburgh et al (1973) and Coetzee and Latsky (1986). Numbers of species of insects and mites found varied with sampling location and Protea species, but included seven orders, and 314 species. Typical numbers of insects found per 10 cut flowers were 50 to 600.

Insects attacking cultivated proteas were classified by Starke (1979) as (i) borers, (ii) leaf miners, (iii) leaf feeders and (iv) flower insects. Four borers were important pests. Speckled Shoot Borer (Cryptolechia spp., Lepidoptera Oechophoridae); Flower Head Borer (Capys alphaeus and C. ammopleura Lepidoptera Lycaenidae); Black Moth (Argyroploce sp., Lepidoptera:Tortricidae) and Flat Head Borer (Sphenoptera sinuosa., Coleoptea Buprestidae). The three leaf miners were Blotch leaf miner, (Lepidoptera:Incuvariidae); Canal leaf miner Eucosma sp., (Lepidoptera:Tortricidae) and Fine leaf miner Phyllocnistis sp. (Lepidoptera:Phyllocistidae). Leaf feeders included species of weevils (Coleoptea:Curculionidae) and a leaf spinner Bostra conspicuals (Lepidoptera:Pyralidae). Flower insects included beetles, butterfly and moth larvae, thrips, bugs, scale insects, flies, bees, wasps, ants, cockroaches and earwigs.

The mites Proctolaelaps vandenbergi (itch mite) causing skin irritation to humans and Aceria protcae causing a growth distortion called witches broom are of phytosanitary and economic importance to proteas (Coetzee, Rust and Latsky 1986). Seedlings infested with witches broom grow poorly; adult plants have a mass of slender malformed shoots (Starke 1979) and poor flower production.

Proteas appear to be attacked by many fewer pests in Australia than South Africa. For instance borers and leaf miners which have caused problems to the South Africa protea industry are not a problem on proteas grown in Australia. Springtails, weevils and moth larvae have all caused rejections of overseas shipments from Australia on phytosanitary grounds (Woods and

Seaton, unpubl.). Native weevils have caused damage to the foliage of Leucodendrons with synthetic pyrethroids an effective control measure.

Postharvest Control

A number of postharvest disinfestation treatments have been applied with varying success as insect eradication methods for Proteaceae. These include methyl bromide fumigation, gamma-irradiation, heating, low temperature, controlled atmosphere aerosols (fogging and/or forced air), insecticide dipping, and slow release insecticides in transit. Most research work has been conducted on Banksia, Telopea, Protea, Leucadendron and Leucospermum species.

Fumigants

Methyl Bromide. For Banksia prionotes, methyl bromide at 24 g m^{-2} for two hours at 28° gave complete control of torticid moth larvae (Arothrophora arcuatalis) living inside the rachis of the inflorescence (Seaton et al, 1989). Flower vase life was unaffected following fumigation. Protea appear more sensitive than banksia to methyl bromide and were damaged after 1.5 hours at 21°C with 30 g m^{-3} methyl bromide (Wit and Van de Vrie, 1985). For Protea neriifolia and P. cynaroids 32 g m^{-3} for 2 hours at 22° gave 100% kill of earwigs (Badumna insignis) 18 hours after treatment (Maughan, 1986). However leaf blackening one week after treatment rendered the flowers unsaleable.

Other fumigants. Sulphur dioxide killed up to 73% of insects in P. neriifolia, but caused some bleaching of flowers and foliage (Maughan, 1986). Dichlorvos pest strips (half a Shelltox® pest strip per flower carton) gave 76% kill of earwigs after 18 hours in P. neriifolia and P. cynaroids (Maughan, 1986). A dichlorves pest strip or para-dichlorobenzene (Parry® fresh air) tablet killed flies and beetles with no damage or loss of vase life of B. menziessi flowers (Seaton unpubl.). Phosphine gas for 14-16 hours gave 100% kill of test insects fumigated along with Protea cut flowers and did not cause leaf browning (Coetzee and Wright, 1990).

Gamma-irradiation. At a dose required to kill insects (i.e. 10 k Gy) flowers and leaves of B. hookeriana were blackened (Seaton and Joyce, 1991a). Blackening of flowers also occurred following gamma irradiation of protea flowers (Maughan, 1986).

Temperature and Storage Treatments. Thirty (30) minutes at 46°C with hot water or 10 minutes at 56° with vapour heat required for insect disinfestation caused increased opening of florets along the inflorescence of B. prionotes and B. hookeriana rendering flowers unsaleable (Seaton and Joyce, 1991b).

Cool storage for one to two weeks which is an effective method of killing insects and has been used extensively for shipping citrus to export markets (Hill, et al, 1988) has been applied to cut flowers. B. prionotes stored well at 1°C, losing only 2% of vase life after two weeks storage, 42% after four weeks storage and 52% after six weeks storage (Seaton and Joyce, 1991b). It may be possible to use this method during sea freight of banksia to export markets in Japan or USA. However leaf blackening may limit this application. Variations were observed between the proteas when cold stored (Jones and Faragher, 1989). Vase life of T. speciosissima lost one quarter of flower vase life (compared to unstored control) after four weeks cold storage (Faragher 1986a, b).

Controlled atmospheres. One hundred per cent nitrogen atmosphere for 24 hours gave 90% control of earwigs but no control of garden weevil when tested on Protea while vase life of flowers was not diminished (Maughan, 1986). Forty per cent CO_2 at 20°C (initial storage concentration) for 48 hours was required for 90% kill of earwigs but there was some loss of vase life of Proteas (Maughan, 1986). Storage at 2°C in a 20% CO_2 and 2% O_2 atmosphere gave 91% mortality of test insects after ten days (Coetzee and Wright, 1990). After this time Protea flower quality had deteriorated.

Aerosols. Applying insecticides as an aerosol to bunches of flowers standing in buckets of water in a 20°C room has been favoured for disinfesting proteas (Meynhardt, 1976). Less damage of flowers with aerosols compared to dipping is expected and flowers remain dry throughout treatment. Aerosol insecticides formulations with CO_2 as the carrier are commercially available as Insectigas® containing dichlorvos (Anon 1986a) and Pestigas P® containing natural pyrethrin (Anon, 1986b). These can be applied by an automatic dispensing system "space controller" (Commonwealth Industrial Gas®, Anon, 1986c).

Pestigas P® or Pestigas P® plus Insectigas D® gave 90 to 95% control of earwigs, spiders (Forficula auricularia), thrips and ants in P. cynaroids, P. neriifolia and P. grandiceps (Maughan, 1986).

A combination of permethrin (0.036 g ai m^{-3}) as Pea Beu Control® and Insectigas D® (0.038 g ai m^{-3} dichlorvos) killed more earwigs within flowers than Pestigas P® (0.008 g ai m^{-3} natural pyrethrin) plus Insectigas D® or permethrin alone (MacFarlane and Franz, 1989). They achieved up to 99.4% kill for earwigs and 98.8% for spiders 48 hours after treatment.

There was 8 to 10% less kill of insects located inside B. speciosa flower bunches than of insects located outside of bunches (i.e. 85 to 99% kill). However, by drawing Insectigas D® through flower boxes located within a disinfestation room (forced draught application) 99% kill was achieved, (Seaton unpubl.).

A novel method of disinfestation of injection of dichlorvos or deltamethrin directly into Protea inflorescences was found to give satisfactory control of insects (Coetzee and Wright, 1990).

Insect Disinfestation Control Methods Used by Australian Protea exporters - a national survey

A survey in 1988 (Seaton unpubl.) found that insect disinfestation methods used by Protea exporters were: field spraying, dipping, aerosols and fumigation (Table 2).

In the survey, insecticidal dips used were Permethrin or dichlorvos. Dipping was found to be suitable for some proteas but in other proteas, flowers took a long time to dry and flower anthers and style became disarrayed. Dipping with dichlorvos is considered too hazardous to operators and the less toxic deltamethrin (0.0025% v/v) is now registered for use on cut flowers (Seaton and Joyce, 1988).

Exporters found they had varying success using methyl bromide fumigation. A prefered method of disinfestation was using aerosols. One exporter recirculating the aerosol through boxes of flowers using a forced air circulation.

Conclusion

To minimize insect damage in proteacea and reduce quarantine problems on export markets there is a need to identify the insect species, the damage caused and to monitor seasonal changes in insect numbers. Insect control would then include a strategic field spray programme to prevent early damage to flowers and to reduce insect numbers before harvest. It would also include a postharvest disinfestation system suitable to the particular protea flower and insect type. Further research is needed in these areas to develop insect free flowers.

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Table 1. Insect pests encountered in Proteas, Waratahs and banksias at post harvest packing sheds during processing for export, from a survey conducted in 1988 of the Australian cut flower industry (Seaton unpubl.)

Cut flower export	Insect
Western Australia	
Banksia spp., *Dryandra* spp.	Gall wasps, thrips, borers, beetles, aphids
Protea (*Protea* spp., *Leucodendron* spp., *Leucospermum* spp.)	Spiders
Victoria	
Protea	Spiders, earwigs, scale, thrips, caterpillars, stink bugs, mealy bugs
New South Wales	
Protea	Spiders, ants, scale insects
Waratah	Spiders, ants
Queensland	
Protea	Mites, weevils

Table 2. Insect disinfestation control methods used by Australian Proteaceae exporters from a survey conducted in 1988 of the Australian cut flower industry (Seaton unpubl.)

Species	Method	Comment
	Proteas	
P. grandiceps, *P. cynaroides*, *P. magnifica*, *Losalignum*, *P. neriifolia* (pink ice), *Leucadendran salignum*	Manual field spray	To dislodge insects Permethrin plus malathion
P. repens, *P. magnifica*, *P. neriifolia*, *P. grandiceps* *P. cynaroides*, *P. obtusifolia* *Telopea speciosissima*	Aerosol	Insectigas D® and/or Pestigas P® in combination 38 gm/m^3 Two hours 15-20°C
Leucospermum spp. (pincussion), *T. speciosissima*	Dip	Permethrin plus fungicide
P. cynaroides, *P. neriifolia*	Dip	Dichlorvos
	Banksias	
Banksia spp.	Aerosol	Insectigas D® and/or Pestigas P® as for proteas as fresh flowers
Banksia spp, *Dryandra* spp, *Stirlingia* spp.	Methyl bromide	32 gm/m^3 two hours at 20-25°C Varying results For fresh or dry flowers

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BIOLOGICAL CONTROL OF *SILVER-LEAF* AND *ARMILLARIA* DISEASES OF WOODY PLANTS, INCLUDING *LEUCADENDRON* WITH *TRICHODERMA*

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ABSTRACT

Isolates of *Trichoderma* species were screened for activity against a variety of crop pathogens and the best strains were selected as potential biological control agents (BCA's). Inoculum from superior *Trichoderma* BCA's was formulated into a variety of gels, liquids, solids and powders for field trials against *silver-leaf* disease of pipfruit and *Leucadendron* and *Armillaria* disease of kiwifruit vines and shelter trees in the Hawke's Bay, Waikato and Bay of Plenty districts of the North Island of New Zealand.

Silver-leaf infected Asian pears became free from symptoms, healthy and vigorous, after one *Trichoderma* BCA injection treatment. Healthy tree where pruning wounds were protected with *Trichoderma* BCA gel, remained largely free from *silver-leaf* infection. By contrast, controls and fungicide treated trees became seriously infected (1988-1991). Field trials to evaluate prevention and cure of *silver-leaf* disease in *Leucadendron* with *Trichoderma* BCA formulations are in progress and the initial results appear to be promising.

The "Tipit" gel pruner, which was specifically developed at Ruakura for kiwifruit in New Zealand, is under evaluation for *Trichoderma* BCA gel application in *Leucadendron*, pipfruit and stonefruit.

Mortality of kiwifruit vines and shelter trees from *Armillaria* disease was reduced and plant vigour increased by various *Trichoderma* BCA treatments (1987-1991).

ECONOMICS

A BUDGET ASSESSMENT OF PROTEA GROWING IN WESTERN AUSTRALIA

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Introduction

Early in 1989 the Western Australian Department of Agriculture decided to undertake an economic evaluation of the states protea industry. Having just completed budgets to evaluate the growing of kangaroo paws and Geraldton wax, I had an opportunity to complete a similar evaluation of the protea industry.

An economic evaluation of the protea industry was required for two main reasons,

1) to assist in identifying the growing costs to indicate the profitability of the species examined
2) these budgets could then assist in the evaluation of both the industry and individual species.

The preparation of long term development budgets for a number of species was considered to be the most appropriate method to conduct this evaluation. A ten year term was decided upon as this was estimated to be the expected viable length of production for most species.

It may be asked why budgets were used to assess the industry:

Well prepared budgets will indicate ;

- the start up capital required
- when that capital was required
- the profitability of the crop
- labour resources required
- the actual growing costs
- it would identify high cost activities which need special attention
- and allow a sensitivity analysis to assess the various risk factors possible, due to changes in management practices or markets.

Such figures assist the Department of Agriculture's advisory work with potential and existing growers.

Aim

The aim of this project was to work with commercial growers of South African Protea species in Western Australia, collecting accurate data to produce long term development budgets for a broad range of protea species. These budgets would show the costs associated with the production, and the expected returns, of the protea crops of these growers. This data would then be used to determine growing practices and to provide ccurate figures to assist in the preparation of budgets for the Department of Agriculture.

Method

From the results of the Wildflower and Protea survey, conducted by Julie Pegrum, research officer with the Department of Agriculture, in 1988, four main species were identified for which to collect data for this project. They were ;

- Protea cynaroides
- Protea repens
- Protea neriifolia
- Protea"Pink Ice"
- Leucadendron discolor
- Leucadendron gandogeri
- Leucadendron laureoleum
- Leucadendron"Silvan Red"
- Leucospermum cordifolium , and
- Seruria florida.

For budgets to be of use to the Department of Agriculture, accurate data had to be collected. To obtain such accurate information, four protea growers were approached to record all those activities that were used in growing their protea crops. Unfortunately the main protea growing region of Busselton in the states south west provided location difficulties, hence growers from Gingin in the north to Mandurah in the south were used. The four growers selected, needed to be reputable growers prepared to cooperate in this project by giving accurate data on their growing activities. They were selected from as diverse an area as possible to give a range of yields from different locations.

At the first meeting with each grower, in March 1989, I described the aims of the project and what I expected to achieve. They were then asked if they were prepared to participate, each being assured that the confidentiality of their data would be maintained. Each showed enthusiasm for the project and all were willing to join. At this first visit, each grower was given a "diary" to record all activities,such as weeding, spraying, fertilising, irrigation and general manitenance, incurring a cost that could be attributed to the growing of their proteas.

Periodic visits were made to each grower to address any queries that may have arisen. At the last visit in December 1989, diaries were collected along with further detailed data regarding harvest costs, the hours required to pick each species and the yields.

All budgets were prepared on the Departments "Wild" program. This program was originally written by Trevor Boughton from the Department's Manjimup Office for use in the fruit industry, which was then modified by myself for use with floriculture crops.

To ensure that the same costing was used for all budgets the individual costs of each grower were not used. All costs were taken from a Department of Agriculture price file costing all items and activities associated with horticulture. This allowed a true comparison to be made between the growers for the final assessment.

Costs associated with harvest, from the picking through to the point of sale, were calculated by determining the number of stems picked and processed in one hour and then expressed as a cost per 100 stems. The labour cost per hour was used to give the actual harvest costs. The number of stems harvested per hour was averaged over the full harvest season where possible. Where this had not been possible to record, grower figures from previous harvests or from crops of similar handling features and times were used.

A joint table was prepared for all management practices used by the growers. These were then assessed to ensure that they were accepted as industry practice before they were used in the final budgets.

RESULTS

My results, based on a wide range of predetermined assumptions, reveal there are minimal profits to be made from growing most protea species.

I have chosen to demonstrate the results in three forms.

Firstly by a graph of the cumulative cash flows over the 10 year term of the budget. (Graph 1.)

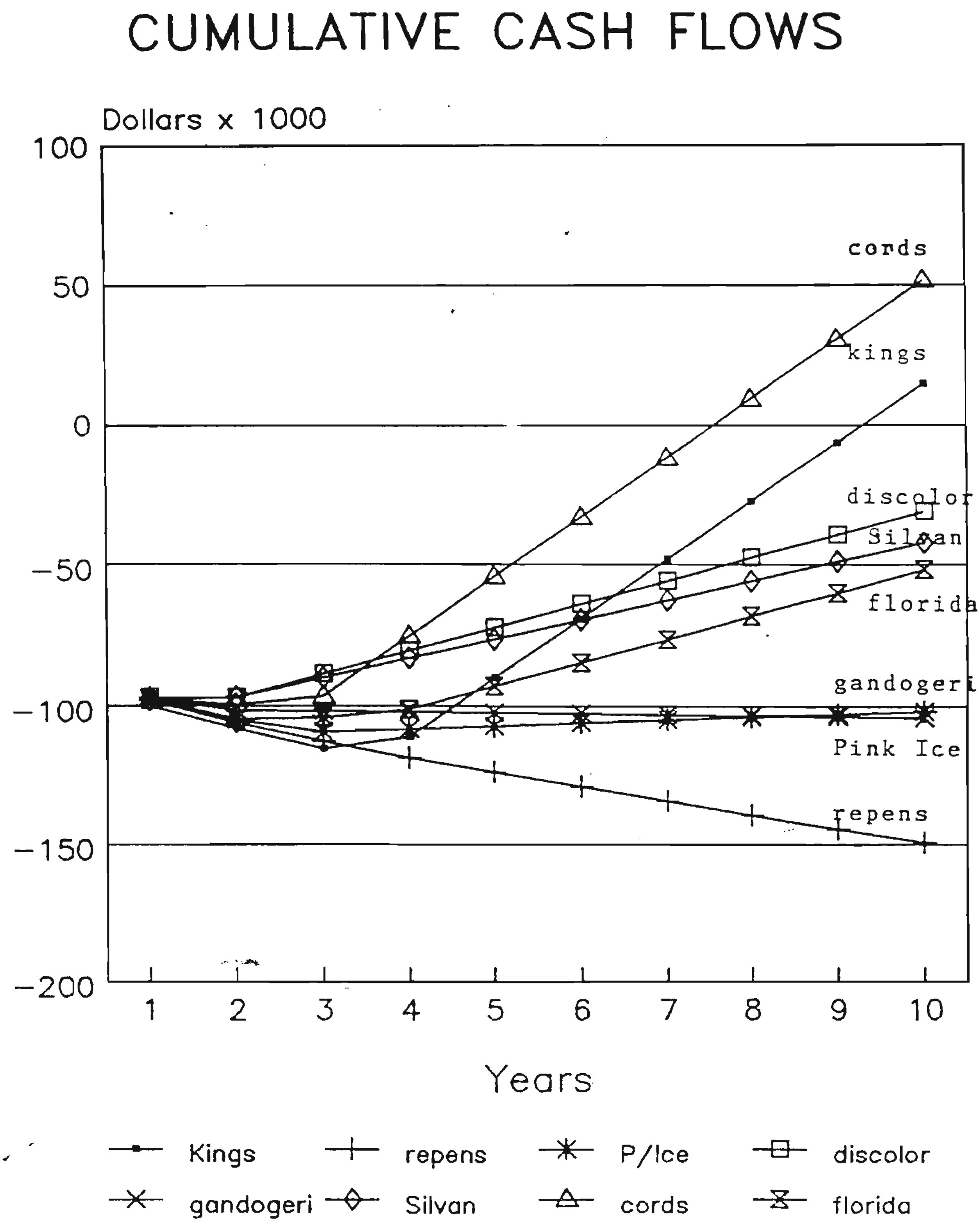
This clearly shows that only P. cynaroides and L. cordifolium return a positive cash flow by year ten.

The second by a table showing a summary of the major costs for each species against the respective return. Table 1. You may note that there is assumed to be little difference in the growing costs and practices for most species.

The only species shown to be profitable to grow are those that command a premium price such as P. cynaroides or are high yielding and fast to harvest, such as L. cordifolium, L. discolor, L. "Silvan Red" and S. florida.

Once again the most profitable species to grow is P. cynaroides at 95.12 cents per stem. This is due to its premium price. L. cordifolium was the only other species showing a reasonable profit margin at 22.86 cents per stem due to its higher price and high yielding capabilities. These two species returned a net profit of 63% and 57% of their respective sale price.

The third method use to show the results is by calculating the break even point for each species. (Table 2.) The break even point being calculated by dividing the total cost of production by the total number of stems produced, over the


CUMULATIVE CASH FLOWS
Dollars x 1000
100
50
0
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Years
cords
kings
discolor
Silvan
florida
gandogeri
Pink Ice
repens
Kings
repens
P/Ice
discolor
gandogeri
Silvan
cords
florida

ten year term of the budgets. No allowance has been made for inflation with regard to cost or changes in return over the term of the budget. All capital costs were excluded from this calculation.

Table 1. Costs and Returns.

Summary of Protea Budget Results Prepared for the Department of Agriculture.

All costs and returns shown in cents per stem

Species	Grow -ing	Pick -ing	Post-Harvest	Over-heads	Total costs	Return	Net Profit (Loss)
P. cynaroides	22.73	7.83	15.1	9.22	54.88	150	95.12
P. neriifolia	6.35	5.85	11.3	2.46	25.96	20	(5.96)
P. repens	6.35	5.85	11.3	2.46	25.96	20	(5.96)
P. Pink Ice	7.94	5.85	11.3	3.07	28.16	30	1.84
L. discolor	5.29	3.13	6.1	2.05	16.57	25	8.43
L. gandogeri	7.94	3.13	6.1	3.07	20.24	20	(0.24)
L. laureoleum	7.94	3.13	6.1	3.07	20.24	20	(0.24)
L. Silvan Red	3.97	3.13	6.1	1.54	14.74	20	5.26
L. cordifolium	5.72	3.13	6.1	2.18	17.14	40	22.86
S. florida	5.29	3.13	6.1	2.05	16.57	25	9.43

Table 2. Break Even Points

Species	Total Stems	Total Cost($)	Return Cents/Stem	BEP Cents/Stem
P.cynaroides	142,210	104,046	150	73.16
P.neriifolia	583,310	173,551	20	29.75
P.repens	583,310	173,551	20	29.75
P.Pink Ice	491,690	157,816	30	32.10
L.discolor	850,000	151,952	25	17.88
L.gandogeri	566,690	125,798	20	22.20
L.laureoleum	566,690	125,798	20	22.20
L.Silvan Red	1,149,970	179,645	20	15.62
L.cordifolium	699,980	137,911	40	19.70
S.florida	725,000	140,441	25	19.37

These figures again show the most profitable species to grow are P. cynaroides and L. cordifolium.

Discussion

A budget is a tool used to make management decisions. It is a set of assumptions to predict future costs and income so the reality of the budgets depends upon the accuracy of the data used. Any set of figures may be used to justify a cause if needed, but if budgets are to be of any use in decision making, they have to be accurate.

To prepare a budget for general use is a dangerous task because of the many differing variables between growers. These include ability, management practices used, yield, location of the property, other business interests and capital required. Because of these variables between growers, it is important to state the parameters that are used.

Four growers is not a sufficient number to survey to get a true indication of growing practices to determine average industry costs. This number was used because of the limited number of growers prepared to divulge their growing costs, methods used , record the data required, and the remoteness of the properties. I have based my assumptions on the data collected from these four growers however, my research indicates that the assumptions used are comparable to accepted industry practice.

In preparing these budgets I have included all capital items that may be required. They include the purchase of a 5ha property, machinery requirements and irrigation equipment. I determined that these initial capital cost to set up a protea enterprise would be $85,000. By returning to Graph 1, it can be seen that growers already owning a property and machinery may grow proteas more profitably. This is demonstrated by shifting the "0" line down by $ 85,000.

For the growing activities I have included every item possible giving a maximum growing cost. These costs include planting, materials used such as chemicals and fertilizer, labour requirements for each activity costed at $9/hour, pump running time for irrigation, machinery use, weed control and pruning.

The most difficult costing to determine accurately was for harvest and postharvest handling. These costs, along with yield, are the most variable within species and differ with the efficiency of each grower. This item ,as a percentage of total cost, represented approximately 60% over all the budgets prepared. Given the importance of this figure to profitability, data specific to the harvest operation was obtained from several other growers to verify this component of the budgets.

Other costs included overhead costs such as telephone, rates and insurance. These have been proportioned down to match the area of the crop. Neither interest payments nor capital repayments have been included in my budgets but the programme has the facility to add these costs if required. The reason no capital or interest repayments are included in the budgets is bacause of the varying levels of capital growers may have access to and the variation in borrowings required.

As the Department of Agriculture is a Government sponsored advisory body, it may err on the side of caution. Data used in the preparation of budgets has to be supported by hard evidence and any data collected from the four growers not conforming to existing written data, had to be thoroughly investigated before being used.

The practice of being conservative on yield estimates and the sale price, then using maximum production costs narrows the profit margin for each crop. However, growers who can trim their costs by being more efficient, by harvesting more stems per hour or produce yields above those used in my assumptions, will increase their profit margin above the level shown. The prices used for each species were assumed to be the farm gate price and were lower than actual prices received by growers. This eliminated the need to determine the freight component of costs. Using a lower price also made allowance for new growers not being able to produce the high quality stem that experienced growers may do and attract a premium price.

A small section of the budget summary is called the "Average Production Cost Summary". This reaveals activity costs and the viability of each species. (Table 2.). This summary is also useful to compare all activities as it also expresses this cost as an overall percentage. (Table 3.)

Table 3. Costs expressed as a percentage of total cost.

Species	Cost as a percentage			
	Growing	Harvest	Postharvest	Overheads
P. cynaroides	41	14	28	17
P. neriifolia	24	23	44	9
P. repens	24	23	44	9
P. Pink Ice	28	21	40	11
L. discolor	32	19	37	12
L. gandogeri	39	15	30	15
L. laureoleum	39	15	30	15
L. Silvan Red	27	21	41	10
L. cordifolium	33	18	36	13
S. florida	32	19	37	12

The combined harvest and postharvest cost of most species is in the vicinity of 60% of the total cost and the growing costs about one third. Budgets prepared for the growers indicated that the growing cost was generally below 20% and the combined harvest and postharvest costs were mainly in the vicinity of 75%. This difference indicates the effect of using maximum growing costs used in my budgets.

CONCLUSION

I hope that I have not discouraged any growers or potential growers with my research. My results are based on the assumption I have drawn from working closely with four growers and will differ from another person preparing similar budgets. However, there are benefits to be gained by my research.

It shows that the large capital outlay to establish a protea growing enterprise will not necessarily return those setup cost in the short term. However, as an extra activity on an existing property, profits can be made as it allows for the better use of existing resources.

One of the great benefits of preparing these budgets is that it identifies less profitable species. Under current market conditions, several species should not be grown in large numbers because of their low returns. These are P. neriifolia, P. repens, L. gandogeri and L. laureoleum.

By studying the intimate activities of growing proteas it is evident that the main cost starts at harvest. Therefore an extra application of fertilzer or chemical, to improve flower quality, will not make a great difference to the overall cost. This is an indication of how the budgets can be used to make management decisions.

My research indicates that the species most profitable to grow are those which command a high price or are high yielding, thus giving a higher margin of profit over species returning lower prices and yields. I would not recommend however, that only these species be grown, for it is necessary to have a variety of flowers to have continuity of supply to your market and to maintain your market share.

Acknowledgements

Thanks to the four growers Don Cameron, Bob Harington, Grant Pearson and Ralph Sedgely who participated in this project. Without their contribution it would not have been possible. Thanks also to Julie Pegrum and John Gallagher from the Department of Agriculture's Division of Horticulture for their technical assistance.

Biographical Profile

Name : Eric Skipworth

Employer : R & I Bank of Western Australia

Position held : Rural Consultant

Eric Skipworth grew up on the family farm just outside the wheatbelt town of Morawa.

He has 20 years' farming experience, both on his family's farm and his own farm, as well as 5 years farm managing and developing properties close to Perth.

He moved to Perth in 1985 and commenced studies at Curtin University of Technology in 1987. Whilst at university he spent several months with the Western Australian Department of Agriculture, Horticulture Branch, working with budgets to assess wildflowers grown in the state. He completed the requirements for the Bachelor of Business (Horticulture) in June 1990 when he graduated as Dux of the course.

Since graduating he has been employed as a Rural Consultant, both in private enterprise and in his current position with the R & I Bank.

THE ECONOMICS OF PROTEA GROWING

FINANCIAL ASPECTS OF PROTEA GROWING

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Australia

Which title do you like? I have chosen the lower one. It seemed to give more flexibility and anyway I have often wrestled with "Profits From Proteas" and the like and it comes out more like "How Long Is A Piece Of String?" There are so many assumptions which differ for each producer. It would be much simpler if the wholesalers were asked to deliver a paper on "Making Proteas Pay" or somesuch because they don't have the same climatic variables and lots of them operate from the same sheds and their flowers come packed in boxes that are relatively standard too. Strangely though over the past few years or so I can't recall seeing an article touching on the profitability of the wholesalers, or their costs or much else really factual about them.

The really big flower growers in roses, carnations etc are wholesalers and there is probably a lesson to be learned from them. Investment in marketing and selling is associated with success in the cut flower business.

We have some great personalities in the wholesalers ranks but am I beginning to imagine that there is some negative selling technique in the wholesalers refrain "Things are not looking too good?" For goodness sake you can't encourage growers expectations.

Florists come and go rather more rapidly than wholesalers - a bit like Protea Growers really. The ones that are very careful not to overbuy and can use all the bits and pieces, old and new, seem to still be around. I remember selling a Banksia spinulosa bunch to one of these people once and saw each flower cut across into colourful slices - it looked attractive, quite different and went much further.

And then there are exporters/importers and rather special traders who somehow manage to continue in existence - even dried flower dealers. You can't omit the nurseryman. Quite extensive studies have been carried out and published on Retail Nurseries. Detailed costings regarding use of space, cost of potplants, display turnover ratios and many other aspects are available. But we know times are difficult for some nurserymen. Perhaps that's why we have reports. Wholesaler nurseries somehow remain more of a mystery. Profitable?

You can see from all this that there are many people involved in making money, perhaps even a lot of money, from Proteas. But everyone wants to know about the growers financial welfare.

It will be apparent that the growers fortunes are not isolated from all these other groups. Growers sell to them and depend on them for volumes and prices. As with the growers there are some very inexperienced business people attracted to and involved in the 'come lately' protea flower industry and this should be borne in mind when conducting business.

These days sound profitable business links have become important. Bad debts are causing great concern. All the links in the selling chain, grower,

...olesaler and retailer or the other intermediaries when used should trade at ...ces which leave adequate margins. But there are some features of cut flower trading which would not be acceptable in other markets. What protection does a grower have when he consignment sells to a wholesaler who also acts as a principal and is also a grower? Should wholesalers disclose ...ir position? Should agency sales be put ahead of principal sales? What is ... basis of pricing between these sources?

... our wholesale markets simply pre-selling stations rather than auction ...ms? To what extent are prices controlled by wholesalers positions rather ...n the supply of produce coming to market? Are market positions/stalls sufficiently available to prevent wholesaler dominance of prices and volumes? I do not believe there are satisfactory clear cut answers to many of these questions.

However it is clear from the margins and costs in Australia that the most profitable outlet for growers is direct to florists..Sydney prices for most Protea/Banksia cut flowers are higher than elsewhere in Australia. Sydney florists are therefore the most profitable outlet for growers who sell direct to florists. But to maintain such a service the grower needs a wide range of products. He needs to maintain close contact by telephone or fax with the needs of the florist uppermost and particqularly there is a need to maintain freshness and quality of his product.. Too often do business associations slip because unwanted inferior and badly packed flowers are 'slipped in' to consignments. Selling direct to florists avoids the 20%-30% wholesale charge and it avoids wastage when freshly cut flowers can not be sold quickly at the market. Freshness is the great asset of cut flower growers. When new technologies are rapidly improving the quality of dried flowers cool storage may be a necessary evil in some situations. But time saved in delivery from cutting to end user should always be top priority. Also it should not be forgotten that 20% of market price represents 25% of the growers net market price and so on. These observations are made in the hope that those setting up wholesale markets, especially if these groups are non-governmental, will aspire to the required standards without the need for cumbersome regulations by "the Authorities".

Probably the next most profitable market is the export market but it means significantly higher risks, additional work and extra time consuming documentation. At this stage there are few fixed price contacts for Australian producers exportingto Japan. The USA is better. There are some and these from personal experience are subject to price under cutting from other protea growers. Growers may export direct to overseas markets or use an agent. Direct export obviously saves charges ranging from 10%-20% generally which is the agents fee. However it also needs a reasonable volume of a single product. Negotiations about freight are very important as up to one half of the shipment value is freight costs. It is possible for smaller shippers to negotiate 'add on' and obtain marginal air freight costs for their flowers. They can also co-operate with other exporters to create consignments, say 1500kg large enough to bring concessional freight rates. Recent lower Qantas freight costs to Japan from Melbourne are:-

100kg	$2.10 per kg
250kg	$1.80 per kg
500kg	$1.60 per kg

Despite the talk Governmental Departments are making it much more difficult for small producers to begin to create new markets with their enterprise. The policy seems to be the trouble not the individual employees; that is

Quarantine Policies not Quarantine Officers. Let me quote one example. A shipment of 30 boxes, say 420 kgs, costs $900 in air freight to Japan. It incurs an additional $400 in costs in Japan and it realises $3000. There are many costs in selling other than those quoted. Boxes at $4.00 each, local transport $1.00/box for example before farming costs of selling such as picking and packing and the farm charges such as spraying and weeding and pruning and depreciation and overheads. These farm charges will range very considerably with the product but let us try a table.

Revenue 30 boxes at A$100/box		**$3,000**
Charges in Japan	$400	
		$2600
Air freight	$900	
		$1700
Boxes, local transport	$150	
		$1550
Farm charges Picking - Labour 20 hrs at$10/hr	$200	
		$1350
Packing - Labour 30hrs at $10/hr (packing for Japan is very laborious)	$300	
		$1050
Farm overheads	$150	
Growers margin		**$900**
Quarantine inspection (15 minutes overtime)	$91	
		$809

It is somewhat of a shock to realise that this compulsory inspection (although quoted at 15 minutes rarely takes longer than 5 minutes of the Quarantine Officers time but much longer for the grower who has to repack and bind opened boxes) absorbs more than 10% of the margin due to the grower. Five minutes work takes $91.00 and the equivalent of 50 hours work (often overtime and Sundays) yields say $809.

It is now proposed in Victoria at least that the hourly quarantine rate should rise by 10% and that a document charge of $20 for the phytosanitary certificate should be added. These new charges are discouraging the smaller growers with the initiative to export.

There is nothing wrong with the 'user pays' princple if it means the proper allocation of costs. However if this is extended to mean "double dipping" by Government Agencies and even worse the attempt to make people bear charges that are not needed or inefficiently applied it is quite wrong. The present method of Quarantine Inspection in Australia as applied to exporting horticulture is entirely unsuitable as to cost and effectiveness and should be completely revamped.

But to come back to the example of our impoverished exporter. The figures I gave are for say exporting Banksia Coccinea and achieving $2.00 a stem for a box of 50 stems of big flowered and long stemmed B. coccineas. The $10 per hour labour rate is the rate applicable to trained staff and compares to say $40 an hour for trained motor mechanics. There is a greater margin if the labour cost is reduced and the only labour input is the farmer and his family. They would be working all hours without penalty rates. It would seem that many growers are working for less than $10/hr - more like $3.. It does take some time for the harmful effect of loss on sales to become evident, usually when the initial investment needs to be replaced. Costs per stem are difficult to calculate because output of saleable quality flowers varies so much. Costs per hectare and profits per hectare (or other measures) are probably easier to work out. But a recent costing of Pink Ice which was quoted in the June 1991 issue of "The Australian Protea Grower" set the per stem cost at 49 cents. It is not quite clear from the article whether costs such as plants, depreciation, chemicals,fertilisers, interest, office overheads etc were included but the cost headings seem to indicate they were not. So for all those who sell nerifolias at say $3.00 a bunch they should be aware that they are in the break even area only.with a very limited future.

One of the areas of special interest to Protea growers is the pricing of flowers that are new to the commercial cut flower market. The Australian "protea" flowers are often novel and rarely hybridised. It has been my experience that quite profitable prices initially established from such flowers are relatively quickly reduced to a cost of production price. In many cases this is quite unnecessary. Once established at the lowest price it is much more difficult to get the market to recognise the new product as a "quality" product.

This placing of new products in quality zones is of greatest importance to growers. Wholesalers can make their margins at varying price levels but growers who receive their payments after the others have made their profits should be far more conscious of their need to take considerable care and commitment in trying to establish good prices for new products. As our industry develops no doubt growers will concentrate more of their resources on promotion. This does not imply that ridiculous prices should be sought . It is the sensible and necessary alternative to the present trend where growers sell down to a cost of production basis which is often underestimated or not estimated at all.

Protea growers are part of the wider world when they sell their flowers. Their market is international and they compete not only with their fellow protea growers but with all other flower growers and in the gift market scene with all other sellers of gifts. Their organisation does need to co-operate/co-exist with the florists.and wholesalers and exporters. However growers have special needs and they should look at marketing their flowers in a way which will lead to a sound future for growers. They should be looking at marketing where they have strong influence in the selling organisation

We are quickly learning where Proteas grow well in Australia and how to look after them. Soon selection will bring better control over quality and flowering times. Hybridisation will take us into exciting new forms and grafting will also greatly enhance commercial viability.

But more of our efforts as growers will have to be directed towards selling our flowers. It has been my experience that to make the best prices and profits a grower needs to take an active part in the selling of his own products. This is the single most important aspect of Protea growing. If a grower talks to the florists who buy his flowers they will learn (1) that freshness is very valuable (2) that early and late season flowering rather than mid season is of great concern for prices. The protea flower industry is exposed to chronic oversupply at times. Interstate suppliers should also be taken into account in setting flush growing times. (3) Each florist has special likes and dislikes in flower choices (4) Florists will sometimes 'talk down' prices but the sale price to florists offers the greatest margin (5) Florists want something new - new flowers and new seasons.

If export is chosen pay close attention to the price being achieved at the retail outlets in the importing country and work back to an anticipated Australian equivalent. The performance of the different importers varies a very great deal. If selling through a market system carefully check the costs which are being charged against your account As well in Japan for example where there are many alternative markets your representative (importer or wholesaler) may quite possibly be selling into the wrong auction for your products. It has again been my experience that these checks should be made no matter how prominent is the name of the importer. In fact some internationally known names can behave in an arrogant manner. Exporting to Japan introduces risks of Methyl Bromide fumigation which is costly and quite harmful to many flowers. Japanese Quarantine standards are very high indeed and a grower must go to great lenghts to examine flowers for any insects or blemishes. Quarantine standards to the USA are not so extreme but only clean material should be exported.

An exporters ideal target would be the end seller in Japan where high prices can be obtained. I know of excellent long term trading relationships being established with a high degree of loyalty and confidence.

Sydney has the best developed wholesale marketing system with the largest volume. Price information coming from wholesale markets is of value to growers. The Melbourne market is not regarded as a good outlet for quality flowers. It is used to dispose of lower quality material and has a relatively small turnover. Large merchant grower/wholesalers supply much of the Melbourne markets directly. Brisbane and more recently Adelaide have established wholesale markets but these markets would be much smaller than the Sydney/Melbourne markets and would not attract a big volume of interstate flowers.

So the growers must learn to look after themselves. If you concentrate only on growing you are likely to head quite quickly into "peasant" status.

MAKING PROTEAS PAY - AN AUSSIE PERSPECTIVE

Byron Scott
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I hope to answer the question "Can you make a living growing Proteas?", and to examine the effect of marginal changes in the cost/price equation of a Protea growing Enterprise.

I wish to present the actual trading figures for my Protea business PROQAL (Protea of Quality) for the period 1/6/90 to 31/5/91.

I will examine this in two sections;

a. Sales of flowers grown on my property, which accounts for about 50% of the total sales.

b. Sales of our own product, PLUS sales of product of other growers in the area (see addendum where the structure of the business is summarised). Expenses have been allocated as appropriate (eg. wages 80% to own material, 20% to purchased flowers).

A. SUMMARISED PROFIT AND LOSS ACCOUNTS

(Figures not fully available at deadline for publication copies will be supplied at Conference date).

PLEASE UNDERSTAND THAT THESE FIGURES ARE NOT BEING HELD UP AS AN EXAMPLE OF EXCELLENCE - BUT SIMPLY AS A POINT OF COMPARISON.

These figures are accurate only for my operation. No other business will have exactly the same mix of costs and returns. Many will be able to operate on a lower cost base, especially small family operated farms. These should also be able to aim at a higher quality/price level, the two factors together giving a significantly better net profit ratio.

From my observation, the larger the business the lower the price level obtained and the higher the cost base, resulting in lower margins.

If you take the time to factor in the inherent differences between your business and mine, you will have a useful reference point from which to estimate your own weak and strong points, and how to work on those. That is the value that I hope you can get from these figures.

Points to note:

1. Without the commission wholesaling side of the business, we would not be able to export successfully in our own right

- insufficient volume (of export quality) for much of the year (a certain minimum volume is needed to make export shipments worthwhile - especially to Japan).

- (Importers want variety in each shipment not just a large quantity of one or two types).

2. Without an export market our profitability would not be as healthy as it is. All products would be sold at the lower Sydney prices. Thus, in the present marketing situation, we would not have the same profitability if we operated as a grower only.

3. But the profitability does not come from commission wholesaling as such - the 10% commission does little more than defray costs. The value arises from the extra opportunities presented by the greater supply period, and variety of product.

4. It follows from this that I would be content to sell my flowers to someone else offering a similar deal as long as I was sure that they would be in business for the long term.

5. Thus any grower can get the same or better profitability, without the commission wholesaling, as long as they can sell to someone offering a comparable price structure.

6. My feeling is that greater economies of scale can be seen, up to approximately double the turnover. Beyond this it may be difficult to keep full control of the quality, under my present system.

7. I am presently planting another 4 - 5 acres, and am expecting a further 8 - 10 acres of recently planted material to come into production over the next 2 years. Along with other newly planted material in the district, I expect our turnover to double in the next 2 years.

B. HOW CAN WE IMPROVE ON THE BOTTOM LINE? or Lets fiddle with the figures

a. Cost Control

Many costs are inelastic. The major variable cost is wages. In my operation wages are about 35% of my net profit. (If I and my wife worked full time in the business it would be a lot less. Conversely as the business grows, wages will increase as a percentage of net profit).

Most of us could reduce our wage bill by attention to the following:

- the flow of work, both field and shed

- better planning and organisation of each days work

- machinery and equipment, more mechanisation

- improved varieties (fewer bypasses etc)

- the efficiency, motivation, work practices and working conditions of individual workers. This will involve formal or semi formal training, instruction sheets for individual tasks, and strict rules of practice for all procedures.

I suggest that 90% of us here, including me, do not pay sufficient attention to these points. In fact, to do the subject justice, we could probably devote a whole conference to it.

For example, if a business that picks, strips, trims, hydrates, transports, grades, bunches, fumigates, cools and packs 100,000 stems per year, were able to save just 5 seconds per stem over the total of all those procedures that business would save around $1300 per year in wages. In some businesses the potential savings are upwards of 15 - 20 seconds per stem.

In my case, if my wage bill can be reduced by 10%, that will result in an extra $2500 in my pocket. Note that I am talking about improved efficiency and less working hours rather than reducing the hourly rate. Paying a lesser rate will probably be counter productive.

Naturally cost reductions should not be at the expense of quality maintenance.

b. <u>Increase quantity</u> (from existing plantings) while maintaining the quality mix.

An increase of 10% would increase labour cost by around 5%. Allowing minor increase of other costs, we would expect an improvement in net profit of around 15%.

Possible means of increasing quantity (average stems/bush)

1. Improved insect and weed control

2. Improved watering (timing and technology)

3. Increased knowledge of specific fertiliser application

4. Better pruning

5. Reducing incidence of missed flowers at harvest, and better marketing during periods of glut.

6. Better varieties/cultivars (applicable to future plantings)

7. Support and apply industry led research into specific problems of cultivation and management.

c. Improve quality (whilst maintaining quantity)

If I could move 10% of production into the next grade up, my gross profitability would be some 13.5% improved leading to a net profit increase of over 20%. Note that there need be no increase in costs or work involved, at all.

How to achieve this;

- all of the points listed in (b) above with special emphasis on 1, 4, 6.

- in addition

8. Attention to all aspects of post harvest handling, water, cooling, pulsing (where appropriate) cleanliness, and avoidance of physical trauma.

9. Packaging materials, packing techniques and presentation, and the method of transport.

Attention to quality will also have the unquantifiable benefit of enabling your flowers to be sold when others are languishing during the inevitable glut periods. During such times superior quality really pays off.

d. Increase price received.

A 10% increase in price received will increase the gross receipts by 10% while not changing the cost structure at all. Again, the bottom line improvement is 20% plus.

Very few of us would fail to benefit from a judicious examination of our marketing and sales efforts. This could involve shopping around for new outlets offering either better prices or more consistent flow of orders.

Whether we are selling mixed bunches to the local deli or selling to a variety of overseas buyers, there are likely to be benefits in getting price comparisons and a little personal representation. In some cases it may be as simple as being more in touch with our existing outlets, to take advantage of shortages of supply, special day promotions etc. Whilst our phone bill may be a little higher, the extra income is all cream.

In my experience flower growers tend to undersell their product rather than oversell. However a flexible attitude of mind is necessary to meet changes in our market environment.

Suggestions on improving prices

1. Attention to quality as in (c)

2. Sound out other wholesalers/florists etc

3. Go direct to florists with part of production

4. Examine markets in other Australian cities

5. Examine the possibilities of export either alone or with someone experienced.

6. Make regular visits to your markets. Get to know the system, the people, the buyer's needs etc.

7. Concentrate on the best forms within a flower variety and the best species. Where possible, take into account the current and likely extent of plantings of specific types. Some highly attractive and popular varieties have been overplanted, (relative to the current market) and enter regular glut periods when prices are forced down. Other varieties, of limited appeal by comparison, are always saleable simply because they are different and available only in small numbers. If possible grow at least a couple of types that are not generally recommended, because you know they will never be available in quantity. Similarly if your conditions are suitable for a variety that most find hard to grow, then you have the opportunity to produce a higher priced line.

8. Aim production at the early or late stages of the period typical of that variety, where possible, eg. Pincushions command a higher price at Christmas than during mid November. Techniques are being studied to delay bud development using chemicals, and there are other more natural ways to use the inherent characteristics of your environment to advantage.

9. Foster a reputation as a good consistent supplier. These are the ones the buyers will wish to retain and help when times are tough.

10. Support Industry promotion designed to bring greater awareness to florists and/or the general public, both within Australia and in selected overseas markets.

e. <u>The Improvements are Cumulative</u>

By selecting one or two relevant suggestions from each of A, B, C, and D it is likely that the bottom line of every enterprise, large and small, could benefit by 15% - 35% with no extra physical effort involved.

It is up to each of us to identify the points where we are weak and to work out a program to overcome these weaknesses. In most enterprises there will be several areas, each of which could yield a 2%, 3% or 4% improvement and these are additive.

The identification of these weaknesses is dependent on a good working knowledge of our Industry. How, for instance, can we come to the realisation that our quality would benefit from better pruning, if we, <u>and our staff</u>, don't understand the basic principles of pruning?

Our beloved leader, Mr Hawke said recently that Australia should become the 'Clever Country' - that we should work smarter, not harder. We need knowledge, training and a degree of lateral thinking to spice up our Management skills. This is one of the few things he has said that I can unreservedly agree with.

<u>FUTURE PROFITABILITY LIES IN EXPORT MARKETING</u>

In the medium term, Australians have to aim at sending a larger percentage of product overseas. Our local market is close to saturation point and we could be on the verge of a serious price collapse. Export sales are rewarding but there are some serious pitfalls to negotiate first:

1. Quality is of paramount importance. Some markets just won't pay for poor quality product. Besides, airfreight space is just as expensive for poor product, so why not use a scarce and expensive resource to best advantage?

2. Airfreight space is at a premium during Spring. A good freight forwarder is worth his weight in gold when the problems pile one on top of another.

3. Government red tape and paperwork is becoming more onerous, more costly and less flexible. In combination with other fresh produce exporters, our Associations must lobby to curb some of the bureaucratic excesses.

4. Associated with the above, our Quarantine Inspection System needs a special shake up in terms of cost, and

particularly out of hours charges.

5. The more material that goes overseas the less likely we are to suffer 'gluts' locally.

6. On the other hand we must not leave only the 2nd grade product for sale in Australia, either. There must be a balance.

7. Promotion of our product overseas will become essential in our drive to increase sales. It is expensive. It will need cooperation between Growers, Industry Associations and Government on a scale which is not yet evident. It is important that all Growers support such schemes proportionally. A successful promotion in (say) Japan, benefits even the smallest grower (see point 5 above).

INDUSTRY BODIES - Are they relevant to our profitability?

Our Industry is still immature and because of that there is little consolidated, authoritative text on cultivation, management etc. However, individual practitioners have a great deal of knowledge in their heads. Most are prepared to share it in the appropriate surroundings.

The funding of research, and dissemination of the results, is a task suited to National and International Associations - another aspect of the information sharing process.

I cannot emphasis too strongly the importance of membership of, and participation in, your local Association. But to get full value, each of us has to put something in - direction, ideas, sharing knowledge and an open mind. The stronger the local body, the greater are the benefits to individual members.

Similarly the greater the cohesion between local Industry Associations on a National and International scale, the greater the advantage to us all.

ADDENDUM DETAILS OF PROQAL

Situation	Adelaide Hills, 30 mins east of GPO, 45 mins from Airport.
Climate	Winter, cold, wet (40" rainfall) Summer, hot, very dry
Terrain	Hilly, well drained
Soil	Poor, thin sandy loam topsoil over sandstone clay in some areas.
Area Under Cultivation	20 acres (10 acres in full production now) another 4 acres being planted.

Varieties — Approximately 50 : 50 Protea, Leucadendron. Moving towards increasing proportion Leucadendron.

PROTEA: repens (summer) magnifica, cynaroides, nerifolia, pink ice, frosted fire, obtusifolia.

LEUCADENDRON: silvan red, safari sunset uliginosum, argenteum, 'harvest', 'pisa', 'maui gold'. Ixodia Achillioides (SA Daisy).

Plant and Facilities — 18 hp Tractor, cultivator slasher, Hardi spray unit, Silvan Turbomiser, 4 wheel motor bike and trailer.

Large shed, coldroom (3.6 x 3.6m) Fumigation chamber (self constructed) sundry trolleys etc.

Bore, drip irrigation system utilising Netafim drippers (self compensating).

Staff — From Feb 91 - one full time person

4 part timers

owner works approximately 3/4 time in this business

Progal is — a grower of flowers

a commission wholesaler of flowers grown on properties in our area.

an exporter dealing direct with overseas clients

an export combining with other exporters when appropriate.

At the present time we export about 1/3 of the flowers that pass through our packing shed. The rest are sold interstate mainly in the Sydney market.

Financial relationship with suppliers.

We remit 90% of the Sydney price to our growers. Export quality material usually earns a 10 - 20% premium, depending on a number of factors: volume, prevailing export price, adequacy of preparation and grading by grower, export demand, etc. Almost all export shipments are invoiced on a fixed price basis.

The premises and plant are all fully owned and no expense figure has been allotted to rent, lease, interest or opportunity cost in the profit and loss statements presented.

BYRON SCOTT - A PERSONAL PROFILE 1991

Born Adelaide 1948

Grew up on a sheep/cattle property in South Australia.

Attended University of Queensland, graduating in 1970 with a Bachelor of Veterinary Science degree.

12 years in private Veterinary Practice including 2 years in UK.

1980 Founded an Investment Newsletter for those interested in International Commodities and Currency Futures Trading. The Australian Investor's Digest gained a respected reputation and World Wide circulation. Sold out in the mid 80's.

Began planting Proteas on a property in the Adelaide Hills in 1982, 30 km east of Adelaide. Cash flow was provided by the Investment Publication and other retail businesses.

For the past 3 years the Protea plantation has been wholly supporting a family including 3 children (2 - 9 years).

The Protea business now consist of production from about half of the 20 acres planted to Protea and Leucadendron, together with marketing and distribution of this material plus that of other growers in the Adelaide Hills area.

Immediate Aims: To further the growth of the marketing side of the business with special emphasis on quality, efficient systems of handling, and further development of Export expertise with Japan receiving highest priority.

THE ECONOMICS OF PROTEA PRODUCTION IN HAWAII

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It is convenient to think of Hawaiian agriculture in terms of two distinct sectors: plantation agriculture (pineapple and sugar cane) and diversified agriculture (all other crops.) The former used to dominate the Hawaiian agricultural economy, but the balance is rapidly shifting to diversified agriculture. Flower production, mostly for export to the mainland, is the major diversified crop. (Department of Agriculture, 1990)

The state Department of Agriculture statistics do not treat protea separately, but clearly protea is a small component of the total flower crop. However, many feel protea's market potential is substantial. Also, in the suitable, higher elevation growing areas, it is an important production alternative. An economic analysis of protea production is necessary to assess the crop's commercial feasibility. Most existing and prospective growers do not know whether or not protea production is in fact profitable or how it compares to alternative production possibilities. The importance of being able to determine the current profitability is emphasized by the long-term nature of the crop relative to the rapidly increasing land values. Much of the land in the protea growing regions has appreciated in value recently and is now commonly valued in excess of $100,000 per acre ($250,000 per hectare).

PROTEA PRODUCTION MODEL AND EXAMPLE FARM

A computerized spreadsheet model of protea production in Hawaii enables one to estimate profitability over a wide range of conditions. In this analysis the measure of profitability is "economic profit" excluding a land charge, that is, gross income less all costs except a return to land. The result is a return to the land resource devoted to protea production. The user will need to determine whether or not this return is adequate, given particular circumstances with regards to land access.

It is assumed that the grower sells in the wholesale market and that the marketing decision is limited to choosing a buyer. Consequently, price risk is a major consideration, and the program allows a sensitivity analysis if 1-in-10 year high and low prices are entered along with the most likely current prices.

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[1] K.D. Fleming and J.M. Halloran are Extension Economists (management and marketing, respectively), Department of Agricultural & Resource Economics; K.W. Leonhardt is Extension Horticulturist, Department of Horticulture.

The example enterprise discussed below is representative, but it is important to realize that conditions vary widely and all of the production and price variables can be modified in the model to conform to particular growing circumstances. The program easily accommodates any reasonable size protea enterprise. The example growing area being considered is 10 acres (4 hectares), but the total area is assumed to be somewhat larger in order to accommodate roads, buildings, and other infrastructure. Furthermore, while this study only examines the protea enterprise, the farming operation may include other enterprises as well. However, protea farms in Hawaii usually specialize in protea production. In any case, the scope of this study is limited to examining the annual returns to the protea-growing land resource, i.e., to the protea-growing land as a whole and per acre (or hectare.)

GROSS INCOME

The revenue equation is yield times price. Producers typically grow a number of varieties to reduce market risk, to achieve a more stable cashflow, and to reduce the risk of disease. Reducing marketing risk is particularly important. As wholesale supply increases relative to the retail demand, most wholesale buyers will continue to buy but at a progressively lower price. However, some will maintain the initial price as long as possible and then at some point, simply refuse to buy anymore at any price.[2] Therefore, in selecting varieties, the producer needs to be very sensitive to the needs of the buyer.

The program allows one to enter up to ten varieties.[3] However, each variety may produce different numbers of marketable blooms per plant and may yield differently according to plant age. The program requires one to enter the actual number of plants and the ages of those currently being grown. The varieties chosen and the plant numbers of each variety in this example, reflect what some buyers believe approximates the current demand.

Yield per unit of land area will vary according plant density. Most growers use à single row planting pattern, although a few are going to double rows to increase plant density. (The double row arrangement of course requires attendant changes in cultural practices.) The program allows one to choose either single or double row spacing. A third option is to grow some varieties in single rows and other varieties in double rows.[4]

The yield problem is further compounded by the necessity to replace a certain number of plants per year. These replacements

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[2] The probability distribution for the former is roughly triangular, whereas that of the latter is rectangular. Later, in the sensitivity analysis, we will assume a triangular 10%/90% distribution.

[3] The names of the varieties are typed in only once, at the beginning of the program.

[4] If this option is chosen, select "3" in the "row plan" box, and enter "0" in those cells that do not apply.

will restart the production cycle, putting the new one year-old plants out of phase with the rest of the crop and reducing the overall yield for a few years. The following cost of production analysis indicates that replacement rate is the single most important production factor.[5]

When all of the relevant production data is entered, the program is able to project an annual yield. Price is the other component in the gross income equation.

With the addition of data on price for each variety and grade of bloom sold, gross income for each of the varieties can be estimated for each of five years. Current off-grade and select grade prices are readily available from buyers. With the grower's select grade percentage of marketable crop, the annual gross income can be estimated for varieties and the whole enterprise.

It is extremely difficult to project what the price for different grades of different varieties will be over the next five years. Presumably most (if not all) production for market will be select grade, and it is probably relatively safe to hold the grade price constant. Over time the greatest impact on gross income will probably be the variability of the select grade prices. If one expects the select price to remain constant (with an adjustment for inflation equal to the inflation rate for the input prices,) the assumption made in the following projection, then the result will reflect a relatively optimistic return to land. If however, one assumes a range of prices, a range skewed to the left, that is with considerable downside risk, and take the median price, the projection will be considerably less optimistic. Furthermore, if we are able to do a simulation with price as a probability distribution rather than a point estimate, we will be able to view the range of possibilities and estimate the probability of achieving a specific target return to land. Therefore, our gross income estimates, and ultimately our estimates of net return to land, will be more useful if we can also include a realistic range of select prices.

The program will function properly if one's price information is relatively limited. However, if one is able to include, in addition to the most likely price, a 1-in-10 year high and low price for each variety, the program will perform a sensitivity analysis. With adequate price estimates the sensitivity analysis, as pointed out earlier, enables one to visualize the likely range of expected returns and the probability of achieving or exceeding a target net return to land per acre.

ANNUAL OPERATING COSTS

Initial land preparation and planting costs are assumed to be a capital investment, to be recovered over a number of years,

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[5] Varieties vary with respect to their inherent replacement requirements, but for the purposes here, one may estimate the weighted average of individual replacement rates to arrive at an overall rate.

rather than an annual operating cost. Maintenance of this initial investment is calculated annually as a replacement cost.

Replacement plants:

The number of plants is calculated from earlier input. The direct costs are assumed to be $2.25 per replant. This cost is comprised of the plant cost (about $1.75), the pre-plant nematicide (about $0.25) and the replanting by hand (about $0.25/plant.) In our example farm, replacement direct costs average less than 2% of total revenue per year. However, with different plantings, replacement rates, and replacement costs, the replacement category could explode into a major annual operating cost. Replacement costs, because of their potential to be a significant annual operating cost, are calculated and itemized for each year. They are not, as are all other operating costs, averaged for the five year period.[6] Indirect costs of replacement, such as reduced annual yields for a number of years, are not immediately obvious here but they have a significant impact on profitability.[7]

Fertilizers and chemicals:

The total cost of fertilizer and chemical inputs, by contrast to plant replacement, is a relatively large component of the gross income. Net returns will be relatively insensitive to small changes in individual price or amounts applied. Therefore, while the different inputs are specified, the prices per unit of input and the precise amounts applied per plant of a given age, are averaged over the five year period. Unlike plant replacement, these costs do not include labor or machinery.

The fertilizers and chemicals selected for inclusion here are meant to be representative and do not constitute either a recommended practice or a product endorsement. Choice of specific applications will depend on local situations, particular field problems, current cost and perceived effectiveness of the input, and legal clearance for use in protea. These conditions often change, but the spreadsheet format allows one to accommodate these changes easily and to make revised projections.

Labor:

Labor is the largest single item, consuming on average over one-third of the gross income. Experienced growers estimate that two full-time, motivated workers could operate up to 10 acres (4 hectares) per year. This labor would be in addition to management. Following the conventions of cost of production studies,

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[6] This model does not calculate this or any other operating cost with respect to age of plant.

[7] The program automatically includes the indirect costs in the yield calculations, but if one wishes to do so, indirect costs can easily be separated out. The profitability with zero replacement can be compared to any level of replacement, with replacement costs set to zero. The difference in annual profitability will approximate the indirect costs of replacement.

management is valued at 5 or 6% of the gross. Again following enterprise budgeting conventions, farmer labor is assumed to total 2500 hours per year, or in the case of protea production, about 500 hours per acre (1,250 hours per hectare.)

Most labor will be hand labor, and this is valued at $8.00 per hour. Machinery labor is valued at $12.50 per hour because this labor is presumably more skilled labor. Many producers do not pay a higher wage for machine labor, arguing that it is not particularly more skilled and is much more popular than hand labor. Hand harvest labor is separated out because producers often will undertake all farm activities but require extra help at certain peak times to harvest a crop. Payment to harvest labor is often on a different basis, either based on piece work or a different wage rate. The allocation of labor to these three categories can be adjusted to fit a particular production system. In the example, it is assumed that 20% of the labor is machinery labor and that all hand labor is paid the same rate. All wages are adjusted upwards by 15% to account for social security and other insurance requirements.

There are many possible labor scenarios. As noted earlier, two owner-operators may attempt to take on all labor and management, with perhaps some peak harvest help. A single owner-operator might assume all management responsibilities and do all of the machine work. Such an arrangement (given the following projection) would generate an average annual cash income, aside from any return on owner equity, of at least $20,000.

Repairs and fuel:

Machinery, equipment, and building annual repairs are estimated as a percentage of the initial capital cost. It is assumed that the machinery, equipment, and buildings are reasonably new. If in fact they are fairly old, and therefore more likely to need greater repair, the percentage rate should be increased. The amount of fuel required to operate an acre (hectare) is based on producer estimates. Lubrication, again following budgeting conventions, is estimated to be about 10% of total fuel costs.

Post-harvest activities:

Harvest labor is assumed to include picking blooms and transporting them to a packing facility. Post-harvest activities include all efforts to get the marketable product to the buyer. Processing is the labor to clean, sort, grade, and dip or pack the flowers. To the degree that some of these activities are performed in the field before the flowers are carried to the packing shed, the harvest costs will be higher and the processing and storage cost item will be lower. Storage will normally be only a minimal consideration and is not accounted for in this budget.

Transport to market involves the labor to deliver the product to the wholesale buyer. Protea fields are assumed to be harvested and a delivery made twice a week nine months a year and once a week during the rest of the time. If the truck is owned,

...ery costs will have already been accounted for. If the ... is hired or if a trucking firm is contracted for transport, ...osts will be accounted for here. In this example, we are ...ing that the grower owns the truck. Marketing costs, in ...ion to management or those marketing-related costs already ...oned, will be minimal or non-existent. In the example, no ...ional marketing costs are assumed.[8]

...erating interest:

...charge is estimated for the cost of an operating loan. If a loan were not used to pay for some operating costs, this amount can be considered as an opportunity cost of the owner's operating capital. In our example we calculate that the loan would only be needed for half the year (equivalent to having the loan for a full year but paying it back monthly.) The loan's term length and interest rate can be adjusted. The operating loan is assumed to include the replacement costs, the fertilizer, chemical, water, and fuel inputs and machinery repairs.

GROSS MARGIN

The gross margin is simply the difference between the gross income and the total operating costs. It is the amount available to pay the annual costs "fixed costs" that will be incurred whether or not any production takes place. Because gross margin does not take into account individual financing considerations, it is especially useful in comparing alternative enterprises for a given a farm, or in comparing production efficiencies between farming operations. Even if one were not making a profit, i.e., if one were generating an inadequate or a negative return to the land resource, microeconomic theory would postulate that one would in the short-run, continue to produce as long as the gross margin were positive, i.e., as long as the enterprise were contributing something to the so-called "fixed costs."

CAPITAL INVESTMENT

Enterprise budgets often divide all costs into one of two categories: variable costs and fixed costs, according to whether they vary or not with relatively small increases in area of production. Unfortunately, there are a number of costs, such as fuel, repairs, office overhead, and labor, which are not easily allocated to a specific enterprise. In this cost of production study, since we are focusing on the protea enterprise, even at the expense of less accuracy for any particular farming operation, we attempt to allocate all costs. At this point in the process, we have allocated all costs except the initial capital investment (and of course land costs.)

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[8] Some growers who have used this program claim that they do not sell any off-grade flowers. Furthermore, of what they do sell, some is for wholesale but also a significant amount is sold retail. For these producers, price categories of wholesale and retail are a more useful distinction than off-grade and select. These growers can replace the headings and enter the appropriate prices and percentages by variety. They will however need to increase the marketing costs appropriately.

In this example we are assuming that land preparation costs, plants and planting, and irrigation total about $10/rather or about $10,000 per planted acre, assuming about 1,000 plants per planted acre. Irrigation would be about 40% of the total $10/plant, land clearing, tilling, fumigation, and ground cloth would require about 40%, and plants and planting, about 20%. We are assuming that about 10% of the ten acres devoted to the protea enterprise is used for infrastructure. Therefore, planted acres totals nine acres. Other capital purchases include a light duty pick-up ($12,000), one tractor and attachable implements, such as sprayers and a mower ($25,000), depreciated smaller equipment items, such as "green machines" ($3,000) and a garage/packing-house structure ($10,000).

Capital Recovery Charge (CRC):

A capital recovery charge is essentially the annual principal and interest payment on a capital investment devoted to a particular enterprise, given an appropriate term (in years) and annual interest rate. (Luening, 1985) An appropriately calculated CRC will account for the depreciation and timely replacement of capital items, and it will account for the opportunity cost of funds, inflation, and the real rate of interest. It is important that these be adjusted to fit the individual grower's situation. In this example the terms approximate the IRS cost recovery categories, and the interest rates reflect the current intermediate and long-term rates of the Farm Credit System. The total CRC is divided by the number of planted acres (hectares) to produce the annual CRC/unit of productive land.

TOTAL AVERAGE COST

The sum of the total average operating cost per unit of productive land and the total CRC per unit of productive land, is the total average cost, per unit of land, excluding any land charge. On a per stem basis this figure is the "break-even" price, again excluding what ever may be required to adequately compensate the land resource. The difference between the total average cost and the gross income, is the return to the land resource.

DISCUSSION

The return to the land resource, the final result of the economic analysis of this crop, is projected to average, over five years and given these assumptions, approximately $5,000 per acre per year. This return is not "profit;" rather it can be thought of as the maximum amount one could afford to pay for land rent. The individual producer will need to determine if this return is adequate, given one's personal goals, one's financial circumstances, the particular ownership situation, and one's perception of the current and anticipated land market. If, after paying the charge for land, a surplus exists, this surplus may be interpreted as "economic profit."

If the land charge exactly equalled the return to land, the "economic profit" would be equal to zero. However, the enterprise could nevertheless be considered "profitable" because all costs had been met and "unpaid" labor, management, and owner equity received an adequate return. Economic theory would lead one to expect that on average and in the long run, in purely competitive industries, such as agricultural production typically are, economic profit will equal zero. If economic profit were positive, new producers would be attracted into the industry; the consequent increase in supply would ultimately reduce the price until economic profit stabilized around zero. If economic profit were negative, producers eventually would exit the industry, reducing the supply of the commodity produced. The reduced supply would lead to a higher price and economic profit would return to an equilibrium point of about zero.

Having said this, it remains difficult to determine if potential producers would perceive that there were economic profits to be reaped in the protea industry. The example farm presented here is not likely the optimal organization of protea production. However, it is representative of the returns one could expect. The land charge will vary from producer to producer, but the $5,000 generated per acre per year in the example is less than what many in Hawaii considered to be a fair agricultural rent for flower and nursery production. At 10% interest $5,000 would not be adequate for debt service or even interest only payments on land with a market value of $100,000 per acre. However, there will be individual situations in which the land can be acquired for substantially less or situations in which one does not have to be purchased or rented specifically for protea production. In these cases, producers will want to consider commercial production of protea.

While the land charge is a major consideration, the degree of economic profit will be influenced to some degree by all of the variables. Labor consumes almost one third of the gross revenue and therefore is a major determinant of economic profit. However, the manager may have some control over labor costs to the extent that one can reduce this cost by increasing labor efficiency. As a "price-taker" the producer's greatest exposure to risk is in the area of price variability. While the foregoing economic analysis of protea suggests that the returns will on average approximate $5,000 per acre per year, the price variability produces a wide range of possible results. It would be more useful to be able to estimate the probability of generating <u>at least</u> $5,000, or any other target amount.

PRICE SENSITIVITY ANALYSIS

The large number of variables in the model limit our ability to say with any certainty what the likelihood is of attaining these returns or better. The variable with the greatest impact for someone selling in the wholesale market, that is, for a "price-taker," is the wholesale price. If we can obtain the 1-in-10 year highs and lows, we can use this model to simulate the market situation. In a few minutes of run-time the program will generate a hundred iterations and allow one to estimate the probabilities of interest. The sensitivity analysis plots a line that represents the likely average return to land over five years, along with the range of variance which will include two-thirds of the returns. The sensitivity analysis also produces for each year a probability curve of returns to land that enables one to visualize the likelihood of reaching or exceeding a target return to land.

The cost-of-production computer program will run properly without the data necessary to perform the sensitivity analysis. However, it cannot be over emphasized that the return to land result obtained above is only one possibility in a fairly wide range of possibilities. At the completion of this and similar analyses, producers often sigh in relief that we have come to some conclusion. More than once someone asks, "So is this the dollar amount I will probably receive as a return to land?" They are somewhat dismayed when we have to report that all we can say for certain is that they will certainly not receive that particular amount. The best we could hope to say is that there is a 55% or 40% or some other percent chance of receiving this amount or more, or perhaps that there is a 90% or some other percent chance of receiving at least zero or some other target.

REFERENCES

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THE ECONOMICS OF PROTEA PRODUCTION IN HAWAII

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The purpose of this program is to determine the return to the land resources devoted to protea production. The program is designed to be used by a producer who wishes to start production or who wishes to maintain or expand an existing operation or to start production.

There are five parts to the program: Part I calculates the enterprise gross income; Part II calculates the average annual operating costs; Part III calculates the annualized investment costs (i.e., the annual capital recovery charge). The end result, the return to land, is simply the gross income (Part I) minus the sum of the operating costs (Part II) and the investment costs (Part III.) Part IV is a summary of results and Part V is a sensitivity analysis.

USER NOTES: Cells which allow data input are highlighted on the computer screen and outlined in the computer print-out.
Reference to a particular product does not imply endorsement or clearance for usage with protea.
This program is available in either metric or U.S. format. The total out-put is 8 pages.

CHOOSE the prefered format (USA or METRIC) => USA

PART I: PROTEA GROSS INCOME:

This part of the computer program estimates the protea crop's annual gross income over a five year period. In order to calculate the gross income, the program needs relatively accurate estimates of marketable production per plant. If the default values in Section A do not reflect your situation, enter more appropriate yields.

In the next section of the program enter farm specific data, such as the size of your protea enterprise, your planting density, your existing plantings, and your replacement rate. Default values are provided as a guide only and should not be used in place of actual farm-specific data.

Initial, one-time entries:

1. Enter the year in which this 5-year plan is meant to begin: 1991
2. Enter the names of up to 10 crop varieties of interest in Section A below.

Section A. PROTEA PRODUCTION ASSUMPTIONS:

P. = Protea
L. = Leucospermum
B. = Banksia

EXPECTED YIELD:

ENTER marketable yield/plant by variety & age:

	AGE OF PLANT =>	1	2	3	4	>4
1.	P. cynaroides "King"	0	1	5	15	20
2.	P. nerifolia "Mink"	0	5	20	30	45
3.	P. May Day	0	2	5	20	30
4.	L. cordifolium	0	15	50	75	75
5.	L. Hawaii Gold	0	15	50	75	75
6.	L. Harry Chittick	0	15	50	75	75
7.	L. Carol	0	15	50	75	75
8.	B. menziesii	0	2	10	15	20
9.	B. coccinea	0	2	10	15	20
10.	Leucadendron	0	5	10	20	50

Section B. SPECIFIC FARM ASSUMPTIONS:

ENTER TOTAL land area dedicated to the protea enterprise =>	10.00	acres
ENTER percentage of land area required for INFRASTRUCTURE =>	10.0%	
Land area available for production, ie, growing area =>	9.00	acres

PLANT DENSITY (Ignore land used for infrastructure)

a. Select single (1), double (2), or mixed (3) row spacing => 1 row plan.

b. ENTER average spacing distance between =>	PLANTS	* SINGLE ROW	+ DOUBLE ROWS	= AREA (unit^2)	=> PLANTS /unit^2	
1. P. cynaroides "King"	4	10	13	40	1,089	/acre
2. P. nerifolia "Mink"	5	10	13	50	871	
3. P. May Day	5	10	13	50	871	
4. L. cordifolium	5	10	13	50	871	
5. L. Hawaii Gold	4	10	13	40	1,089	
6. L. Harry Chittick	4	10	13	40	1,089	
7. L. Carol	4	10	13	40	1,089	
8. B. menziesii	5	10	13	50	871	
9. B. coccinea	5	10	13	50	871	
10. Leucadendron	4	10	13	40	1,089	

===

Enter EXISTING NUMBER of PLANTS by age & variety:

AGE OF PLANT =>	1	2	3	4	>4	5-YEAR TOTAL
1. P. cynaroides "King"	588	588	588	588	588	2,940
2. P. nerifolia "Mink"	78	78	78	78	78	390
3. P. May Day	78	78	78	78	78	390
4. L. cordifolium	158	158	158	158	158	790
5. L. Hawaii Gold	196	196	196	196	196	980
6. L. Harry Chittick	196	196	196	196	196	980
7. L. Carol	196	196	196	196	196	980
8. B. menziesii	157	157	157	157	157	785
9. B. coccinea	79	79	79	79	79	395
10. Leucadendron	98	98	98	98	98	490
EXISTING TOTAL =	1,824	1,824	1,824	1,824	1,824	9,120
				Ave.no.of ea.age =		1,824

ACREAGE CHECK:

Calculated area now planted =	9.0	acres
EXCESS area calculated =	0.0	acres

NUMBER of REPLACEMENT plants required each year for protea enterprise:

NOTE:
In order to maintain the size of the above existing and expansion acreage, a percent of this acreage must be replaced with seedlings (1 year old plants) each year.

Enter the REPLACEMENT RATE for each year:

Replacement rate =>	10%	10%	10%	10%	10%

Calculated Replacements REQUIRED IN YEAR =>		1 1991	2 1992	3 1993	4 1994	5 1995	5-YEAR TOTAL
1.	P. cynaroides "King"	294	294	294	294	294	1,470
2.	P. nerifolia "Mink"	39	39	39	39	39	195
3.	P. May Day	39	39	39	39	39	195
4.	L. cordifolium	79	79	79	79	79	395
5.	L. Hawaii Gold	98	98	98	98	98	490
6.	L. Harry Chittick	98	98	98	98	98	490
7.	L. Carol	98	98	98	98	98	490
8.	B. menziesii	79	79	79	79	79	393
9.	B. coccinea	40	40	40	40	40	198
10.	Leucadendron	49	49	49	49	49	245
TOTAL REPLACEMENTS =		912	912	912	912	912	4,560
						Average =	912

==

Section C. PROJECTED GROSS INCOME (by variety):

This section calculates the weighted average price and the annual gross income by variety.

ENTER prices & percentages (1-in-10 year lows & highs are for the risk analysis.)

		OFF-GRADE Average Price:	SELECT GRADE Prices: 1 in 10-yr. LOW:	MOST LIKELY:	1 in 10-yr. HIGH:	% of crop:	WEIGHTED AVERAGE PRICE:
1.	P. cynaroides "King"	$1.00	$1.50	$2.00	$2.10	75%	$1.75
2.	P. nerifolia "Mink"	$0.25	$0.45	$0.65	$0.80	75%	$0.55
3.	P. May Day	$0.50	$1.10	$1.25	$1.50	75%	$1.06
4.	L. cordifolium	$0.10	$0.25	$0.40	$0.45	75%	$0.33
5.	L. Hawaii Gold	$0.10	$0.25	$0.30	$0.35	75%	$0.25
6.	L. Harry Chittick	$0.15	$0.40	$0.50	$0.60	75%	$0.41
7.	L. Carol	$0.10	$0.25	$0.30	$0.35	75%	$0.25
8.	B. menziesii	$0.35	$0.50	$0.75	$0.80	75%	$0.65
9.	B. coccinea	$0.50	$1.20	$1.25	$1.35	75%	$1.06
10.	Leucadendron	$0.10	$0.20	$0.25	$0.35	75%	$0.21

Projected ENTERPRISE GROSS INCOME (by variety & year), using weighted average price:

	YEAR =>	1 1991	2 1992	3 1993	4 1994	5 1995	5-YEAR AVERAGE:
1.	P. cynaroides "King"	37,970	50,843	60,428	66,429	68,117	56,757
2.	P. nerifolia "Mink"	3,861	5,039	5,873	6,310	6,522	5,521
3.	P. May Day	4,251	5,840	7,015	7,831	8,102	6,608
4.	L. cordifolium	9,936	12,062	13,414	13,882	13,882	12,635
5.	L. Hawaii Gold	9,482	11,510	12,800	13,247	13,247	12,057
6.	L. Harry Chittick	15,644	18,992	21,120	21,857	21,857	19,894
7.	L. Carol	9,482	11,510	12,800	13,247	13,247	12,057
8.	B. menziesii	4,317	5,538	6,406	6,815	6,983	6,012
9.	B. coccinea	3,551	4,555	5,269	5,606	5,743	4,945
10.	Leucadendron	1,593	2,277	2,775	3,124	3,329	2,620
TOTAL GROSS INCOME =		$100,087	$128,166	$147,900	$158,347	$161,028	139,105

PART II. ANNUAL AVERAGE PRODUCTION COSTS/ACRE

I. GROSS RECEIPTS:		Quantity /acre:	Unit:	Price/ Unit:	Value /acre:	% of ave. Gross:
	Year 1:	21,617	*stems*	$0.51	$11,121	
From	Year 2:	26,941	*stems*	$0.53	$14,241	
Part I	Year 3:	30,506	*stems*	$0.54	$16,433	
above	Year 4:	32,104	*stems*	$0.55	$17,594	
	Year 5:	32,433	*stems*	$0.55	$17,892	
5-year Average:		28,720	*stems*	$0.54	$15,456	100.0%

II. OPERATING COSTS					Cost /acre:	
Replacement plants:						
1-yr old plants:	Year 1:	101	*plants*	$2.25	228.00	1.5%
	Year 2:	101	*plants*	$2.25	228.00	1.5%
	Year 3:	101	*plants*	$2.25	228.00	1.5%
	Year 4:	101	*plants*	$2.25	228.00	1.5%
	Year 5:	101	*plants*	$2.25	228.00	1.5%
	5-yr Average:	101	*plants*	$2.25	228.00	1.5%
Fertilizer & lime:						
1. Osmcoat 13.5-13.5-13.5		125	*pounds*	$0.95	$118.75	0.8%
2.			*pounds*	$0.00	0.00	0.0%
Herbicide:						
1. Round-up		2	*gallons*	$85.34	170.68	1.1%
2. Rout		200	*pounds*	$1.76	352.00	2.3%
Insecticide:						
1. Malithion		0.75	*gallons*	$30.00	22.50	0.1%
2. Sevin 50W		40	*pounds*	$6.22	248.80	1.6%
Fungicide:						
1. Benlate		10	*pounds*	$18.65	186.50	1.2%
2. Dithane M45		40	*pounds*	$3.68	147.20	1.0%
Nematicide:						
1. Nemacur 10G		100	*pounds*	$3.43	343.00	2.2%
Irrigation:						
Water (2 tier pricing)@		25.0	*Kgal @*	$1.21	30.25	0.2%
182	gal/plant/yr.	11.9	*Kgal @*	$0.61	7.25	0.0%
Energy for pumps, etc.		0	*kwh*	$0.10	0.00	0.0%
Labor: base rate +	15.00%					
Machine		100.0	*hours*	$12.50	1,437.50	9.3%
Hand (includ. pruning)		250.0	*hours*	$8.00	2,300.00	14.9%
Harvest		213.0	*hours*	$8.00	1,959.60	12.7%
Fuel:						
Gasoline		96	*gallon*	$1.70	163.20	1.1%
Diesel		24	*gallon*	$1.50	36.00	0.2%
Lube (% of fuel cost)				10%	16.32	0.1%
Repairs:						
Mach. & eq. (% of cost)		$25,000	*cost* *	2.0%	500.00	3.2%
Buildings (% of cost)		$10,000	*cost* *	2.0%	200.00	1.3%
Post-harvest (includes labor):						
Processing & storage		28,720	*stems*	$0.01	287.20	1.9%
Transport & marketing		28,720	*stems*	$0.04	1,148.81	7.4%

operating costs of	2,770	@ .5 *	12.50%	173.15	1.1%
Cash overhead costs:					
Management (% of gross)	$15,456	*gross*	6.0%	927.37	6.0%
Office exp. (% gross)	15,456	*gross*	1.0%	154.56	1.0%
Equipment tax, insurance & repairs (%)			0.5%	213.00	1.4%
Excise tax (% of gross)	15,456	*gross*	0.5%	77.28	0.5%
Miscellaneous				250.00	1.6%

TOTAL PRODUCTION COSTS/ACRE

Year 1 =	$8,684		78.1%
Year 2 =	$7,578		53.2%
Year 3 =	$7,613		46.3%
Year 4 =	$7,629		43.4%
Year 5 =	$7,650		42.8%
5- year Average =		$7,831	50.7%

GROSS MARGIN /ACRE (Returns/area unit minus operating costs)

Year 1 =	$2,437		21.9%
Year 2 =	6,663		46.8%
Year 3 =	8,820		53.7%
Year 4 =	9,965		56.6%
Year 5 =	10,242		57.2%
5- year Average =		$7,625	49.3%

PART III. ANNUALIZED INVESTMENT COSTS

(Capital Recovery Charge = CRC)

Total production *acres =* 9.0	Total Cost:	Term (yrs):	Interest:	Annualize CRC:	% Ave. Gross:
Land preparation	$3,600	10	10.00%	65.10	0.4%
Amort. of initial planting	$1,800	5	10.00%	52.76	0.3%
Truck	$12,000	5	12.00%	369.88	2.4%
Other machinery	25,000	7	11.00%	589.49	3.8%
Equipment	3,000	7	11.00%	70.74	0.5%
Buildings	10,000	20	10.00%	130.51	0.8%
Irrigation system	3,600	5	11.00%	108.23	0.7%
Other initial investment	1,000	1	11.00%	123.33	0.8%

TOTAL DEPREC'N & INTEREST/UNIT PROD.LAND =	$1,510	9.8%
TOTAL AVERAGE COST/ UNIT PROD. LAND =	$9,341	60.4%
AVERAGE RETURN/ UNIT PROD. LAND =	$6,115	39.6%
AVERAGE RETURN/ UNIT OF ALL PROTEA LAND =	$5,504	

(Average per land unit returns minus total costs)

PART IV. FIVE-YEAR SUMMARY OF RESULTS

per stem, per unit of ALL land, & for the whole enterprise.

	YEAR 1 1991	YEAR 2 1992	YEAR 3 1993	YEAR 4 1994	YEAR 5 1995	5-YEAR AVERAGE
Ave. no. of stems sold =	*21,617*	*26,941*	*30,506*	*32,104*	*32,433*	*28,720*
I. GROSS RECEIPTS:						
Ave. Price rec'd./stem	$0.51	$0.53	$0.54	$0.55	$0.55	$0.54
Expected Gross/unit land	$10,009	$12,817	$14,790	$15,835	$16,103	13,911
Expected Total Gross	$100,087	$128,166	$147,900	$158,347	$161,028	139,105
II. TOTAL OPERATING COSTS:						
Ave. Total op. $/stem	$0.36	$0.25	$0.22	$0.21	$0.21	$0.25
Total op. costs/unit land	$7,815	$6,820	$6,852	$6,866	$6,885	7,048
Total operating costs	78,153	68,199	68,520	68,664	68,847	70,477
GROSS MARGIN (Returns over operating costs):						
Ave. Gross margin/stem	$0.15	$0.28	$0.31	$0.33	$0.34	$0.28
Gross margin/unit land	2,193	5,997	7,938	8,968	9,218	6,863
Enterprise gross margin	21,934	59,967	79,380	89,683	92,180	68,629
III. INVESTMENT COSTS (Annual Capital Recovery Charge):						
Average CRC/stem	$0.06	$0.05	$0.04	$0.04	$0.04	$0.05
CRC/unit land	1,359	1,359	1,359	1,359	1,359	1,359
Enterprise CRC	13,590	13,590	13,590	13,590	13,590	13,590
TOTAL COST (except land charge):						
Ave. Total cost/stem	$0.42	$0.30	$0.27	$0.26	$0.25	$0.30
Total cost/land unit	9,174	8,179	8,211	8,225	8,244	8,407
Total cost/enterprise	91,743	81,790	82,110	82,254	82,438	84,067
NET RETURN TO LAND:						
Average Net Return/stem	$0.09	$0.23	$0.27	$0.29	$0.30	$0.23

Detailed projection of NET RETURN TO ONE UNIT OF LAND (by variety and year), using weighted average prices:

		1991	1992	1993	1994	1995	5-Year Average
	P. cynaroides "King"	1,045	2,631	3,580	4,176	4,339	3,154
1.	P. nerifolia "Mink"	(70)	97	179	222	242	134
2.	P. May Day	(31)	177	293	374	400	243
3.	L. cordifolium	69	382	514	559	558	417
4.	L. Hawaii Gold	31	333	459	502	500	365
5.	L. Harry Chittick	647	1,081	1,291	1,363	1,361	1,149
6.	L. Carol	31	333	459	502	500	365
7.	B. menziesii	(487)	(265)	(181)	(142)	(127)	(240)
8.	B. coccinea	(107)	43	113	146	159	71
9.	Leucadendron	(299)	(181)	(133)	(99)	(79)	(158)
10.	NET RETURN TO LAND/AC. =	$828	$4,632	$6,573	$7,604	$7,854	$5,498
	ENTERPRISE NET RETURN =	8,283	46,323	65,735	76,038	78,535	54,983

CURRICULUM VITAE
July 1991 *(Abreviated version)*

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Extension Economist (Management)
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EDUCATION:
University of Massachusetts, Amherst (1990): Ph.D. (Strategic Management).
University of Wisconsin-Madison (1984): M.S. (Agricultural Economics).
The Royal Agricultural College, Cirencester, England (1981): M.R.A.C., with Honors (Farm Management).
California State University, San Francisco (1966): M.A. (English).
University of California, Berkeley (1964): B.A. (English).

EMPLOYMENT:
University of Hawaii, Manoa (1990-present): Extension Economist
University of Massachusetts, Amherst (1984-1990): Extension Specialist, Farm Financial Management and IPM Economics.
University of Wisconsin, Madison (1983-1984): Teaching Assistant (Microeconomic Theory) & Research Assistant (Farm Management).
Black River Farms, Withee, Wisconsin (1981-1984): General partner and farm manager (200 acres: 55 cow dairy with young stock, forage & agroforestry.)
Colesbourne Estate Farm, Colesbourne, Gloucestershire, England (1979-1981): Assistant Farm Manager. (2,500 acre: sheep [1,000 ewes], 135 cow dairy, 1,000 acres wheat & barley, with 600 acre forestry operation).
University of California, Berkeley (1971-1979): Lecturer (English) and Rowing Coach.

STATE-WIDE EXTENSION PROGRAMS: *(selected to reflect research & educational expertise & interests relevant to sustainable agriculture)*

Financial Management & Long Range Planning:
Hawaii State FINPACK Leader (1990-present).
Introduced FINPACK to Hawaii (1991): Teaching extension agents and lenders how to use program and developing enterprise budgets for use with the Hawaii.
Massachusetts State FINPACK Leader (1986-1990).
Trained 80 FmHA and extension staff in use of FINPACK (series of 4 workshops,1987).
"Strategic Planning with FINPACK," Invited Seminar, 1987 University of Massachusetts Agricultural & Resource Economics Department Seminar Series.
"Improving Dairy Farm Profitability with Whole Farm Planning," Invited Paper, 1987 Massachusetts Dairy Farmers' Seminar (*1987 Proceedings*).
Introduced FINPACK to New England states: Organized training workshops for extension & developed enterprise budgets for use with New England version.
Related publication: "Farming in the Shadow of the City," chapter in 1989 USDA annual *Yearbook of Agriculture* (volume devoted to farm management).

Integrated Pest Management (IPM) Economics:
"Economic Analysis of Proposed Regulations on the Storage and Handling of Pesticides," Univ. of Mass. IPM Report to Mass. Dept.of Ag. Pesticide Bureau.
"How to Calculate Your After-tax Cost of [Pesticide Regulation] Compliance Alternatives," [computerized worksheet], *Agronomy Digest,* Spring 1990.
"Using 'Economic Thresholds' in IPM," seminar presented to the University of Massachusetts 1990 Short Course for Commercial IPM Certification.
"Developing an Effective, Least Cost Fungicide Regime," Fruit Notes, Summer 1990.
"The Economics of Pesticide Regulations and Organic Agriculture," invited paper delivered to New Alchemy 1990 Annual Conference.

UNIVERSITY-RELATED COMMITTEES: *(selected)*

Regional Extension Farm Management Committees:

1990-present: Hawaii State Representative to Western Extension Farm Management Committee (my participation funded by the Farm Foundation.)
1989-1990: Chair, Northeast Extension Farm Management Committee (NFMC).
1989: Appointed by USDA Program Leader to be Northeast representative to FmHA National Advisory Committee.
1988-1989: Vice-Chair and Secretary, NFMC.
1986-1988: Chair, In-service Education Sub-Committee.
1986-1990: Mass. State Representative to NFMC (funded by Farm Foundation).

Extension Priority Initiatives Committees:

1990-present: Chair, Hawaii Sustainable Agriculture Priority Initiative.
1988-1990: Co-Chair, Massachusetts Competitiveness and Profitability in Agriculture Priority Initiative [fore-runner of "Sustainable Agriculture" Priority Initiative] represented Massachusetts at National USDA Conference on Competitiveness and Profitability in Agriculture Priority Initiative (St. Louis).
1988: Represented Massachusetts at National USDA Conference on Competitive Advantage (St. Louis).
1987: Chair, State Task Force on Competitiveness & Profitability of Agriculture.

COMPETITIVE GRANTS: *(selected)*

Using Legume Cover Crops for Vegetables to Reduce Soil Loss and Nitrogen Inputs, 1989; Co-Principle Investigator. Purpose: to analyze the economics of replacing conventional cover crops (e.g., rye) with legumes (e.g., vetch) in order to reduce chemical inputs. USDA-LISA: $38,500; total $87,000.

Using Intensive Pasture Management to Increase Farm Profitability, 1988. Massachusetts P.I. Purpose: to analyze the economics of using intensive rotational grazing to lower chemical inputs, as practiced in New Zealand, compared to the predominant system of feeding mechanically conserved forage year round. USDA-LISA: $13,000. (Total project: $140,000.)

Using Fungus-resistant Apple Tree Cultivars to Reduce Chemical Inputs, 1988. Purpose: to analyze the economics of replacing commercial apple varieties with trees which would not need to be sprayed. USDA-LISA: $41,000

ACADEMIC REFERENCES:

Dr. Richard O. Hawkins, Director, Center for Farm Financial Management, Professor, and Extension Economist (Farm Management), Department of Agricultural & Applied Economics, University of Minnesota, 1994 Burford Avenue, St. Paul, MN 55108. Tel: (612) 625-1964.

Dr. Buel F. Lanpher, Program Leader, Farm Management, U.S. Department of Agriculture, Room 3340, So. Building, Washington DC 20250. Tel: (202) 447-7165.

Dr. Cleve E. Willis, Professor & Chairman, Department of Agricultural & Resource Economics, University of Massachusetts, 210 Draper Hall, Amherst, MA 01003. Tel: (413) 545-2491.

Dr. John F. Yanagida, Professor & Chairman, Dept. of Agricultural & Resource Economics, University of Hawaii, 3050 Maile Way, Gillmore Hall, Honolulu, HI 96822. Tel: (808) 956-7602.

PROFIT FROM PROTEAS

By Jack Harre'.

Ladies and gentlemen in your industry there has been more than enough junk planted already so let us now start on a programme of eliminating the poor stock from your plantations and turn those losses into profits.

How are we going to go about this programme of plantation improvement.

As I said this-morning we must always bear in mind that the plants you plant must be capable of producing a flower that is acceptable to the consumer and profitable for the producer to grow. So, let us look at the parameters that I outlined this morning, the ones that a plant must match before we can adopt it as superior stock.

THE CONSUMER PARAMETERS

* a satisfactory vase life.
* a near straight stem.
* a stem length that is as long as possible. ie. for premium prices, not less than 45cm. for flowers and 60cm. for foliage.
* a flower/foliage must have a shape, form and colour which is visually appealing and acceptable within seasonal fashion or ethnic demands.

THE PRODUCER PARAMETERS

* all of those factors as set out for the consumer.

PLUS

* resistance to leaf blacking.
* resistance to fungal invasion above the ground.
* resistance to fungal invasion below the ground.
* resistance to by-passing of flower heads.
* productivity per unit.
* season of harvest in relation to accessible markets demand.

Those that are additional to the above and are specific to particular climates, locations or management regimes are:-

* tolerance to sub-zero temperatures.
* tolerance to high temp/low humidity.
* tolerance to high light levels.
* resistance to nematode invasion.

For the evaluation programme, I have broken these parameters into sections so that they can be carried out by you in a practical manner on your properties. In this programme there are three sections of field observations and one of pack house testing. They are:-

PACK HOUSE TESTS

leaf blackening during transit
vase life

FIELD OBSERVATIONS.

Physical properties of plants.

- stem length
- stem straightness
- shape form and colour of flower
- resistance to bypassing
- season of harvest
- production per unit

Health properties of plants.

- resistance to fungi above the ground
- resistance to fungi below the ground
- resistance to nematode invasion

Tolerance of plant to:-

- sub zero temperatures
- high temperature - low humidity conditions and
- high light levels

All this is pretty simple and is easily carried out with the minimum c equipment or previous experience. By using this programme you should be ab to identify superior stock in your plantations within a year and for so varieties within a month or two, depending on when they flower on yo properties.

So where do we start? I said this morning that my philosophy was:

IF IT WON'T TRAVEL, DON'T PLANT IT and to me this must come first in a evaluations because if the product won't travel and then give a satisfacto vase life, then nobody will want to buy it. So we will start with the pa house tests because if your flowers ever arrive at the wholesalers as blackened mess then you have a problem.

Some flowers may look like a million dollars on the bush but after three t five days in transit from the bush to the consumer they look like and are disaster.

How do you test for travel? First of all the flowers must always b harvested and post-harvest handled under the standard system that you use c intend to use in your pack house.

For this they should preferably be harvested before 9am, placed in wate immediately and in a cooler within 45 minutes especially if the da temperature is over 18C.

After any field heat has been removed the flowers should then be processe and packed into cartons at normal density. Don't fill up spare space in th carton with paper or leave big air cavities as this will cause the flowers t dehydrate more than they normally would. Use small cartons for smal quantities of flowers. You then place the carton in a building where it wil be subjected to normal day and night temperature variations the same as i would be in transit to a distant destination, or alternatively, give it t the local carrier for three days to cart around. After three days unpack th flowers and then, and only then, will you recut the ends and place them i water for observation. The evaluation of flowers in a static vase life programme; ie. just picking them and putting them in a vase at normal room temperature is a totally worthless exercise unless they are meant to only ever be sold on a local domestic market. Export flowers must be put through either actual or simulated travel first and then evaluated for vase life.

How long should flowers stay fresh in a vase at normal room temperature after transit to be regarded as satisfactory? Well I have set my selection at an absolute minimum of ten days and you will find that the flowers of only about one in fifteen plants will produce flowers that will sustain three days travel and then give ten days vase life.

When is a flower spent? I have set my level for this as being when the flower is obviously degenerating when viewed at two meters in a light level of 100 lux., eg. this is what the daytime light level is in most houses.

Having vetted out the flowers for traveling ability and vase life, you can then start to assess all the other things they and the plants that produce them must measure up to be able to be called a superior clone.

FIELD OBSERVATIONS.

Stem length. Where do you measure the stem length to? Some flower dealers claim that it should be the length of the stem only while others say it includes the flower head as well. In all other flowers the term of stem length refers to the stem plus the head, so why not proteas? For my calculations I measure all proteaceae products over the full length of stem and flower the same as every other genus of flower.

How long do they need to be? For most markets a minimum of 45cm for flowers and 65 cm for foliage but this may vary from market to market such as in Japan which usually requires all material to be longer than this.

Stem conformity. As straight as possible, this also may vary between markets but as a general rule flower arrangers prefer to bend the stem themselves rather than have to try to straighten it. Also bent stems are a nightmare to pack into cartons and are very wasteful of space and consequently cost you more to ship to your end user. So for practical reasons they should be as straight as possible and certainly have no more than a 15 degree curve.

Shape, colour and form of flower. It is here where we get into market fashion or ethnic or even personal preferences and because of this it is a facet of quality that can not actually be measured. For instances, in shape and form some markets like one thing and another likes something else. Also colour preferences are often seasonal or ethnic in such things as reds for Christmas and Valentines day white for Mothers day gold for western springs and Chinese new year.

To match these market demands you must know what month the plant will produce most of its crop in and whether there is indeed an accessible viable market in that month for that product. So along with the shape, colour and form of the flower we must also consider its season of harvest.

Season of harvest. If we look at the present supply and demand pattern of our flowers we find that most of the worlds population live in the northern hem. [illegible]here and buy our type of flower in their winter months. Trying to supply this northern winter demand, there is a large proportion of proteas being produced in the southern hemisphere where they have their natural cycle of flowering during the southern winter. If we analyze this northern demand and southern production pattern we find that as the demand picks up in the northern hemisphere the supply from the southern hemisphere generally drops off, and as the northern demand picks up again as they enter winter, then the supplies drop off as the southern hemisphere goes into summer. <u>This southern supply to meet the northern demand is exactly the wrong sequence</u> and it is this miss-match of supply and demand that causes the gluts and shortages of protea flowers in the international markets.

Because of this it is important that when you are making selections that are to be grown in the southern hemisphere and their flowers are to be sold in the northern hemisphere, then they should have their flowering period during the northern winter and not during the northern summer.

Currently, with the natural winter flowering cycle of proteas, Australia with its relatively high domestic winter demand is in a much better position than New Zealand, Zimbabwe and South Africa are because these three have to rely almost totally on export to the north. Production from the two principal northern hemisphere zones of Hawaii and California are defiantly better positioned than those from the south but even so they also must select to avoid "glut" periods.

As an instance of miss-timed product availability from the southern hemisphere for the northern hemisphere markets, let us look at the huge crops of Silvan Red and Safari Sunset that Australia and New Zealand are capable of producing for harvest during the northern summer of April to August. These red leucadendrons don't sell well into the northern hemisphere after mid April because they are in their red colour, (a hot colour), summer is starting and demand is falling off. However from Sept onwards by which time the crop is almost over, then the demand is rising again because (a). the colour is much more acceptable to the consumers because they have changed from that red colouring to their more popular rainbow colouring and (b). the demand is picking up again because the northern hemisphere is entering autumn/winter. At this season these leucadendrons are often worth two or even three times per stem more than they were in the April/August season.

If you as a producer have the ability or the plants available to produce some special product and you are unsure of whether that particular flower is;-

a. flowering at the right time of the year for your accessible markets;
or,
b. whether or not it is the right colour or product for a particular market at that time of year;
then it is your wholesaler or exporters who should be able to advise you.

They should be able to tell you which specific products are viable for which specific time slots into which specific markets, provided of course they are true wholesalers or exporters and are not just freight forwarders. It is here where you sort out the professionals from the wheelers and dealers.

In the main, you should always be able to profitably sell any recognised commercial proteaceae flower or foliage provided it is of top quality and produced at a time of year when there is known to be a demand for flowers in the markets that are accessible to you.

Resistance to by-passing. This is a facet that you may not think is particularly important, but let me assure you that it is very important, not only from a quality angle of stem length but also in the man hours involved in removing them and the cost of getting this excessive foliage to market.

Proteas fall into two catagories of growth habit. There are those that make three growths terminally and then set a flower and then there are those that grow once, then set a flower bud, then they bypass and set another bud and often they bypass and set another bud before the first bud ever comes into flower. Such plants are a production disaster and there are tens of thousands of these plants in your plantations that fall into this category.

To remove these unwanted by-passes either in the field or in the pack house, it will take an average worker an average of six seconds per growth to cut them away. If you don't believe me go out into the field and see how many you can remove in half an hour including the peripheral time consuming operations such as coffee breaks, looking intelligently at the birds in the sky and watching your watch.

If for instance one flowering head had eight growths to remove then at six seconds per growth multiplied by eight equals forty-eight seconds. Say a minute by the time you take into account every function connected with this operation, picking up the flower and putting it back into the water again in the pack house or, moving from bush to bush in the field or coffee breaks.

If you are paying around eight dollars per hour as many of you will be in Australia, Hawaii, California and New Zealand, then this will amount to around thirteen cents per stem. If your margin of profit per stem is less than this you are down the drain, if your margin of profit, over and above harvesting, sorting, packaging and freight was thought to be say around 80 cents then you are reduced by about 15%. in nett returns just to remove those growths.

You may claim that you don't have to remove those bypasses as the florists like them as foliage and you are getting paid for them. This may be true for the Californians but let me tell you that for the rest of you, then for other than local domestic sales those by-passes are costing you big dollars in packaging and transport because it is you who pay the cost of the extra cartons and the freight and so it is you who will loose out. The cost of shipping a neriifolia flower with six bypasses on it from New Zealand to Nth America is around NZ $1.04 compared to 67 cents for one without bypasses.

Production per unit.
Proteaceae plants of each particular variety of each species vary greatly in their productive life span and the crop that they can regularly produce each year.

If we look at say serruria florida we will find that it will produce relatively few salable stems each year and have a short productive life of two or three years. Are these worth growing unless you can get at least say seventy cents per floret? A stem with six florets should be worth $4.20 in your pocket but I doubt if you will get it. On the other hand lets think of a crop of leucospermums, which, provided they are matched to the climate where they are planted, are capable of carrying a bountiful crop of salable stems each year and will continue to do so for many years. Leucospermums are capable of producing a crop many times the value per square meter and per man hour input than any serruria can unless the price received for serrurias can be increased many times over.

Production per unit is a very easy thing to calculate visually in the plants you have under observation provided you have carried out all the observations already outlined.

Therefore to assess the productivity of a plant you must determined the number the stems that are long enough and straight enough to meet the parameters set. The flowers must also be the right size, be the right shape and be the right colour for the season or the particular market. Further to this the plant must produce the majority of its crop at the prime time of the year for your accessible markets.

Ladies and gentlemen you must look for this type of plant to establish in your plantations rather than the hotch-potch of plants which you have planted in the past as any continuation of this shot gun approach can only result in more poor quality flowers on the market and more unprofitable plantations.

HEALTH PROPERTIES OF PLANTS

This will be of varying interest to each of you depending on where you live and what your problems are.

Resistance to fungi above the ground. Proteaceae plants vary greatly in their resistance to, or susceptibility to, the local strains of fungi. Anyone who has visited some of the plantations of Zimbabwe will know what can happen when the plants are miss-matched to the local climate. In all production zones the incidence and severity of fungal invasion is linked to the prevailing temperature/humidity ratio of your location and anyone can easily measure what their local conditions are.

For calculation purposes I have given this factor the equation of th/C which is calculated by reading the temperature in Celsius, and adding to it the humidity measured in %.

For instance if you have a temperature of 27C and a relative air humidity of 85% then you would have a th/C102. For most proteaceae varieties th/C105 is right into the danger area where as th/C85 is safe for at least most of the commercial ones. There are combinations where you can get a low th/C even although one or the other of either the temperature or humidity are high such as in W.A. where in the summer you could have a high temperature and a low humidity or in New Zealand which has a low temp/high humidity ratio in the winter. On the other hand we have situations where we have high temp/high humidity and we have huge problems like in Zimbabwe in the summer and Hawaii in a freak summer weather pattern, some parts of east Australia and some parts of northern New Zealand in the summer months.

If you already have a plantation of seedling stock then the plants will already have told you whether or not they can take your particular th/C because if they can't they will either be seriously diseased or dead.

However, if you are just starting out and you are faced with purchasing plants to establish your plantation then you should determine what your th/C levels are during your most humid period of the year and then purchase clones that are know to be satisfactory in those conditions. By the same token, persons offering plants for sale should be able to give you information on those plants as to their tolerance to specific levels of th/C. If they can't then they haven't researched their plants properly.

Diseases below the ground. It is a fact of life that if phytophthora is really persistent in a given location then that location is almost certainly not a satisfactory place for the commercial production of protea flowers and you should look for other land or forget growing proteas because you will never beat phytophthora, the best you could expect to do is to control it but the cost of this control may not be viable.

At this stage it is not possible to be positive whether a plant is resistant to phytophthora. However there are indications that there are certain plants of every variety that do show some resistance in varying degrees and when you are importing plants into your local climate from one that is greatly different to yours you should seek information from your suppliers as to those particular clones which have shown susceptibility or resistance to this disease.

Resistance to nematodes. In areas where nematodes are a problem these little beasts pose a real problem and unless the plant has some natural resistance it will usually start to visibly degenerate by its second year. There is no doubt that selections can be made of plants that are resistant to nematodes such as some in Zimbabwe that I have seen which were showing resistance. When cutting grown plants of these were planted in an area known to be highly infected with nematodes they proved to be totally immune to invasion.

Observations through-out many plantations in Zimbabwe show that a percentage of plants of every variety seem to be immune or at least partially resistant to nematode invasion but at this stage it is not known whether plants selected in Africa which are showing immunity from their local strain would also be immune from say the Hawaiian ones or the Australian ones.

Tolerance to sub zero temperature. Big variations exist in the sub-zero tolerances of plants even within a single variety of a species. For instance lsp. cord. Riverlea will take temperatures down to -5C for six hours without damage while on the other hand we have lsp. cord. Harry Chittick which will only take -3C for six hours before it shows damage.

Once again if you are making selections from an established seed based plantation most of the screening will already have been done by natural selection but this does not however solve the problem of whether plants that are OK in Joe Boggs plantation over the hill will be OK in your plantation unless you both know what your minimum temperatures are and how many hours those temperatures last because it is the minus degrees below zero multiplied by the hours it lays which will destroy your plants or your crop.

I call this frost factor, abbreviated to f/f and it is calculated by measuring the minus degrees C. and multiplying that figure by the number of hours. If for instance you had minus four degrees C for four hours it would give you a f/f of 16. It is important for you to have that information about your location and it is imperative that it is known in the location where any selections are being made because if those selections are intended to be used in any other location where there may be frosts, you must know whether those plants will take your frosts. Therefore for those of you who have to buy your plants in or who wish to import from another state or country you should know what your f/f is and your supplier should be able to tell you what the f/f tolerance is of the plants they are selling. If they can't then once again they have not researched their stock properly.

Tolerance to high temperature/low humidity and high light levels. This is the other end of the scale from frosts but the calculation and damage caused by it is similar to frosts. The results of this will manifest itself in scorched looking foliage, burnt up looking flower buds and at times the aborting of flowers.

Again self selection will have done its job in an existing plantation but when stock is being brought in it is important to be aware of which leaf types and in most instances their flowers as well will be more tolerant to high temp/low humidity and high light levels.

In places around the world where you find high light and temperatures, you will find that those proteas with blue leaves or green leaves with a red edging are much more resistant than those with green leaves. In leucospermums it is those with grey/blue and/or hairy leaves which are best and the same with leucadendrons, with reds, blues and/or hairy leaves rather than those with plain green leaves being most resistant.

As there are so many variables in the temp/humidity/light intensity that are possible, it is almost impossible to predetermine which will be satisfactory in any given area but it should be borne in mind that a plant from a temperate low light area such New Zealand may fry up if it is planted in an area such as some parts of California or more than about 15km inland here in Western Australia.

Ladies and gentlemen. If you want to make a profit from your proteas then you must first research what the markets demand of your product and then look for the plants that capable of producing that crop viably in your climate. In the past few years there have been dozens of plants named and proclaimed as being the ultimate in proteaceae cut flowers. In many instances these fall into one of three catagories;-

1. Their product is only suited to a particular market which may be very small and low priced or it may not be viably matched to any market at all.

2. The plants are only suited to being grown in a particular climate where the temp/humidity ratios, light levels, soil types and rainfall patterns are matched to their specific and sometimes very exacting genetic characteristics.

3. They are no more than a pretty face in the garden that looks like a million dollars on the bush and a disaster at the end of three days travel in a carton.

If I were starting out now to set up a plantation for the profitable production of proteaceae cut flowers, I wouldn't plant a single seedling nor would I plant the stock of a single selected clone unless the supplier of the plants of that clone could give me all the information I needed for me to be able to make a judgement that the plants of that clone would grow well in my climate and produce a product that was viable in my accessable markets.

Thank you for your attention.

BREEDING AND PROPAGATION

TRENDS - THE DECADE AHEAD

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INTRODUCTION

It was with great interest, and some concern that I accepted President Maggie Edmond's kind invitation to consider with you, the subject of "Trends - the decade ahead"! After all, it was only six years ago that Joe Hands provided me a similar opportunity during his meeting in Adelaide entitled, "Protea Panorama". Fortunately, we are only half way through that 10 year forecast, so there is still time to take another look in our crystal ball and to look ahead to the dawn of the 21st century.

Background

How many of you were with us, 10 years ago, when Proteaflora Enterprises convened the first International Protea Conference at the picturesque country Inn, Baron of Beef, in the beautiful Dandenong Mountains of Victoria? It was an historic event! 116 people from 5 countries came together to discuss areas of mutual cooperation in the orderly development of a brand new cut flower crop. Our host, Peter Mathews, challenged us in his introduction to the conference, saying that the future of the protea industry depended upon the extent to which proteas, as a legitimate floral commodity, could take a significant share of the world market. This could happen only if growers produced the very best flowers possible, consistently. In order to produce 1st class flowers, support was urged for research in the production of hybrids, propagation, disease control and plantation management. At the conclusion of the conference, everyone agreed that they would like to meet again. An interim constitution was adopted, and the IPA, the International Protea Association, was "off and running".

Production base

At our second meeting, in 1983, area representatives reported, as best they could, on the number of acres planted to proteas. Australia reported 750 acres in the ground, of which 200 were in production. California - 500 acres and Hawaii 111 acres. Israel reported 115 acres had been planted and New Zealand - 200 acres. South Africa reported that only a very small acreage was planted, while 3 million dollars U.S. was generated in exports from material gathered primarily in the wild. Zimbabwe rounded out the report with another 200 acres in the ground. So, in 1983, we estimated that there were approximately 2,000 acres of cultivated *Proteaceae* planted, worldwide. I look forward with great interest to this year's reports, but even 2 years ago, at the 5th Biennial Conference in 1989, the reports totaled 11,000 acres, an increase of 9,000 acres planted in 6 years! The most dramatic increases came in South Africa (7,000 acres in cultivation), and Australia (1,800 acres). California was next, with 700 acres, Zimbabwe with 680, Hawaii - 300, New Zealand - 185 acres, Israel - 78 acres, Madeira - 14 acres, Tenerife - 5 acres and El Salvador - 5 acres.

What will the future bring, in expansion of plantings? It is my fervent wish that we see no "explosion" of production in the near future, until we can work toward the solution of some well defined constraints - both in our ability to produce high quality flowers, to maintain their quality enroute to the customer and to market them effectively and profitably.

MARKET POTENTIAL

During our discussions in the Protea Panorama, emphasis was placed on the importance of determining consumer preference and demand and controlling production to grow what the customer wants. During our first 2 decades of an emerging protea industry, Economist would say that the market is production driven. That is, the novelty value was so high, and the supply was so low, that almost anything we could get to market was sold, in other words - production determined what was marketed.

In the decade ahead, it is easy to see two things happening. New markets - those where proteas are relatively unknown, will continue to be production driven in the short term. If they don't know what a protea should look like, they may be a bit more tolerant of shorter stems, or less than vivid colors, etc. but, in the 30 years or more, that proteas have been seen on the major markets of Europe and North America, there is a definite swing to a consumer driven market. Once a customer - whether that customer is a wholesaler, retailer or ultimate consumer, gets a taste of quality, then they are spoiled for life! They will refuse to accept the lower quality, at the higher price they once did. The bright and promising future of the protea industry continues to rely upon producing the highest quality flowers, and marketing them in a manner that will produce the highest customer satisfaction - a market driven by consumer preferences - not by grower preferences.

Size of Market

Is it worth it? Based on the reports from delegates at the last IPA Conference, world wide sales of proteas were estimated to be approximately $12 million dollars U.S. (South Africa-$4, USA-$4, Australia $2.5, New Zealand $1, Other $0.5) Herb Mitchell, a floral marketing specialist, told the Conference that this represented less than 1/2% of the world's annual expenditure for flowers and floral products of $25 billion dollars U.S.

In the March, 1991 issue of "EUROfloratech", the 1990 per-capita consumption of floral products in U.S. dollars of the top 15 nations was reported by the Holland Flower Bureau. The U.S. figure was $48. Multiply that by 250 million people, and you have a U.S. national market of $12 billion. Trade estimates generally agree that the market share for "speciality" flowers is 10%, or $120 million dollars U.S. If one agrees with Herb Mitchell's assumption that proteas could easily represent 2% of the "speciality" market, then it is reasonable to predict that protea sales in the U.S. alone, could total $24 million dollars U.S. per year - a potential increase of 6 times over that reported in 1989. The exercise could continue by multiplying the population figures of each country, by their per capita consumption (e.g. Norway - $154, Switzerland - $143, Sweden - $126, Denmark - $116, Italy - $112, W. Germany - $101, and Japan - $53 per person of flowers, only!, it is easy to see why we feel that there is indeed, a great potential market for quality protea production.

RESEARCH

As our founder Peter Mathews put it so succinctly that October morning, a decade ago, "To produce first class flowers, we are going to have to do what growers of roses and carnations have done - i.e. to support research programmes - ..." And in her talk, "Protea - An International Review", at Protea Panorama II, 3 years ago, Dame Joyce Daws concluded her remarks by urging, "..support for research ...(as being) vital to a flourishing industry". And we HAVE! For the first time, an international commodity group has banded together to support two activities, critical to the development of an industry - PROMOTION and RESEARCH. Support of these activities, through your annual dues, has made it possible to provide "seed" money, or matching funds to encourage research on protea problems of importance to your area, and to all of us.

Research on proteas has expanded drastically since IPA came into existence. In 1981, we heard research reports from 2 men from South Africa, Drs. Van Staden and Jacobs; 2 men from Australia, Greenhalgh and Nichols and I reported on work in Hawaii. In 1983 - Marketing and Promotions for the North American Markets were emphasized, and in 1985, the first international protea research symposium was held in South Africa under the joint auspices of IPA, and the International Society for Horticultural Science, (ISHS) Twenty-four papers and ten poster presentations were given. The complete text of all 34 reports were published by ISHS in Acta Horticulturae #185. Proteas were beginning to be recognized on the world stage. In 1987, our New Zealand conference provided us with a balance of current research reports, local production practices, and international marketing. Our last conference 2 years ago once again jointly sponsored an international protea research symposium, and gave us an insight into growing and marketing - California style. The proceedings of the second international protea research symposium containing 16 reports are available in Acta Horticulturae #264.

Since I firmly believe that our future trends are based on what is happening today, let us take a look at some of the research that is currently in progress, around the world.

IPA RESEARCH GRANTS

The IPA is partially supporting three research projects: one is a "non-chemical" approach to disease control - Biological control of *Phytophthora cinnamomi* in proteas by *Pseudomonas cepacia* (Lois Turnbull, University of Queensland), one in cultivar improvement - The establishment of a selection and breeding program to produce cultivars of *Banksia* and *Dryandra* for floriculture (Margaret Sedgley, University of Adelaide) and one in tissue culture - In vitro propagation of *Banksia* and *Conospermum*, Eric Bunn, Kings Park and Botanic Garden). IPA has also approved two student research scholarships - one to Mark Wright, working on an entomology project in proteas, in South Africa, and one to Cathy Girard, working on the effects of temperature and moisture on the survival of *Pseudomonas cepacia*, in Queensland.

ISHS PROTEA WORKING GROUP REPORTS

Immediately following the conclusion of the 23rd International Horticultural Congress in Italy, August 27 - September 1, 1990, an international protea research workshop was convened in Israel, September 2 - 7. The abstracts were reprinted in Volume 21, of the IPA Journal. It is interesting to see once again that the focus of research activity depends upon the needs of the clientel group supporting that activity. The theme for the Israel meeting was, "Intensive Cultivation of Protea".. Scientists from the host country reported on cultivation in inert growth media, the use of grafted plants, and foliar micro-element sprays. Dr. Jaacov Ben-Jaacov, leader of the protea research project in Israel, states that, "difficulties in cultivating proteas in Israel are usually related to soil problems". So in addition to looking for cultivars that can grow under their conventional field conditions, they are also developing systems of growing the more sensitive cultivars using volcanic ash and a mix of 3:1 volcanic ash and peat. For potted plants, peat and 20% perlite is used. Fertilizer is added with every watering. Of perhaps greater potential interest to protea growers throughout the world, is the work currently in progress in South Africa and Israel on the development of appropriate rootstocks to overcome soil problems such as disease and adverse pH. What an exciting development it would be, if we could establish our protea plantations on rootstock - resistant to root rots, to nematodes, to high ph and see the same vigorous growth and production from our superior cultivars grafted or budded on these rootstocks that we get from grafted roses or fruit trees! Then, as cultivars became available, instead of tearing out a field and starting all over again, we could merely "top work" our newest varieties onto the established rootstocks and enjoy a significant reduction in the "down time" before harvesting and sales could be expected. There is also increasing activity on the cultivar improvement front. Gert Brits reported on the interspecific hybridization in *Protea*, *Leucospermum* and *Leucadendron* at the International Congress, and on breeding programs for *Proteaceae* cultivar development at the Workshop in Israel. Malan gave papers on improving shoot growth and flower quality with sprays of Gibberellic Acid and Benzyladenine, and discussed some of the factors affecting flowering of *Leucospermum* cv Red Sunset. The patterns of growth and flowering, as a guide to future control for market advantage was touched upon both by Dr. Wallerstein, from Israel, and Steven Dupee, from Australia. As the number of improved cultivars increases, the pressure for more efficient methods of rapid propagation increases. Abstracts of 9 papers concerned with propagation, from 4 countries are to be found in the proceedings of the workshop, soon to be published in Acta Horticulturae.

CONCLUSIONS

What are the trends for the Decade ahead? In the short term I see a "settling out" period continuing. We may expect to see some of our growers, who are not serious about the industry, or who unfortunately are located in less than favorable soil and climatic areas with no compensating marketing advantage, drop by the wayside as the market for proteas shifts from being production driven, to consumer driven. There continues to be a bright future for an expanding market for proteas. However, in a onsumer driven market, we must be sensitive to what the consumer wants, and when he wants it. We must continue to educate the consumer regarding the existence of proteas and how to handle them. We must continue to improve the quality of our product, not only in the field, but in the marketplace. We must continue our efforts to specialize our product line and grow only what we can grow best and cooperate with others in providing markets with a dependable, high quality product - throughout the year.

With the final decade of the 20th century upon us, it is time to "get serious" we can't do it alone! Through increased cooperation, communication and support of research, we can solve the production problems within our region. Through increased cooperation, communication and support of marketing and promotion, we can tell the world about our product, and deliver it in the form and quality that a consumer driven market demands.

Cooperating and working together within our production area, within our country, and within the International Protea Association, we WILL see the protea achieve the status on world markets that it deserves. WATCH OUT ROSES - MOVE OVER ORCHIDS - HERE WE COME!!!

Biographical Profile

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GRAFTING AND THE USE OF ROOTSTOCKS IN LEUCADENDRON AND OTHER PROTEACEOUS PLANTS

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Abstract:

Proteaceous flower production under Israeli conditions is limited mainly by soil-root problems, namely: high pH of the soil, diseases and nematodes. Grafted plants using selected resistant rootstocks can overcome these problems. In addition grafting is being used as a method for vegetative propagation of species which are difficult to propagate by cuttings.
Species of *Leucadendron* are the main group of Proteaceous plants being used, in large scale production, of cut flowers and decorated branches. From the climatic point of view they are very suitable for cultivation in Israel. The purpose of the present study was to test the possibility of using suitable rootstocks to overcome soil problems encounted in the production of Leucadendrons in Israel and in other places with similar soils.
Wedge-cleft grafting was used. The rate of success was 40% to 100% depends on season and scions - rootstocks combination.
In experiments conducted in high pH soil (8.2 pH) grafted *L.* "Safari Sunset" and *L. discolor* plants grew very well, whereas these varieties planted on their own roots suffered extremely by chlorosis and died 18 months after planting.

Introduction

Species of the genus *Leucadendron* are the main Proteaceous plants being used as cut flowers. This genus includes male and female plants. Both kinds of inflorescences have the potential of being used as cut flowers and decorative cut branches. There are at least 25 commercial cultivars belonging to about 10 species which are being used worldwide as cut flowers.
Most species were orignated in acid soils and all commercial cultivars were developed for cultivation in acid soils (in Australia, S. Africa and N.Z.). Few species of *Leucadendron* were originated in limey soil parts of South Africa. These species are grown relatively easy in Israel.

Leucadendrons have been grown commercially in Israel since the early 1970's. Production has been limited, mainly, because of difficulties in cultivating these plants. Difficulties are related to soil problems; too high soil pH, too high soil phosphate and soil born deseases.

About 5 years ago the hybrid "Safari Sunset" has been introduced to Israel. In few locations it grows well: - on some soils of the Golan Heights and on some of the well earated-light soils of the coastal plane. Some farmers developed a method of cultivating "Safari Sunset" in volcanic ash trenches. Quality of flowers is excellent (prices up to $0.35 per stem) and the yield is good. These plantations however need special care - daily irrigation and fertilization. The investment is very high and life spend of the plantation is very limited.

Some leucodendrons grow very well in Israel and individual plants (L. muirii) have survived for over 20 years.

The present study describes technologies developed for grafting several commercial cultivars of Leucadendron on selected Leucadendron rootstocks. The report includes initial observations on the performance of several scion/rootstocks combinations under field conditions.

The idea to use rootstocks in Proteaceae has been suggested as early as 1968 by Rousseau. But even though several studies were carried out on the subject (see the enclosed list of publications) there is still no use of rootstocks in commercial Proteaceous cut flower production.

Large assortment of Leucadendrons native in high PH soil have been introduced to Israel since the beginning of Protea's interest in this country in the early 1970's. The following species have been planted and are grown in several locations in Israel (Table 1).

There is a need for using rootstocks and grafted plants, under Israeli condition, not only in the genus Leucadendron but also in other Proteaceous genera: Most Banksias grow well in Israel and the main reason for grafting is vegetative propagation. The reason for grafting Protea and Leucospermum is the possibility to use resistant rootstock.

Methods and Materials

Plant Material:

Experiment no. 1: In experiment no. 1, which was more a small scale observation than a planned experiment, we used `Orot' (a local clonal selection of L. coniferum) as a rootstock and L. discolor and L. `Safari Sunset' as scions.

Experiment no. 2: In experiment no. 2 L. `Orot', L. coniferum and L. muirii were used as rootstocks - the first one propagated by cuttings and the other two by seeds. As scions L. discolor and L. `Safari Sunset' were used. Small scale observations using other rootstocks and scions are also presented.

Other Proteaceous plants: With Banksias we tried B. integrifolia and B. ashbyi as rootstocks and B. ashbyi and B. coccinea as scions. In the genus Protea we used P. obtusifolia and P. susannae as rootstocks and P. neriifolia, P. cynoroides and some selected cultivars as scions. In the genus Leucospermum the main rootstock tried was L. patersonii with observations also with L. conocarpodendron. As scions we used cultivars of L. pattersonii, selected clones of L. cordifolium and some of the L. cordifolium x L. lineare hybrids.

Methods of propagation and grafting

Propagation of L. `Orot' (and silver bush) were done by cuttings: Stem segments, 10 cm long and 2-3 mm in diameter were taken from 2 years old L. `Orot' plants grown in 35 litre plastic containers containing 75% tuff: 25% peat growth medium. Leaves were stirpped off the bottom 1/2 of the cuttings. The bases of the cuttings were placed for 10 seconds in aquaeous solution of 4000 PPM K-IBA. The cuttings were stuck in 1 inch-cells plug trays ("speedling") containing rooting medium of 50% peat: 50% styrofoam. Temperature at the bases of the cuttings was kept at 24°C ± 2. The rooting was done in a temperature controlled (max 25°C winter, 32°C summer, min. 11°C) glasshouse. The cuttings were kept under intermittent mist (on 20 sec. off 20 min.). Rooting of 55-75% occured 8 weeks after stuckings, when the rooted cuttings were repotted into 5 cm. plastic pots. Grafting was done 3-6 months after repotting when the plants were actively growing (Fig. 1 and 2).

Other rootstocks; L. coniferum, L. muirii and L. linifolium were propagated by seeds. Seeds were sown in October and seedling were ready for grafting 10-12 months after germination. Stem segments, 5 cm. long with 2 fully developed leaves (see Fig. 2) were used as scions. The top - cleft grafts and the side grafts were tied with plastic stripes and covered with white plastic bags. Most successful grafts started sprouting 2-3 months after grafting (2-3 weeks after removing the white plastic logs.).

The plantation:

Soil and soil preparation: The experimental field is located at the Dept. of Floriculture, A.R.O. The Volcani Center, Bet Dagan. The soil is sandy loam, reach in lime agrigates. The pH is 8.1 - 8.4 at depth of 10 cm. The soil was ploughed well to depth of 40 cm. treated with Methyle Bromide and leached well before planting.

Planting was done in experiment no. 1 in May 1989 and in experiment no. 2 in May 1990. Plants are watered with on-line (3/meter) 2 liter/h. drippers. Watering is done once a week providing 2 liter/plant/day. Every irrigation includes 100 g/m^3 ammonium sulfate, 30 g/m^3 Potassium nitrate 2.5 g/m^3 Fe Chelate (Sequestreen) and 30 ml/m^3 microelements complex ("Korateen").

Plants were planted 3 meters between the rows and one meter between plants in the rows. A strip of "ground cover" (one meter wide) was placed along the rows to conserve soil moisture, and prevent weed growth.

Results and Discussion

Grafting

Some initial results of graft take are presented in Table 2 (Experiment no. 2). The main groups tried were "Orot", L. coniferum and L. muirii as rootstocks and "Safari Sunset", L. discolor and L. "Yaeli" as scions. When this plant material was grafted in late full, winter and mid spring 40-100% graft take was achieved. Early March seems to be generally favorable date for grafting of all combinations. There is still no sufficient data to indicate favorable rootstock/scion combinations.

Growth response under field conditions

Experiment 1: This experiment included 2 groups of plants planted in adjacent rows. In one group the plants planted in the following order:

1) "Orot"
2) "Safari Sunset" on its own roots
3) "Safari Sunset" on "Orot"
4) "Safari Sunset" on its own roots.
5) "Safari Sunset" on "Orot".

In the second group "Safari Sunset" was exchanged by L. discolor. Within 18 months all the 4 plants of "Safari Sunset" and L. discolor grown on their own roots died (Fig. 3 Table 3). The grafted plants and the "Orot" rootstock grew very well - at least as good and even better than "Safari Sunset" plants in identical age grown on their own roots in best plantations in the country (in volcanic ash artificial medium and on low pH sandy loam of the coastal plane of Israel. Grafted L. discolor grow well and produce very dense bushes, denser than L. discolor grown on its own roots in sandy soils. Now, the 2 years old grafted plants are continuing to grow very vigorously.

Experiment 2: The main part of Experiment 2 include 3 rootstocks: L. "Orot", L. coniferum, L. muirii and 2 cultivars; L. "Safari Sunset" and L. discolor. Each treatment (a scion/rootstock combination) included 3 blocks of 4 plants each. It is clear that these cultivars grow better when grafted. The different rootstocks produced different rate of growth. "Orot" seem to be the strongest, followed by L. coniferum and L. muirii.

Based on these limited information (Table 4) there seem to be no interaction between the scions and the rootstocks. The effect of the rootstocks seem to be however more pronounced with "Safari

Sunset" than with L. discolor. L. muirii produced slower growth of the grafted plants than the other 2 rootstocks. The color of the scions folliage is deeper green when grated on L. muirii.

Since it is hard to grow Leucadendrons in most soils in Israel, the above technology may make it possible to grow successfully L. "Safari Sunset" and L. discolor in much wider range of soils. In addition, the proposed method may make it possible to grow in Israeli soils much wider range of Leucadendron cultivars. Continuation of the present study and further planting of other scion/rootstock combinations may lead to specifically selected scion/rootstock/soil combinations.

Results obtained with other Proteaceous genera

We were successful in grafting only few Banksias. Scions of selected Banksia ashbyi clones were grafted successfully on one year old B. ashbyi seedlings.

Rate of grafting success was very low (10-15%) but these grafted plants grow well in our experimental plantation (see method and material - The plantation).

In the genus Protea best results both in grafting take and of being used as rootstocks was achieved with protea obtusifolia. We have not encountered any in compatibilty problems even P. cynaroides was grafted successfully on P. obtusifolia.

With Leucospermum grafting is very easy. We have not, however, identified the most suitable rootstock. L. pattersoni seem to be the best - it is very lime (high pH) tolerant. However it has relatively short life span and it is sensitive to nematodes.

List of Publications on Grafting of Proteas

Barth, G. and M. Bennell. 1986. Selection and grafting studies of *Banksia coccinea* and *Banksia menziesii*. Int. Plant Prop. Soc. 36: 220-224.

Ben-Jaacov, J. *et al*. 1989. New approaches to the development of Proteaceous plants as floricultural commodities. Acta Hort. 253: 193-199.

Burke, D. 1989. The cuttings Graft. Australian Plants 14: 119

Gibian, T. and P. Gibian 1989. Experiences with Gravillea cutting grafts. Australian Plants. 14: 119-120.

Hodge, M. 1991. Grafting Native Plants. Australian Plants. 15: 369-377.

Jacobs, G. 1981. Vegetative propagation of Proteas - Recent Development. In: P. Mathews, Growing and Marketing Proteas. Proteaflora Enterprises Publication, Melbourne, Victoria, Australia.

Meynhardt, J.T. 1976. Propagation of Proteas (ed.) Farming in South Africa no. B.2. Published by Horticultural Research Institute, Pretoria.

Rousseau, G.G. 1968. Budding of Proteas. Farming in South Africa. January 1968. Page 17-19.

Table 1: Relative success, use and adaptability of Leucadendrons grown in Israel.

Species	Relative success[y]	distribution[z]	Comments
L. argenteum	++	+	5 meter tall trees on sandy loam soils of the coast. Life span 15 years.
L. coniferum	+++	+	-
L. discolor	++	++	2 local clones. 3 hectares commercial plantations. Flowering starts at 3rd year. Life span 6-10 years.
L. galpinii	+++	++	Few commercial plantations. limited commercial value.
L. Laureolum	+	+	-
L. meridianum	+++	+	Sold as silver bush. Limited commercial value.
L. muirii	+++	+	Grow very slowly but very well. Have long life span (20 years up).
L. 'Yaeli' (L. salignum)	++	+	A local selection of yellow salignum.

y = Relative success
++ = Grow very well.
+ = Grow well.
= Difficult to grow.

z = Distribution
+++ = Widely distributed. There are commercial plantation.
++ = Restricted distribution.
+ = Very restricted indistribution.

Species	Relative success[y]	distribution[z]	Comments
L. thymifolium	+++	+	May have commercial value
L. tinctum	++	+	-
L. uliginosum	+++	+	Sold as a silver bus Limited commercial value.
L. 'Safari Sunset'	++	+++	Grows well on volcan soils and artifici "tuff" trenches. variable success sandy soils of t.. coast.
L. 'Orot' (*L. coniferum*)	+++	+	A new, cuttings' propagated rootstc selection.

y	=	Relative success
+++	=	Grow very well.
++	=	Grow well.
+	=	Difficult to grow.

z	=	Distribution
+++	=	Widely distributed. There are commercial plantation.
++	=	Restricted distribution.
+	=	Very restricted indistributic

Table 2: Percentage take-off *Leucadendron* grafts

Rootstock	Scion	Date of grafting								
		8/11	29/11	24/12	31/12	27/1	3/2	7/3	28/4	1/5
"Orot"	"Safari Sunset"	–	–	–	–	–	–	–	10	0
	Salignum "Yaeli"	–	–	30*	–	60	–	–	–	–
	discolor (early)	–	–	60	–	–	–	–	–	–
	discolor (late)	–	–	–	–	–	–	–	–	–
Muirii"	"Safari Sunset"	–	–	–	–	–	–	100	–	–
	Salignum "Yaeli"	25	20	60	60	–	–	–	–	–
	discolor (early)	–	–	40	40	–	–	40	–	–
	discolor (late)	–	–	–	–	–	–	60	–	–
Coniferum	"Safari Sunset"	–	–	–	–	–	–	40	–	–
	Salignum "Yaeli"	35	25	20	20	80	–	–	–	–
	discolor (early)	0	–	–	80	–	–	80	–	–
	discolor (late)	–	–	–	–	–	–	40	–	–
Uligonosum	*Salignum* "Yaeli"	–	60	–	–	–	–	–	–	–
Linifolium	*discolor*	–	–	–	–	–	0	–	–	–
	"Safari Sunset"	–	–	–	–	–	0	–	–	–

* = At each date 50-70 plants were grafted.

Table No. 3: The effect of "Orot"' rootstock on survival and growth of <u>Leucadendron</u> "Safari Sunset" and <u>L.</u> <u>discolor</u> planted in Sept. 1989 and measured in June 1991.

Scion	Rootstocks	Gain in stem diameter 11/90 - 6/91 (mm)
L. "Safari Sunset"	"Orot"	16.5
" "	Own roots	0 (plants died)
L. discolor	"Orot"	11.5
"	Own roots	0 (plants died)
L. 'Orot"	Own roots	19.5

Table No. 4: The effect of *Leucadendron* "Orot", *L. coniferum* and *L. muirii* rootstocks on gain in stem diameter (mm and %) of L. "Safari Sunset", *L. discolor* and *L.* "Yaeli". Planted in May 1990 and measured in June 1991.

Scion	Rootstock	Gain in stem diameter 11/90 - 6/91 (mm)	%
L. "Safari sunset"	L. "Orot"	11.0	208
	L. "*coniferum*"	10.7	202
	L. "*muirii*"	7.0	132
	Own roots	5.3	100
L. discolor	*L.* "coniferum"	7.3	183
	L. "*muirii*"	5.0	125
	Own roots	4.0	100
L. "Yaeli"	*L.* "*muirii*"	4.0	-

Fig 1: "Orot" (a cloner selection of L. coniferum) plant ready for grafting.
- cuttings stuck Feb. 25, 1990. photographed May 25, 1990

Fig. 2: A grafted plant ready for outdoor planting. Three months after grafting.
Scion: L. "Safari Sunset"
Rootstock: L. "Orot".

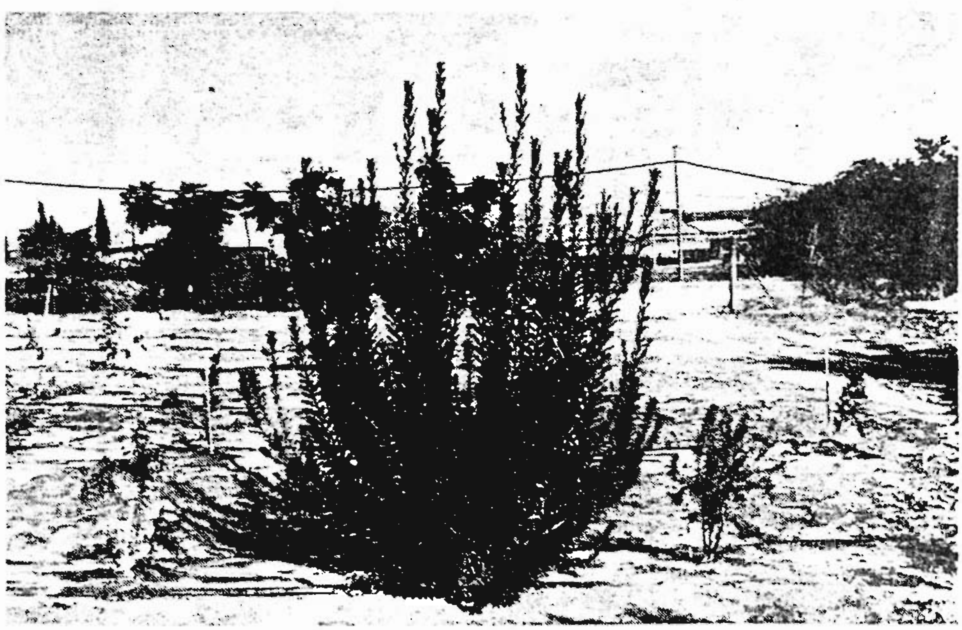

Fig. 3. Eighteen months old plants of grafted and own roots grown "Safari Sunset" plants.
Front row-center; "Safari Sunset" grafted on "Orot" rootstock.
On its both sides "Safari Sunset" plants grown on their own

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DR. J. BEN-JAACOV - CURRICULUM VITAE Dec. 1990

Dr. Ben-Jaacov was born in Israel in 1937.

After graduating from an agricultural high school and serving in the Israeli Millitary forces, he received his BSc. from the University of California and completed his PhD. work at Cornell University in Floriculture , Plant Physiology and Plant Breeding in 1970.

Returning to Israel in 1970, he started working at the A.R.O. - Volcani Center in Floriculture. In addition to his research activites he headed the Department of Floriculture (40 Scientists and Technicians) during several terms (1970-1975, 1988, 1990-to present).

His main research activities include:

- Vegetative Propagation and Tissue culture; micropropagation of Chrysanthemum, development of Selected Disease free spray carnation via tissue culture, micropropagation of Proteaceous and other woody plants.

- Domestication and development of new Floricultural crops; Proteaceous plants, Genista, Aster, Euryops and other woody plants.

- Pot plants research; Development of woody flowering pot plants: (Leucospermum, Grevillea, Gardenia, Alberta) Storage of foliage pot plants.

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In recent years emphasize has been placed on Proteas and other woody plants as cut flowers and potted plants. Ben-Jaacov is deeply involved in these plants both as a scientist as well as a grower (as a grower since 1973).

Ben-Jaacov has served on various national and international scientific bodies including being the President of the Israeli Plant Propagator Society, member of the Israeli Department of Agriculture Floricultural Steering Committee and a member of the International Protea Association Research Committee.

He has been involved in research during sabbatical (one year) periods, both in Florida and the Rep. of South Africa. He visited on study tours in Australia, N.Z. and Japan, and conducted consulting activities in Floriculture for the F.A.O. in the Rep. of Korea and in Nigeria (tropical floriculture).

He presented scientific papers and delivered popular lectures in national and international forms; American and International Societies for Horticultural Science (ASHS, ISHS); USA (1966), Israel (1970), Australia (1978), Rep. of South Africa (1985), Denmark - invited lecturer by the Denish Growers Association (1988).

Ben-Jaacov has published over 75 scientific and popular papers in local and international journals.

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REVIEW OF FLORICULTURAL RESEARCH IN SOUTH AFRICA, WITH SPECIAL EMPHASIS ON THE PROTEA CULTIVARS RELEASED BY THE FYNBOS RESEARCH UNIT

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South Africa is a country with a most interesting plant kingdom. More than 22 000 different plant species are found in this region. Some of the world's best-known flower crops like Gladiolus, Freesia and Pelargolium were developed from this gene source.

The flora of southern Africa can be divided into six phyto-geographic regions (Fig 1), of which the Cape Floristic Region or Cape Flora is the smallest. Although it is less than 4% of the total land area of the southern African region, it is considered one of the world's Floral Kingdoms and is also referred to as the Cape Fynbos. With more than 8 504 species the Cape Flora (Bond & Goldblatt, 1984) is one of the most stunning floral regions in the world. Due to the tremendous diversity and potential of the flora, there are several research organisations in South Africa and abroad who are involved in the conservation and utilization of the plants.

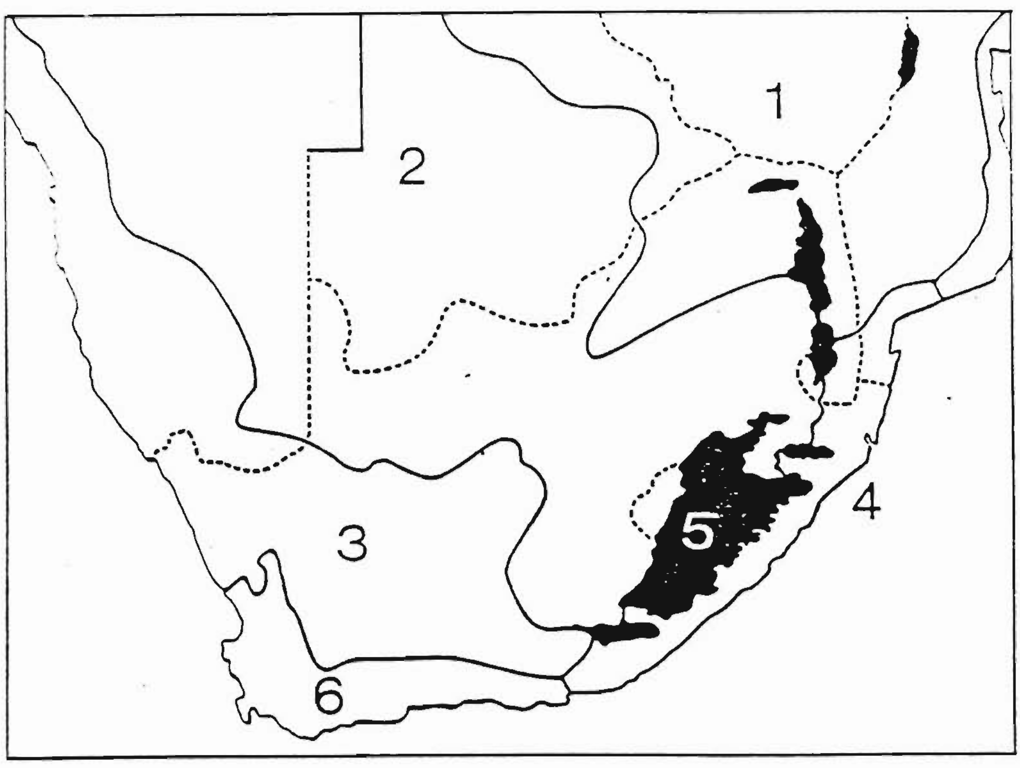

Figure 1. The phytogeographic regions of Southern Africa (Goldblatt, 1978) 1. Zambezian Region; 2. Kalahari-Highveld Transition Zone; 3. Karoo-Namib Region; 4. Tongaland-Pondoland Region; 5. Afromontane Region; 6. Cape Region.

Establishments such as the Department of Environmental Affairs in South Africa are mainly concerned with the conservation of flora. The function of this department is to protect threatened species and to see that the natural habitat is not disturbed and fragmented. However, a vast amount of flowers in South Africa is picked in the natural environment and it is therefore important that the exploitation is monitored.

The role of the National Botanical Institute is to develop and maintain regional botanical gardens, such as the world-renowned Kirstenbosch. The Institute also pays attention to a variety of botanical subjects such as taxonomy, ecology and the protection of threatened species. Several of the country's universities are also involved in botanical research projects on the indigenous flora.

Research on the floricultural potential of the indigenous flora of Southern Africa is mainly the responsibility of the Vegetable and Ornamental Plant Research Institute of the Department of Agriculture. The Institute has a floricutural research unit stationed at Elsenburg, outside Stellenbosch (Fynbos Research Unit) and its head office at Roodeplaat, outside Pretoria.

The objective of this unit is to develop new floricultural crops by making use of the natural gene sources of southern Africa. In other words, new flower cultivars must be developed and existing cultivars must be improved.

Certain plant families have been identified that show good floricultural potential, namely:

Proteaceae
Ericaceae
Asteraceae
Bruniaceae
Amaryllidaceae
Iridaceae
Hyacinthaceae

The basis of the research programme is the establishment and maintenance of a gene-bank. The collection consists of plants that show outstanding potential and that can be used in the breeding programmes.

In the Proteaceae gene-bank there are more than 1 000 different selections of species, varieties and ecotypes. Cultivars developed by the Institute and collected from elsewhere, are also maintained in the collections. These cultivar collections serve as a mother block for multiplication. An attempt is being made to collect and conserve important protea cultivars from over the world in this protea gene-bank.

<u>Breeding and selection</u>

The aim of these research actions is firstly to develop new and improved protea cultivars and secondly to develop flower bulb cultivars. Of the latter type especially those that are disease resistant, such as Gladiolus cultivars that are resistant to the rust fungus, Uromyces transversalis. An attempt is also made to develop improved cut flower cultivars such as an orange or yellow Ornithogalum cultivar. Much attention is also being given in the bulb breeding programme to the family Amaryllidaceae, because there is a large number of species in this family that show potential both as cut flower and/or pot plant cultivars.

The flower bulb breeding programme has already released a very successful series of Lachenalia cultivars to the industry. At present 20 of the cultivars are being multiplied and will be made available world-wide from an international company.

The aim of the Proteaceae breeding and selection programme is to develop new and improved cultivars that have, amongst others, smaller inflorescences and that also flower out of season. To achieve these aims, artificial crosses are being made and an intensive selection and evaluation programme is being followed. The development programme followed for releasing a protea cultivar can take 8-12 years and involves the following:

If a hybrid seedling or selection should start flowering, the flower is evaluated. When a plant shows potential as a cut flower, foliage, pot plant or for landscaping, it is given a code number and the plant is included initially in the collection as phase I material (pre-evaluation phase). This plant is then multiplied by vegetative propagation, and during the evaluation phase, including three years of flowering, is classified as phase II material. Fully evaluated selections are phase III. Those with cultivar potential are given the status of "elite selections". The final evaluation is then made which will determine whether the candidate cultivar can be released. If the cut flower meets with the requirements, the material is multiplied on a large scale, and evaluation on the flower markets is now also done. Only if the elite selection meets all the requirements, is it registered as a cultivar and plant breeder's rights are taken out.

The Fynbos Unit has already released the following 35 cultivars to the industry.

LEUCOSPERMUM

Tango (L. lineare x L. glabrum F_1 hybrid):
A brilliant red flower with an unusual flower head shape and high yield as a result of hybrid vigour. Leaves are particularly neat and flowers can be produced to the end of November with debudding.

Ballerina (L. lineare hybrid):
Attractive, soft pink-orange flowers which display well in artifical light. Marketable flowers are produced until January by means of disbudding, on straight, neat, long stems. They can also be used as flowering pot plants.

Starlight (L. lineare selection):
An unique bicoloured flower (creamy-white and red) which

naturally blooms late and can be made to flower up to December by debudding. The most outstanding characteristic of the flower is its long stems (up to 1 m) with a highly attractive purple-red colour and fin linear leaves.

High Gold (L. cordifolium Yellow Bird x L. patersonii);
A vigorous, erect grower producing long stems with large yellow flowers. This cultivar bridges the problems of both Yellow Bird and L. patersonii and has a high yield as a result of hybrid vigour. It can tolerate slightly alkaline soil.

Vlam (L. cordifolium);
The largest red pincushion available - diameter 12 cm. Flower colour: deep orange-red, style tip yellow. Peak flowering time: early October to mid-November. It has strong, erect stems, and produces a good late harvest after debudding or ethephon treatment.

Goldie (L. cuneiforme)
Flower colour: deep yellow with orange-red style tips. Peak flowering time: early November to mid-December.

Helderfontein (L. glabrum):
Outstanding L. glabrum. Flower colour: deep orange-red. Peak flowering time: mid-August to mid-October.

Luteum (L. reflexum var. luteum):
Flower colour: medium yellow. Peak flowering time: early September to end October.

Scarlet Ribbon (L. glabrum x L. tottum):
Flower colour: deep salmon pink. Peak flowering time: early September to mid-October. Exceptionally vigorous grower with a high yield.

Sunrise (L. cordifolium x L. patersonii):
The earliest pin-cushion cultivar available. Flower colour: medium red. Peak flowering time: early August to mid-September. An exceptionally vigorous grower due to strong hybrid vigour, can tolerate slightly alkaline soils.

Flamespike (L. cordifolium):
Deep red, small flower head. Peak flowering time: early September to mid-October.

Fire dance (L. cordifolium)
Flower colour: Deep red (like Flamespike). Peak flowering time: early September to mid-October. It has smallish flower heads.

Pink Star (L. cordifolium):
Flower colour: deep pink-orange. Peak flowering time: early October to mid-November.

Caroline (L. cordifolium x L. tottum):
Medium pink-orange flowers on long, thin stems. Peak flowering time: early October to mid-November. Exceptionally high yield.

Yellow Bird (*L. cordifolium*):
Flower colour: Medium yellow. Peak flowering time: early September to mid-October.

PROTEA

Guerna (*P. repens*):
Selected from the Kouga variant of *P. repens*. Flower colour: deep red. Peak flowering time: end December to mid-February.

Sneyd (*P. repens*):
A medium-sized, deep red flower of the Alicedale variant. It has a high yield and good stem length, flowering from mid-January to March, i.e. between *P. repens*, Guerna and Embers and forms a continuous series (early February to end March).

Embers (*P. repens*):
A medium-sized flower, each bract a deep red at the tip and creamy-white basally. It has a shiny, smooth texture and flowers after *P. repens* Sneyd in March to mid-May. It forms the last in a continous *P. repens* series, Guerna - Sneyd - Embers.

Rubens (*P. repens*):
This deepest of red *P. repens* flowers from February to March and along with Guerna and Sneyd gives a continuous flower-season from the end of December to May. It is especially suited for the garden.

Andrea (*P. compacta* x *P. magnifica*):
Produces a large pink-red flower with numerous series of bracts. It has a high production; long, straight stems; flowers from mid-July to mid-September.

Brenda (*P. compacta* x *P. burchellii*):
A medium-sized, deep pink-red flower with a shiny, smooth texture. It has a high yield and flowers from May to July.

Cardinal (*P. eximia*):
An outstanding eximia type. Has a medium-sized, deep pink-red flower with a satin sheen. Long, straight stems and high yield; flowering time is November to February.

Red Baron (*P. obtusifolia* x *P. compacta*):
A medium-sized flower with dense, deep red bracts lined with short, white hairs. It has a high yield and flowers from mid-June to mid-September.

Satin Pink (*P. longifolia* hybrid):
A small, multicoloured flower with soft pink-red and cream shades. It has a high yield and flowers form June to mid-August.

Susara (*P. magnifica* x *P. susannae*):
A small to medium flower with an unusual shape, having soft salmon pink and light red shade. It has a very high yield and flowers from mid-March to May. It can tolerate slightly alkaline soil.

Sylvia (_P_. _eximia_ x _P_. _susannae_):
A medium-sized, deep pink-red flower with satin sheen. It has a high yield and flowers from November to February.

Atlantic Queen (_P_. _magnifica_):
A strong grower with a high yield of reasonably long stems. Propagates well from cuttings. Produces large, pink flowers from June; can be used as a cut flower or a garden plant.

Fiery Duchess (_P_. _eximia_):
This selection is a superior _P_. _eximia_. It grows into a tall shrub with a high yield of deep red flowers on long stems. It is suitable as a cut flower as well as a garden plant with a tidy, dense growth form.

Red Robe (_P_. _neriifolia_):
A good _P_. _neriifolia_ selection with an attractive plant shape. The bright red flowers are conspicuous and the plant is a strong grower that flowers in June until August. It is well suited as a landscape plant.

Pink Duke (_P_. _compacta_ type):
An outstanding _P. compacta_ type flower. The inflorescence is larger than _P_. _compacta_ with a denser involucre, and has a delicate, yet bright pink colour. It flowers from June to August and is suitable for cut flower production and as a garden plant.

Red Rex (_P_. _cynaroides_):
This deep red _P_. _cynaroides_ flowers from November to mid-December and is a strong grower that produces long, flowering stems. This plant is suitable for both cut flowers and as a garden plant.

LEUCADENDRON

Candles (_L_. _salignum_):
A conebush with deep red bracts surrounding the flower-head, alternating with yellow and orange shades on the inside. It flowers from April to August.

Duet (_L_. _salignum_ hybrid):
This hybrid produces bright red to yellow inflorescences that give the shrub a bicoloured appearance. It flowers from June to September. The height of the shrub is 1,5 m and it is an unusual landscape plant.

Winter Red (_L_. _salignum_ selection):
A low growing conebush. The flower is red outside and yellow on the inside, with an attractive shape. It is suitable as a landscape plant.

Pom-pom (_L_. _discolor_ selection):
Bears long, straight flower stems and large yellow involucral leaves with a bright red male pom-pom inflorescence. It flowers from September and is suitable as cut flowers. Available in limited amounts.

Crop Science. Of the many problems that arise when developing new crops, it is essentially necessary to solve cultivation problems so as to ensure that the new crop can be produced successfully.

In the field of crop science, the Fynbos Research Unit is at present developing techniques to mass propagate selected plant material. Research is undertaken here on aspects such as tissue culture, micro-propagation and ordinary vegetative propagation, including grafting and budding of proteas. The pruning of proteas has become a very important practice of which, until now, little is known. The right pruning practices could make it possible, for example, to induce the plants to bear longer flowering branches.

Certain Leucospermum, Leucadendron and Serruria varieties are developed as flowering pot plants. This development could open up a whole new market for proteas. Presently attention is directed to identifying suitable varieties. The manipulation of mother plants is studied, as well as other techniques, in order to develop suitable products.

Plant protection

Diseases and insect pests are amongst of the greatest problems that adversely affect the development of the floral industry. Serious objections have already been raised by environmentalists about the use of toxins to produce flowers. This could have serious consequences for the protea industry. Attempts are therefore made to develop environmentally friendly control methods.

Another serious project is to develop a pincushion rootstock that is tolerant against the root rot fungus, *Phytophthora cinnamomi*.

Heavy emphasis is also placed on biological control of insects, like borers.

It is clear that a wide field of research is being carried out in South Africa at present. It is, however, also true that we have only scratched the surface of the rich plant kingdom of southern Africa, and that a great potential still lies locked away.

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CONTROL OF SEED DORMANCY IN LEUCOSPERMUM

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ABSTRACT

Control of the multiple dormancy imposing mechanisms in *Leucospermum* is important in breeding projects and in commercial seed propagation. Although some species such as *L. cordifolium* can now be germinated with 97% success with viable seed, others such as *L. reflexum* remain relatively unyielding to known dormancy breaking treatments. Seed dormancy was studied within the eco-physiological context. Dormancy parameters investigated include optimal daily alternating temperature requirements in six commercial species, anatomical seed coat properties associated with dormancy and dormancy breaking mechanisms operating in nature. It was found that the "heat pulse" effect of fire is probably a desiccation effect on the testa. Gradual scarification of the seed coat in the ground can be linked to improved oxygenation of the embryo. This explains both the post-fire phenomenon of synchronous germination of the majority of seeds in the underground seed bank and the erratic, extended germination of a fresh seed batch. Dormancy control measures are discussed.

INTRODUCTION

Germination problems of *Leucospermum* have interested scientists and growers for over 50 years. Environmental factors identified so far which control germination include: diurnal high temperature, diurnal low temperature (Brits, 1986) removal of oxygen deprivation (Van Staden & Brown, 1973) and, possibly, "heat pulse" after fire (Bond *et al*, 1990). Success rates of up to 97% successful germination of viable seed is presently possible with *Leucospermum cordifolium* (Brits, 1990). Some species however are still difficult to germinate. It is essential in *Leucospermum* breeding to have full control over seed dormancy.

The Protea industry can not be neutral to the pressing issues of conservation biology (Greyling & Davis, 1989). The harvesting of flowers from the wild creates additional pressures on populations, some of which are vulnerable or even endangered (Rebelo & Holmes, 1988). Seed biology research is an integral part of conservation research which clearly concerns the Protea industry. Indeed the whole of the protea world has an interest in the conservation of the natural gene pools of commercial Proteaceae species - and should therefore support conservation seed biology research of these species.

A number of studies have been conducted recently to unravel the dormancy mechanisms in *Leucospermum* and to develop an eco-physiological model for seed regeneration. These are reported in logical sequence below in order to outline the model.

RESULTS AND DISCUSSION

<u>Germination temperature requirements in 6 *Leucospermum* species</u>

The germination temperature regime required for *Leucospermum cordifolium* seed germination was previously estimated at diurnal 8 °C low x 24 °C high. This regime corresponds reasonably closely to soil temperatures in the habitat following a fire, during the late autumn seed germination season (Brits, 1986). The question was: to what extent does the *L. cordifolium* regime apply also to other species?

Seeds of six species were scarified in concentrated sulfuric acid, washed and soaked in water for 24 h. They were incubated under 15 different temperature regimes, using 6 replicates of 25 each. The regimes were 4 °C, 10 °C, 16 °C, 22 °C, 28 °C and all combinations of these. The lowest temperature in all cases were maintained for 16 h and the high for 8 h daily. Tetrazolium tests were conducted on all seed batches to estimate viability. Germination was recorded weekly. The species were *Leucospermum cordifolium, L. cuneiforme, L. erubescens, L. glabrum, L. reflexum* and *L. vestitum*.

The results showed that the requirement for alternating temperatures is common in *Leucospermum* (Fig. 1). Furthermore that in some species these requirements are very specific (e.g.. *L. glabrum*) whilst in others there is more latitude (e.g.. *L. cordifolium*). A previous conclusion that species differ in the temperature levels required and that this is correlated with the climatic regime of their habitat, is also supported by the results (e.g.. *L. reflexum* vs. *L. glabrum*).

Some species did not germinate completely when evaluated against viability data. *L. glabrum* for example germinated only two-thirds of its viable seeds. It is not known why a large portion remained dormant.

<u>Effects of heat pulsing, dehydration and rehydration on the testa of *Leucospermum cordifolium*</u>

The majority of *Leucospermum* seeds in nature germinate uniformly *en masse* after fire (Rourke, 1972). Attempts have been made to correlate the germination response of seeds with heat pulse intensity i.e. with direct effects of heat (Bond *et al*, 1990).

The pericarp of *Leucospermum cordifolium* seeds were removed by soaking the seeds in lukewarm water for 2 h and by rubbing. Seeds were redried and those with an intact exotesta were selected under the stereo microscope. Intact seeds were subjected for varying periods to 30, 40, 60 and 80 °C in an

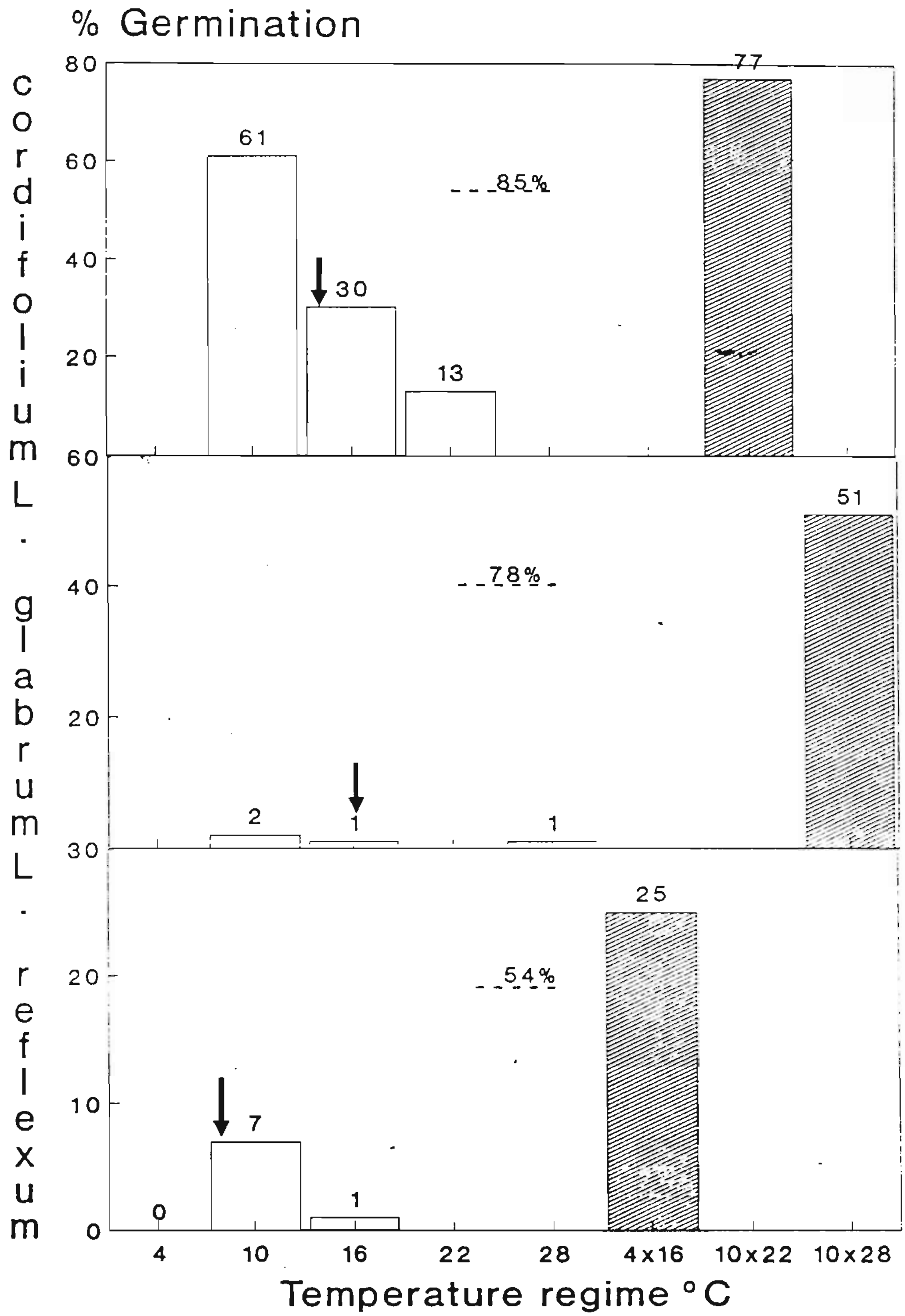

Fig. 1 Germination percentage of sample 3 *Leucospermum* species under constant and alternating temperatures; ▨ - maximal response; --- estimated % viability; ↓ mean temperature of maximal response regime.

oven with forced air circulation. Seeds were kept at room temperature in airtight bottles for 2 h after removal from the oven. The degree of breakage of the exotesta was judged on a 0-10 scale by inspecting seeds under a stereo microscope. Seeds were subsequently thrown into water (20 °C) without delay, for 1 min. After redrying the exotesta was removed by hand and the degree of endotesta breakage judged on a scale: 4 - parts of endotesta broken out, exposing the embryo, 3 - visibly cracked, 2 - hairline crack when wetted, 1 - no cracks but breaks if pressed between fingers, 0 - does not break with finger press test. Embryos were then extracted and treated with tetrazolium to establish the effect of heat treatments on seed viability. Viability was scored as the proportion of each embryo coloured, on a scale 0-10.

Heat intensity and duration correlated positively with the degree of breaking of both the exotesta and the endotesta. A typical response was the result of exposure to 60 °C (Fig. 2). The breaking of the testa layers was apparently due only to the desiccation effect of the heat treatment (separate results not presented here). At maximum average breakage the exotesta was approximately 30% and most endotestas were visibly broken. The viability of embryos were not affected significantly. The results suggest that in nature desiccation by fire could break the exotesta and the endotesta as well, if fire is followed soon by rain. Repeated cycles of dehydration/hydration caused by normal hot summer weather followed by summer rainy spells, especially after fire, can presumably also contribute to the progressive weakening of the hard endotesta. This could relieve mechanical constraint of emerging seedlings.

A practical method employing the desiccation principle would be to remove the pericarp (by soaking and rubbing), sun-bake seeds in warm dry weather (± 40 °C), then throw seeds in water and redry. Successful treatment is indicated by seed coats becoming brittle under finger pressure.

Effects of scarification, oxygenation and "heat pulse" on germination of *Leucospermum* seeds

The effects of heat pulse and various related treatments were determined on seed germination response. The objective was to discern between the effects of oxygenation, desiccation and heat. The species investigated were *L. cordifolium, L. glabrum* and *L. reflexum.*

Treatments: The pericarp of *Leucospermum* seeds were removed by soaking the seeds in lukewarm water for 2 h and by rubbing. Seeds were redried and those with an intact exotesta were selected by stereo microscope. Treatments 2, 4, 5 and 6 received similar "background" heat treatments.

1. Control 1: remove pericarp only - exotesta intact.

2. Control 2: As 1., pretreat at (55 °C x 100% RH x 7 min.) + (40 °C x 100% RH x 6 h); cool [giving similar background heat treatments as in 4, 5 and 6].

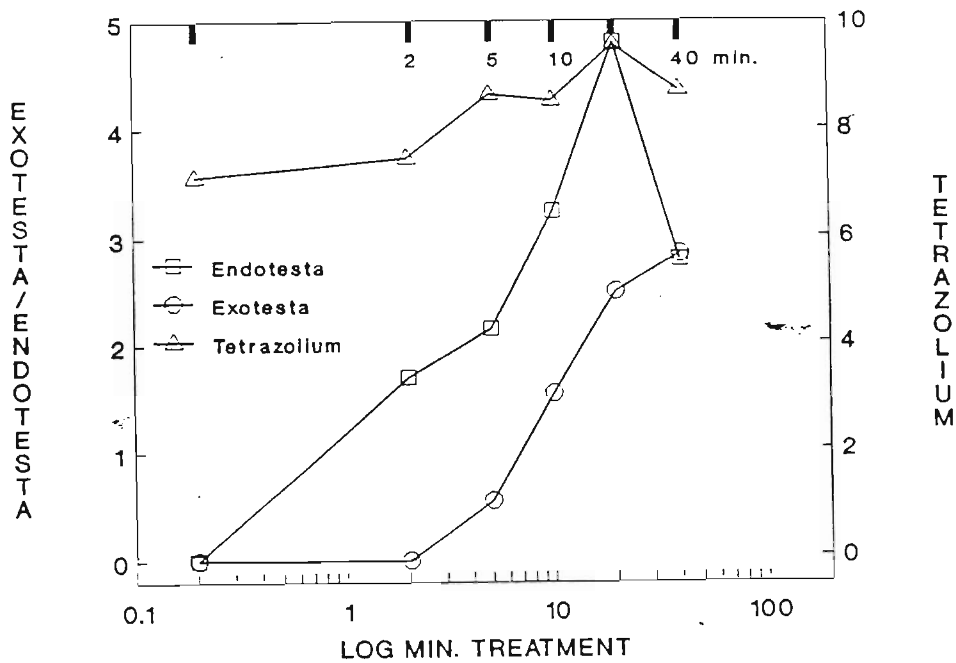

Fig. 2 *L. cordifolium* seeds treated for various periods at constant 60 °C: degrees of breakage of exotesta and endotesta, the latter following immersion in water after cooling; and tetrazolium viability scores - see explanation of methods and scales in text. Each value represents the mean of two replications of 10 seeds each.

3. Acid scarification 8 min. (standard procedure).

4. Hand remove exotesta completely. (preheat 55 °C x 7 min. to partially remove exotestas to facilitate removal) Rehydrate at (20 °C x 100% RH x 16 h) [i.e. eliminate desiccation effects].

5. Heat pulse - exotesta only: 55 °C x 7 min. i.e. partially remove exotesta; apply (40 °C x 6 h) as in 6; rehydrate at (20 °C x 100% RH x 16 h).

6. Heat pulse - exotesta as in 5. + desiccate endotesta at (40 °C x 6 h); cool at (20 °C x 2 h) in airtight bottle followed by cold water immersion (20 °C x 10 min.); dry seeds with paper towel.

7. Acid scarification 8 min. + oxygen incubation in 1 *l* flasks.

Seeds were disinfected with thiram powder treatment and incubated under a temperature regime of (25 °C x 8 h) + (10 °C x 16 h). Six replications of 25 seeds were used per treatment.

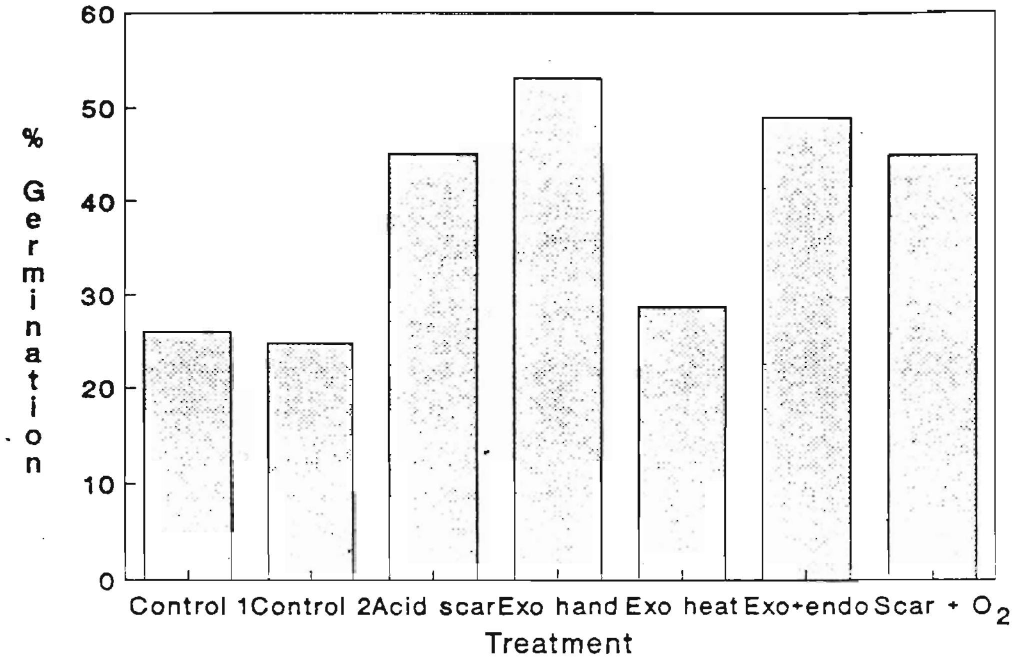

Fig. 3 Influence of scarification, oxygenation and heat pulse on germination of *Leucospermum glabrum* seeds (see text for explanation).

<u>Results</u>: The parity found between treatment 1 (untreated seeds) and treatment 2 (preheat control) in *L. glabrum* was typical for the three species (Fig. 3). It demonstrates that the effects of heat pulse is not related to physiological changes caused by high temperature. Hand removal of the exotesta gave a response on a par with acid scarification (difference not statistically significant). This suggests that the exotesta plays an important role in oxygen exclusion from the embryo. Additional oxygenation by incubation in pure oxygen did not increase germination any further. "Heat pulsing" of the exotesta alone had little effect, but heat pulsing of both exo- and endotesta resulted in significant increases over controls. The results suggest that in nature degradation of both the exo- and endotesta could result in increased oxygenation of dormant seeds.

<u>Extended germination of *Leucospermum cordifolium* seed</u>

Observations of erratic germination of many Proteaceae seeds within the first germination season and even over subsequent seasons are well documented (e.g.. Knight, 1809; Van Staden & Brown, 1973) but this has never been studied systematically.

Fresh intact seeds of *L cordifolium* were oxygenated with 1% H_2O_2 or soaked in water and the pericarps removed. Seeds were sown in a seed bed in autumn 1986. Six replicates of 25 seeds were sown in a randomized block design. Germination was recorded weekly for 20 weeks in the first winter season and in each subsequent winter until 1990 (5 germination seasons). The seed bed was weeded continually to maintain a sun-exposed soil surface.

The results show that H_2O_2 oxygenated seeds gave a much stronger germination response than untreated seeds (Fig. 4). Sporadic germination occurred continually over five germination seasons, demonstrating that seeds can remain viable underground for extended periods. It was noted that seeds germinated only during autumn and early winter each year (Fig. 4). The results support the model of long-living, soil-stored seeds in which the testa is gradually scarified leading to the extension of germination over several seasons only during a cool winter germination season. If dormancy conditions in the wild are reimposed after the first germination season then germination could be postponed until after the occurrence of the next fire, thus buffering the species against a possible catastrophe that could decimate the population before maturity. The results also support the model that most of the soil-stored seed bank would be in the scarified condition with mostly seeds of the latest flowering season being in a partially scarified condition. This suggests that after fire the majority of seeds would germinate synchronously during autumn with only a very small proportion remaining dormant; some of the latter will germinate erratically during the first autumn/winter after fire.

<u>Seed anatomy in *Leucospermum*</u>

The objectives of this study were:

- to study the origin and structure of the different seed covering layers in relation to their functions;

- to study the fates of the seed covering structures in relation to their functions;

- to resolve the conflicts in terminology and interpretation present in the literature of *Leucospermum*.

A large number of inflorescences of *L cordifolium* cvs Vlam and Yellow Bird were marked on the same day at the beginning of anthesis. Developing ovules were collected weekly from these until mature seeds were released at week 13. Collected material were fixed in FPA or stored dry, and light and SEM microscopy performed on especially the covering structures. The results are presented in Table 1.

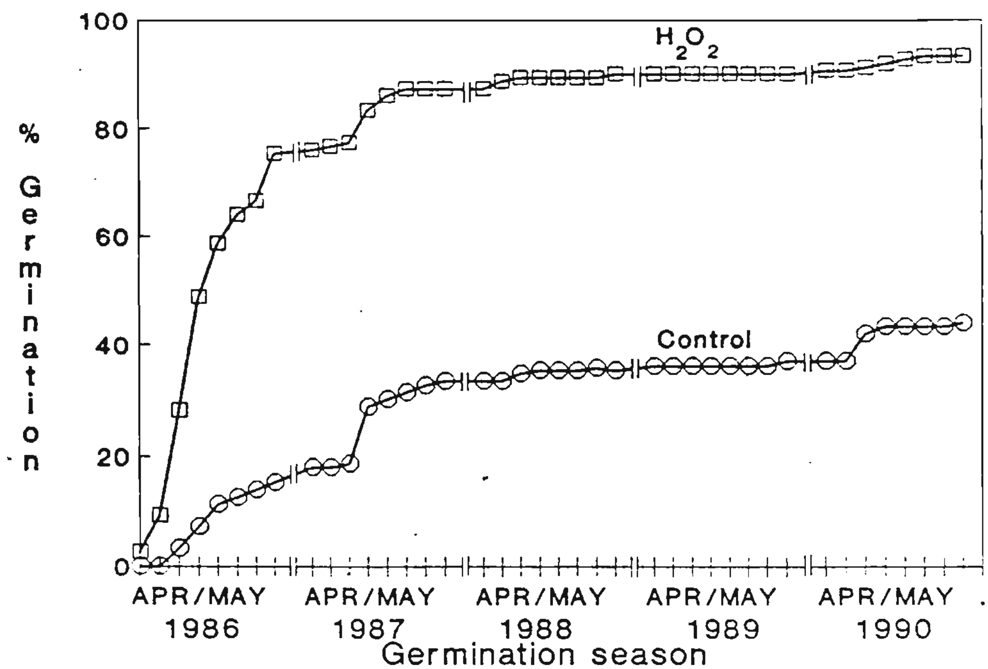

Fig. 4 Seed bed germination of *Leucospermum cordifolium* seeds extending over five germination seasons

Table 1 Principal *Leucospermum* seed covering structures identified, typified and their functions.

Structure	Tissue type	Functions	Fate
Elaiosome = pericarp = outer layer	parenchyma	attracts ants, => dispersal into soil at 20-50 mm;	eaten by ants; decomposed microbiallly
Therefore true seed survives, germinates in soil			
[Vascular bundles	xylem	transports substrates, H_2O	eaten, dries]
Exotesta	lignified 3-5 cell layer; + thick cuticle	absorbs water; excludes O_2 from embryo; extends germin.	broken by desiccation; decomposed microbially
Endotesta	palisade: sclerified single cell layer	absorbs water; protects embryo mechanically	broken by desiccation/ hydration

CONCLUSIONS

1. The elaiosome is removed soon in the soil leaving only the true seed.

2. Low and high daily germination temperature requirement are common in *Leucospermum* species but individual species differ considerably in their requirements.

3. Temperature requirements are correlated with habitat climate regime.

4. The exotesta excludes oxygen from the embryo in intact seed and is gradually removed by desiccation effects and microbial decomposition. This leads to extended germination of a fresh seed batch; a scarified seed batch will germinate immediately and synchronously given other favourable conditions.

5. The endotesta mechanically protects the embryo indefinitely underground. The embryo remains viable for a long period. The endotesta is broken gradually by dehydration/hydration cycles and this may further enhance germination.

RECOMMENDATIONS

The following methods are recommended especially for breeders of *Leucospermum* who wish to maximize germination of selected or hybrid seed. The steps are simple and safe to follow.

1. During high summer: remove the pericarp by soaking seeds in lukewarm water for 2 h, transfer to linen bag, rub vigorously, wash gelatinous skins (elaiosome) away. Dry seeds thoroughly in tray.

2. Place dried seeds in hot sun for at least 5 h. Throw into water in very dry condition for five minutes. Dry with paper towel. Seeds should break under finger pressure if treatment was successful. (Store if necessary until autumn).

3. In autumn: soak seeds in 1% H_2O_2 for 24 h. Dry superficially with paper towel. Dust seeds with thiram wp @ 0,5 g per 100 seeds - very lightly, black seed coat must be clearly visible under thin layer of fungicide.

4. Sow immediately in disinfected, sun-exposed, sandy seed bed.

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BIOGRAPHICAL PROFILE

Mr Gert Brits

Present position: Specialist Scientist of the Fynbos Research Unit, Vegetable and Ornamental Plant Research Institute of the Department of Agricultural Development.

Honorary member of IPA.

Chairman: International Protea Working Group.

Background: Head of the Protea Research Unit 1973-1988.

Gert has "fathered" the release of 35 new protea cultivars to the South African protea industry, some of which have become popular internationally.

He has published over 20 scientific and 75 popular articles on proteas.

He won several awards for outstanding contributions to protea research and the industry.

Gert has been involved with the industry as consultant for 18 years and has paid numerous visits overseas in connection with consultation and research.

Research interests:

Gert is a trained plant breeder but also has degrees in Botany and the Arts.

He is specially interested in plant physiology and is presently doing a Ph.D. on the eco-physiology of *Leucospermum* seed germination.

Towards in vitro propagation of Western Australian Proteaceae

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Introduction

Western Australia has over 500 taxa of proteaceous plants. Long periods of climatic and geologic isolation has resulted in a high rate of endemism in the native flora. Many unique and floristically outstanding proteas have evolved during these times. Unfortunately this isolation has resulted in a susceptibility to invasive pathogens and weeds which accompanied broad scale agriculture and other land use patterns introduced by white settlement over the last 150 years.

The floristic impact and value of many native Western Australian protea has been recognized world wide. However the propagation of nearly all species especially the woody shrub and tree species is still restricted largely to seed and in a few cases vegetative propagation (K. Dixon, pers comm). The need for rapid production of superior individuals to improve the quality and consistency of the harvested product and indeed the process of harvesting itself, is now recognized as imperative for the long term future of proteas as a commercial crop. Western Australia has an unparalleled genetic resource of protea species and would stand to benefit greatly from such technology.

Tissue culture and micropropagation systems present the best available means for rapid clonal propagation but have succeeded with only a few taxa of Proteaceae to date (Ben-Jaacov et al. 1981, Bunn et al unpubl., Gorst et al. 1978 and Kunisaki. 1989). This paper presents preliminary results of attempts to tissue culture some Western Australian proteas in the genera *Banksia* and *Conospermum*.

Materials and methods

Explants were obtained from cuttings of *Banksia menziesii* R.Br., *B. hookeriana* Meissner, *B. attenuata* R. Br. and *B. coccinea* R. Br. and from *Conospermum crassinervium* Meissner and *C.* sp. nov. (aff. *stoechadis*) from specimens in natural bushland or in the Botanic Garden of Kings Park in late August to October. Cuttings of *Banksia menziesii* and *B. hookeriana* were also collected in May and June. Seed of *Banksia menziesii*, *B. hookeriana* and *B. coccinea* was obtained from the seed store (Kings Park). In one trial *Banksia menziesii* shoots on the parent plants were etiolated by covering the shoots for 3 to 4 weeks (in November) using bags of several layers of black shadecloth over which was placed a black plastic bag. Cutting material was utilized on the day of harvest for all material or on the following day. A minimum of five to 10 explants were used for any one treatment unless otherwise quoted in the text or indicated in tables. Explant sources included meristematic (excised apical and axillary buds and axillary nodes), floral (immature perianth, style and stigma and immature flower spike), leaf, seed and etiolated material (meristematic explants taken).

Generation of aseptic explant material was attempted with sterilizing solutions at various concentrations for varying times (table 1). All material was sterilized in 250 cc glass jars. In most cases cutting material was sterilized in approximately 50 mm long sections and explants excised from these, unless otherwise indicated. Seed was sterilized and the testa left intact or removed from half of the seeds and seeds placed one per tube on 8g/L agar/water medium and incubated in the dark until germination commenced. All cultures were incubated at room temperature (20-30°C) or in an incubation chamber with 18-20°C temperature regime with 16 hr light/8 hr dark with lighting supplied by fluorescent lamps (40μmol $s^{-1}m^{-1}$).

TABLE 1.

Media were prepared and 10 ml placed in 30cc polycarbonate tubes with polypropylene closures or 25 ml placed in 250 cc glass jars with polypropylene lids. All media were autoclaved at 121°C for 15 minutes. Media with agar in tubes were sloped to cool. Heat labile substances were filter sterilized and added to bulk sterilized media which was then added to sterile culture vessels. Filter paper supports were sterilized twice then autoclaved liquid media were added to the tubes. Three basal media were used for initiation of explants and included 1/2 MS (Murashige and Skoog, 1962) supplemented with 500 µM myo-inositol, 3µM thiamine HCl, 2.5 mM pyridoxine HCl, 4µM nicotinic acid, 90mM sucrose, pH 6.0 and 10 g/L agar, MS formulation with the same additives and WPM (Lloyd and McCown, 1981) supplemented with WPM vitamins, all other components as above. Anti-phenolic substances such as polyvinylpyrrolidone (PVP) charcoal were each added at 0.5 g/L. Anti-oxidants (ascorbic acid and citric acid) were each added to 1/2 MS media at 0.5 g/L as a filter sterilized concentrate.

Manipulation of all sterilized explants was performed under aseptic conditions in the laminar flow cabinet. Liquid cultures were shaken on an orbital shaker at approximately 40 revolutions/min continuously for three weeks. The effectiveness of procedures was based on assessment of the incidence of contamination and later, on explant viability after transfer to solid initiation medium.

Results and discussion

a) Banksias

Explants

Tissues of the Banksia species used in this program are all very hirsute (figure 1a). The hairs on the shoots and leaves of these species appear to consist of a dense layer overgrown by numerous longer hairs. Hirsuteness poses numerous problems for sterilization and initiation of explants. The obvious effects of hirsuteness includes trapping large numbers of contaminating dust and spores, harboring small insects and hindering the essential close surface contact of the sterilizing solution. There is also the difficulty of removing residual sterilizing solution to avoid damage to sensitive tissues. *B. attenuata* buds showed evidence of a resinous exudate (figure 1b). Buds, particularly of *B attenuata*, when sectioned (figure 1a) have hard, crinkled, tightly packed and very brittle leaves which were difficult to remove without damage to softer, inner tissues. These difficulties aside progress was made in developing a reasonably successful sterilization procedure for meristematic tissues (figure 1c,d). Meristematic tissues i.e. apical, axillary buds and nodal explants containing a bud were the most desirable explants but have proven very difficult to initiate in previous studies (Bunn, unpubl.).

FIGURE 1.

Sterilization

Table 2 summarizes the results of sterilization procedures. Considering that source material was collected from the natural habitat or cultivated but exposed sources, there was a good recovery of aseptic explants for most tissue groups. Seeds gave the best results when compared to other explant sources and were easy to manipulate in vitro. Floral explants i.e. perianth, style and immature flower spike sections required more manipulation than seeds but were relatively easy to decontaminate. Meristematic, leaf and etiolated shoot material generally required the most manipulation in terms of cutting and trimming the explants prior to transfer to media and were most difficult to sterilize effectively. The relatively harsh sterilization with 2% sodium hypochlorite (NaOCl) has killed explants of Banksias in previous experiments (Bunn, unpubl.). Thorough washing (in 6 changes of sterile water) was considered necessary to remove residual sterilizing solution.

TABLE 2.

Media

Previous experience with *B. hookeriana* established that explants placed on solid (agar) media directly after sterilization invariably died, usually within the first week of incubation even if antioxidant dips were used prior to or after sterilization. Liquid media were tested to try and overcome this initial high mortality. Charcoal and polyvinylpyrrolidone (PVP) were used as a possible means of nullifying the effects of any harmful exudates from explants and cultures were shaken to prevent accumulation of exudates around the shoot. The choice of MS (1/2 or full strength) and WPM as basal media was based on the success of these two formulations with a wide range of woody species. The optimum period of immersion in liquid culture was not determined in this study and it is possible that this step only slows down the inevitable decline of explants after sterilization and that a new strategy is required altogether. Although liquid culture results in superior explant survival after sterilization it is not yet clear if successful initiation and establishment can be achieved solely in the liquid phase. The observation with seedling explants of Banksias on solid media which have had free water is that vitrification sets in quite readily, supporting the removal of explants to solid media as soon as practicable. The effectiveness of antioxidant compounds i.e. citric and ascorbic acid was not substantiated. At best these compounds did no harm. There was also no obvious difference between WPM and MS in sustaining explant growth nor between media with or without Charcoal and PVP additives.

The effect of liquid medium may be to shelter explants from exposure to air and subsequent oxidation. Explants which were trimmed and removed from liquid media showed browning within a few hours of transfer to solid media. Such explants blackened the next day and did not recover. Explants transfered without further excision did not show this rapid browning response.

Transfer to solid medium

Subsequent transfer from liquid to solid medium (WPM supplemented with 1 or 10 μM 2iP) has resulted in varied responses (table 3). Meristematic explants of *B. attenuata* and floral and meristematic explants of *B. menziesii* have remained viable for several weeks but meristematic and floral tissues of *B. hookeriana* died one to two weeks after transfer. Sections from an immature flower spike of *B. hookeriana* were in poor condition when removed from liquid culture and none survived more than a few days after transfer. Perianth explants of *B. menziesii* were the most successful floral explants, with a good survival rate after transfer to solid media. Meristematic explants of *B. hookeriana*, many of which had appeared viable when in liquid medium, died when transfered to solid medium. The results with leaf explants of all three test species of Banksia are promising but latent contamination was a problem, with many explants not showing contamination (particularly fungal) until transfer to solid medium. Leaf explants have been placed on high cytokinin media to induce adventitious shoot growth as has been demonstrated with leaf explants of other proteaceous species (Bunn and Dixon , unpubl.). Explants derived from etiolated shoot material of *B. menziesii* were not successful when placed on solid medium directly after sterilization. An initial liquid culture phase was not tested with this material. Specific nutrient levels in culture media, e.g. phosphorus, may be important in establishment and long-term maintenance of cultures and this aspect will receive attention in future trials.

Seedling cultures

Seedlings have provided an opportunity to investigate in vitro requirements of shoot cultures which will be invaluable when shoot cultures are able to be generated from mature material. Seedling apices of *Banksia hookeriana* (figure 2a) were placed on WPM supplemented with cytokinins (figure 2d). BAP (N-(phenylmethyl)-1H- purine-6-amine) and TDZ (Thidiazuron) were most active in inducing shoot growth. Figure 2b shows the effects of BAP on shoot regeneration from cotyledon explants from seedlings. On medium supplemented with 10 μM BAP, shoots form from the cut ends of the cotyledons and can be severed from the initial culture and grown separately (figure 2c). Results with seedling explants indicates that if juvenile material can be obtained from mature plants, perhaps from basal suckering after fire (or pruning), more responsive explants may be obtained. Cotyledons could also be used for somatic embryogenesis studies. This procedure could be a valuable means of mass propagation.

Conospermum

Conospermum species had a high initial loss of explants due to contamination(table 2). Once established in culture (table 3) explants of *Conospermum* sp. nov. (aff. *stoechadis*) multiplied four-fold on MS medium supplemented with 1μM BAP after a 6 week incubation period. Lower concentrations of BAP (0.2, and 0.5μM) and 2iP at 1,2 and 5 μM produced only 2 fold multiplication compared to controls. Root induction on 1/2 MS supplemented with IBA induced roots on explants, with 5μM giving the best result (over 50% rooting). No explants have been potted out to date.

Conclusion

Liquid media were used for initiation of explants of *B. attenuata, B. hookeriana and B. menziesii*. This procedure was successful in obtaining viable explants which survived transfer to solid media. There was no difference in response of explants to MS or WPM or addition of activated charcoal, PVP or antioxidants (citric and ascorbic acid). Adventitious shoot formation in cotyledon explants and the information gained from tissue culture of seedlings has provided valuable information for further experiments.

In vitro multiplication of *Conospermum* sp. nov. (aff. *stoechadis*) was achieved after incubation on MS medium supplemented with cytokinins and root induction on 1/2 MS supplemented with auxins. Best results were obtained with 1 µM BAP for shoot proliferation and 5 µM IBA for rooting.

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Captions to figures

Figure 1. Explant material of *Banksia attenuata* showing (A) a longitudinal section of an apical bud, (B) resinous exudate from an apical bud(arrow), (C) a bud after incubation in liquid medium, (D) a bud after transfer to solid medium.
Bar = (A) 1mm, (B) 0.5mm, (C) 0.7mm, (D) 1mm.

Figure 2 Seedling explant material of *Banksia hookeriana* showing (A) seedling apice on proliferation medium, (B) adventitious shoots growing from cotyledonary explants, (C) excised adventitious shoots sourced from cotyledon, (D) apices on media with cytokinins (N-(3-methyl-2 butenyl)-1H-purine-6-amine = 2iP, thidiazuron = TDZ) or without (control).
Bar = (A) 2mm, (B) 0.5mm, (C) 1mm, (D) 10mm.

Table 3 Percent of explants of Western Australian Proteaceae initiated in vitro.

Explant	Species	Initiation
meristematic	*Banksia attenuata*	48% (11/23)
	B. hookeriana	0% (0/7)
	B. menziesii	28% (4/14)
	Conospermum. crassinervium	0% (0/2)
	C. sp. nov.(aff. *stoechadis*)	100% (2/2)
leaf	*Banksia attenuata*	33% (1/3)
	B. hookeriana	75% (3/4)
	B. menziesii	17% (1/6)
floral	*B. hookeriana*	0% (0/6)
	B. menziesii	43% (10/23)
seed	*B. coccinea*	50% (5/10)
	B. hookeriana	63% (15/24)
	B. menziesii	52% (12/23)
other(etiolated)	*B. hookeriana*	0% (0/3)

Table 2 Percentage of aseptic explants of Western Australian protea species incubated on solid or in liquid media.

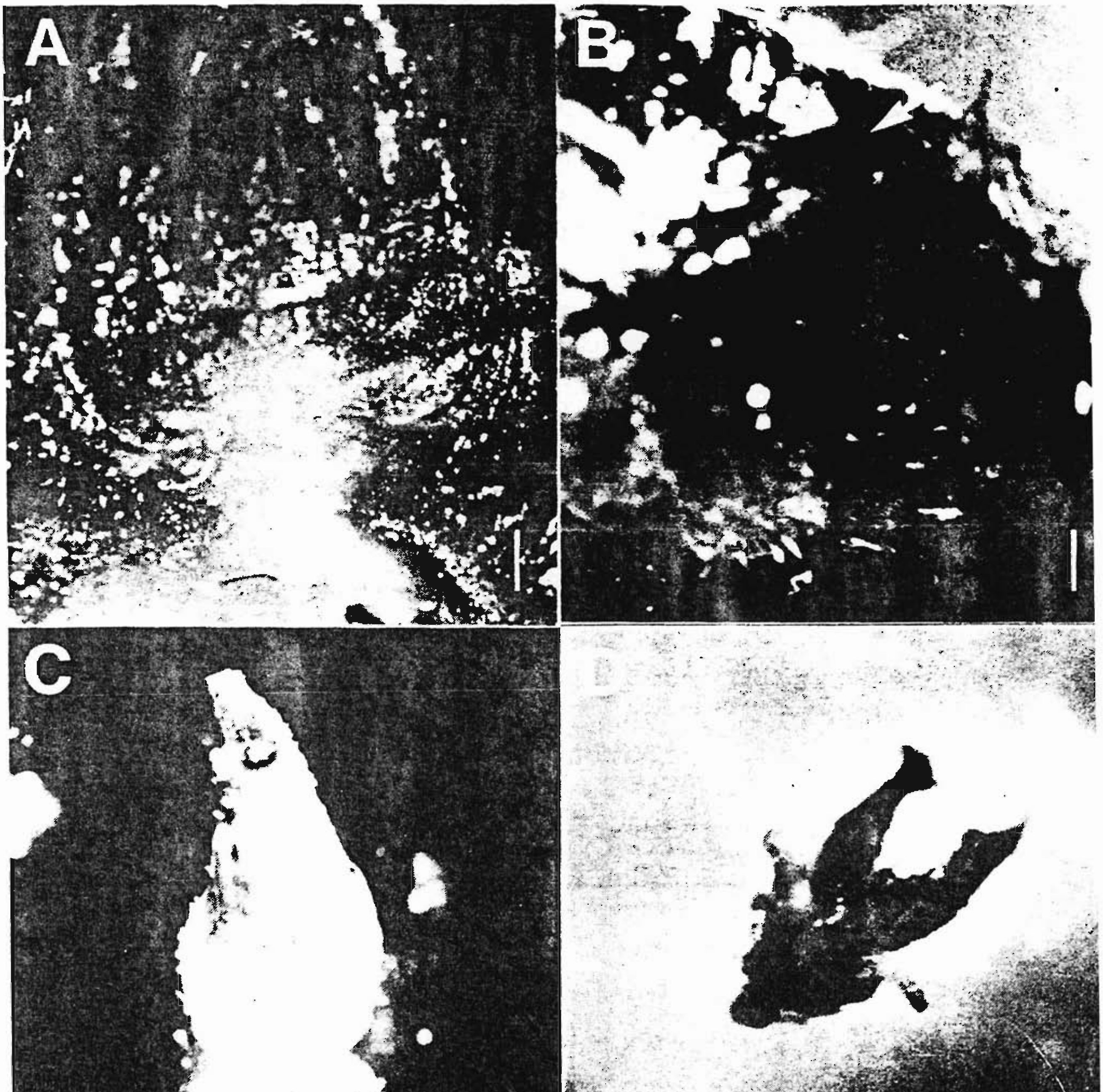
Explant	Species	Percent aseptic explants (No. aseptic explants/total No. explants)
meristematic	*Banksia attenuata*	51% (23/45)
	B. hookeriana	28% (7/25)
	B. menziesii	38% (14/40)
	Conospermum. crassinervium	14% (2/14)
	C. sp. nov.(aff. *stoechadis*)	11% (2/19)
leaf	*Banksia attenuata*	33% (3/14)
	B. hookeriana	50% (4/8)
	B. menziesii	43% (6/14)
floral	*B. hookeriana*	40% (6/15)
	B. menziesii	77% (23/30)
seed	*B. coccinea*	50% (10/20)
	B. hookeriana	80% (24/80)
	B. menziesii	79% (23/29)
other(etiolated)	*B. hookeriana*	21% (3/14)

Table 1 Sterilization procedures for Western Australian Proteaceae.

Initial preparation	sterilization	species
A)		
washed under running tap water for 5hrs	•2% NaOCl for 10 min(0.5% tween-80) •rinse in 6 changes of sterile distilled water •store in sterile distilled water (change when discoloured)	*Banksia attenuata*, *B. hookeriana*, *B. menziesii*
B)		
wash seeds in 1% tween-80 for 2 min and rinse in 80% EtOH.	•5% Ca OCl for 30 min •rinse in 3 changes of sterile distilled water	*B. coccinea*, *B. hookeriana*, *B. menziesii*.
C)		
wash under running tap water for 1 hr.	•0.05% tween-80 for 2 min. •80% EtOH for 5 sec. •1% Ca OCl for 10 min •rinse in 3 changes of sterile distilled water.	*Conospermum* sp. nov. (aff. *stoechadis*), *Conospermum crassinervium*.

NaOCl = sodium hypochlorite
CaOCl = calcium hypochlorite
EtOH = ethanol

FIGURE 1.




A
B
D
Control
2iP 1μM
2iP 10μM
TDZ 1μM

SELECTION AND BREEDING OF BANKSIAS

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INTRODUCTION

The aim of the program is the development of improved cultivars of banksia for ornamental horticulture, including the cut flower, pot plant and amenity horticulture sectors of the industry. At present the emphasis is on the development of cultivars for cut flower production, involving selection for a range of characters including bloom number, quality and colour, and disease tolerance of the plant. The project has recently been extended to include the expertise of Eileen Scott and Kim Tynan of the Waite Institute, K. Sivasithamparam of the University of Western Australia and Kingsley Dixon of King's Park and Botanic Garden in the area of selection for *Phytophthora* tolerance. A wide range of approaches and techniques is employed in the research.

SELECTION PROGRAM

The selection program involves plants of four species of *Banksia* located on commercial properties in South Australia, and at the Waite Institute (Table 1). All plants are pruned and managed for commercial cut flower production, and the plants are checked regularly for number, quality and colour of blooms and the time of peak production (Fuss and Sedgley 1991a).

Table 1. Mature plants under selection

Banksia coccinea	696
Banksia menziesii	444
Banksia prionotes	354
Banksia hookeriana	342

Banksia coccinea

The number of blooms of *Banksia coccinea* increased with plant age up to an average of 42 per plant at 14 years. The range of bloom numbers per plant varied from zero to 98 (Table 2). October was the month of peak production, with a spread from June to November (Table 3). The majority of the blooms were scarlet, with orange, dark red and pink in decreasing proportions (Table 4).

Table 2. Bloom numbers per plant of *Banksia coccinea*

Age of plants (years)	Number of plants	Number of blooms per plant (mean ± standard error)	Range
4	137	5.4 ± 0.4	0 - 20
5	59	12.9 ± 1.3	0 - 44
7	122	21.7 ± 1.2	0 - 58
10	68	33.0 ± 1.8	1 - 58
14	310	41.7 ± 1.2	0 - 98

Table 3. Time of maximum production of *Banksia coccinea*

Percentage of plants with maximum production in:					
June	July	August	September	October	November
1.5	2.1	10.1	27.5	58.6	0.2

Table 4. Colour of *Banksia coccinea* blooms

Percentage of plants with blooms:			
Orange	Red	Dark red	Pink
22.2	71.0	6.6	0.2

Banksia menziesii

Maximum production was 21 blooms per plant at 14 years of age, with a range from zero to 52 blooms per plant (Table 5). Peak production was during May, with a spread from February to August (Table 6). There was considerable variation in bloom colour of *Banksia menziesii*, depending on the combination of perianth and style colour, from yellow to dark red (Table 7).

Table 5. Bloom numbers per plant of *Banksia menziesii*

Age of plants (years)	Number of plants	Number of blooms per plant (mean ± standard error)	Range
4	138	11.0 ± 0.7	0 - 50
7	297	17.5 ± 0.7	0 - 52
14	9	21.3 ± 4.1	3 - 36

Table 6. Time of maximum production of *Banksia menziesii*

Percentage of plants with maximum production in:						
February	March	April	May	June	July	August
1.1	11.3	41.7	20.3	16.5	5.9	3.2

Table 7. Colour of blooms of *Banksia menziesii*

Percentage of plants with blooms:			
Yellow	Apricot	Pink	Red
1.1	3.6	65.3	30.0

Banksia prionotes

Banksia prionotes produced the maximum number of blooms per plant at 10 years of age, with a slight decrease by year 14 (Table 8). The range was between zero and 63 blooms per plant. Peak production was in March (Table 9).

Table 8. Bloom numbers per plant of *Banksia prionotes*

Age of plants (years)	Number of plants	Number of blooms per plant (mean ± standard error)	Range
5	50	17.0 ± 0.8	7 - 33
7	115	18.4 ± 0.8	0 - 43
10	138	26.7 ± 0.8	6 - 63
14	53	22.6 ± 1.5	5 - 45

Table 9. Time of maximum production of *Banksia prionotes*

Percentage of plants with maximum production in:				
February	March	April	May	June
1.4	60.2	35.0	3.1	0.3

Banksia hookeriana

Banksia hookeriana produced an average of 26 blooms per plant at seven years, with a range from zero to 79 blooms per plant (Table 10). Peak production was during October and November (Table 11).

Table 10. Bloom numbers per plant of *Banksia hookeriana*

Age of plants (years)	Number of plant	Number of blooms per plant (mean ± standard error)	Range
4	73	28.1 ± 2.0	0 - 79
7	109	25.6 ± 1.5	0 - 62
5 - 14	160	20.9 ± 1.0	0 - 59

Table 11. Time of maximum production of *Banksia hookeriana*

Percentage of plants with maximum production in:						
June	July	August	September	October	November	December
4.2	12.0	13.8	15.6	26.3	27.2	0.9

Young plants of *Banksia prionotes* and *Banksia hookeriana* were also available for assessment of precocity. After two years from seed 31% of *Banksia prionotes* plants had produced a bloom, as compared with 51% of *Banksia hookeriana* plants after three years from seed (Table 12).

Table 12. Precocity of *Banksia prionotes* and *Banksia hookeriana*

Species	Age of plants	Percentage flowering
Banksia prionotes	2	31.2
Banksia hookeriana	3	50.6

Selection from the population of *Banksia hookeriana* plants has resulted in the registration of the cultivar 'Waite Orange' (Sedgley 1991). This is probably an interspecific hybrid between *Banksia hookeriana* and *B. prionotes* as the leaf length and width are intermediate between that of the two species. Flowering time is intermediate, and the blooms are similar to those of both species. 'Waite Orange' is also very vigorous, producing more blooms per year than the mean production for either species. The selection of 'Waite Orange' allows continuous production of orange banksias from March to November. Emphasis is now placed on the selection of early *Banksia prionotes* and late *Banksia hookeriana* to further extend the production period for orange banksias (Table 13).

Table 13. Flowering times of orange banksias in South Australia

Species	Range	Peak
Banksia prionotes	February - June	March
Banksia 'Waite Orange'	May - June	May
Banksia hookeriana	June - December	October/November

Selection amongst the populations of *Banksia menziesii* and *Banksia coccinea* is also for bloom number per plant and flowering time, particularly for early flowering of *Banksia menziesii* and late flowering of *Banksia coccinea* for the Christmas market (Table 14).

Table 14. Flowering times of *Banksia menziesii* and *B.coccinea* in South Australia

Species	Range	Peak
Banksia menziesii	February - August	April
Banksia coccinea	June - November	October

A further important selection criterion for *Banksia menziesii* and *B. coccinea* is for colour variants, so that the full range of yellow to burgundy is available for the former and orange to dark red for the latter.

VEGETATIVE PROPAGATION

Once superior cultivars have been selected, the major commercial gains will flow from establishment of plantations of clonal material. This will significantly reduce the variability in yield and quality currently observed in plantations established using seedling material. Research into vegetative propagation is underway with *Banksia prionotes*, *B. hookeriana* and 'Waite Orange', using standard techniques of cutting propagation employing bottom heat, misting and treatment of cuttings with 1200 ppm indoylbutyric acid. An experiment was conducted using eight plants of each species, and one of 'Waite Orange'. Ten cuttings were taken from each plant at two month intervals for one year. The highest percentage success overall was achieved in July, with little or no success during spring and summer (Table 15). The period of poor success rate coincides with the period during which the plants are undergoing floral initiation and development (Fuss and Sedgley 1990, Leisl Rohl, personnal communication 1990). These plants were not managed for vegatative propagation, and it is possible that pruning to stimulate branching and cytokinin sprays may inhibit floral initiation and improve the success rate during spring and summer.

Table 15. Percent rooting success of *Banksia prionotes*, 'Waite Orange' and *B. hookeriana*

Month	*B. prionotes* (8 plants)	'Waite Orange' (1 plant)	*B. hookeriana* (8 plants)
January	1	0	0
March	4	0	11
May	10	20	6
July	33	70	39
September	0	0	0
November	0	0	0

When the results are presented on an individual plant basis, it is clear that there are differences between plants in the ability to form roots. Of the eight plants of *Banksia prionotes*, one produced no rooted cuttings during the period of the experiment, whereas two produced rooted cuttings in three separate months, and the maximum percentage rooting for a single plant on one occasion was 70% (Table 16).

Table 16. Percent rooting success of eight plants of *Banksia prionotes*

Month	Plant number							
	1	2	3	4	5	6	7	8
January			10					
March					30			
May			10		60		10	
July	30	70	10	10	30	50	60	

Similar results were obtained with *Banksia hookeriana*, with one plant producing no rooted cuttings, two producing rooted cuttings on two separate occasions, and the maximum percentage success 80% (Table 17).

Table 17. Percent rooting success of eight plants of *Banksia hookeriana*

Month	Plant number							
	1	2	3	4	5	6	7	8
March					10		50	30
May			20		10			20
July	30	80	20		10	60	40	70

These results indicate that rooting ability should be a selection criterion in the breeding program. In addition to the variable success rate, propagation by cuttings was also very slow, with some cuttings taking up to a year to form roots. the technique also uses large amounts of material so that a limited number of cuttings can be taken from each plant. Thus, although cutting propagation is possible, we are currently investigating the possibility of micropropagation in tissue culture.

BREEDING

One of the main aims of the breeding program is the development of interspecific hybrids. This has proved to be successful in generating superior cultivars of a number of plants including some other proteaceous crops. To assist in the interspecific hybridisation program, we are studying the range of structure of pistil and pollen within the *Banksia* genus using scanning electron microscopy. This will provide useful information on potential compatibility between the species. Interspecific hybridisation is conducted using the hand pollination techniques developed by Fuss and Sedgley (1991b). This involves removal of open flowers, bagging of the inflorescence until new flowers have opened, and removal of all unopened flowers. This leaves 20 to 30 open flowers for pollination. Pollen is removed from the pollen presenter of the open flowers using a looped pipe cleaner. The inflorescence is rebagged until peak receptivity of the stigma three days later. Pollen transfer is achieved by rubbing a pollen-laden pollen presenter from the male parent against the stigmatic groove of the female parent. All crosses are monitored using fluorescence microscopy to check pollen germination and pollen tube growth.

CONCLUSIONS

Considerable gains in productivity of cut flowers of banksia can be expected following the development of vegetatively-propagated high-yielding, high-quality superior cultivars. This research has so far resulted in the registration of one cultivar 'Waite Orange', which should be generally available in the near future provided successful micropropagation techniques can be developed. This will be followed by superior selections of *Banksia menziesii*, *B. coccinea*, *B. prionotes* and *B. hookeriana*. In the future it is hoped that the breeding program will result in interspecific hybrids with the vigour and bloom quality already observed in the natural hybrid 'Waite Orange'.

ACKNOWLEDGEMENTS

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Biographical profile

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EXPORTING MARKETING & PROMOTION

A GROWER'S GUIDE TO THE BUSINESS OF EXPORTING CUTFLOWERS

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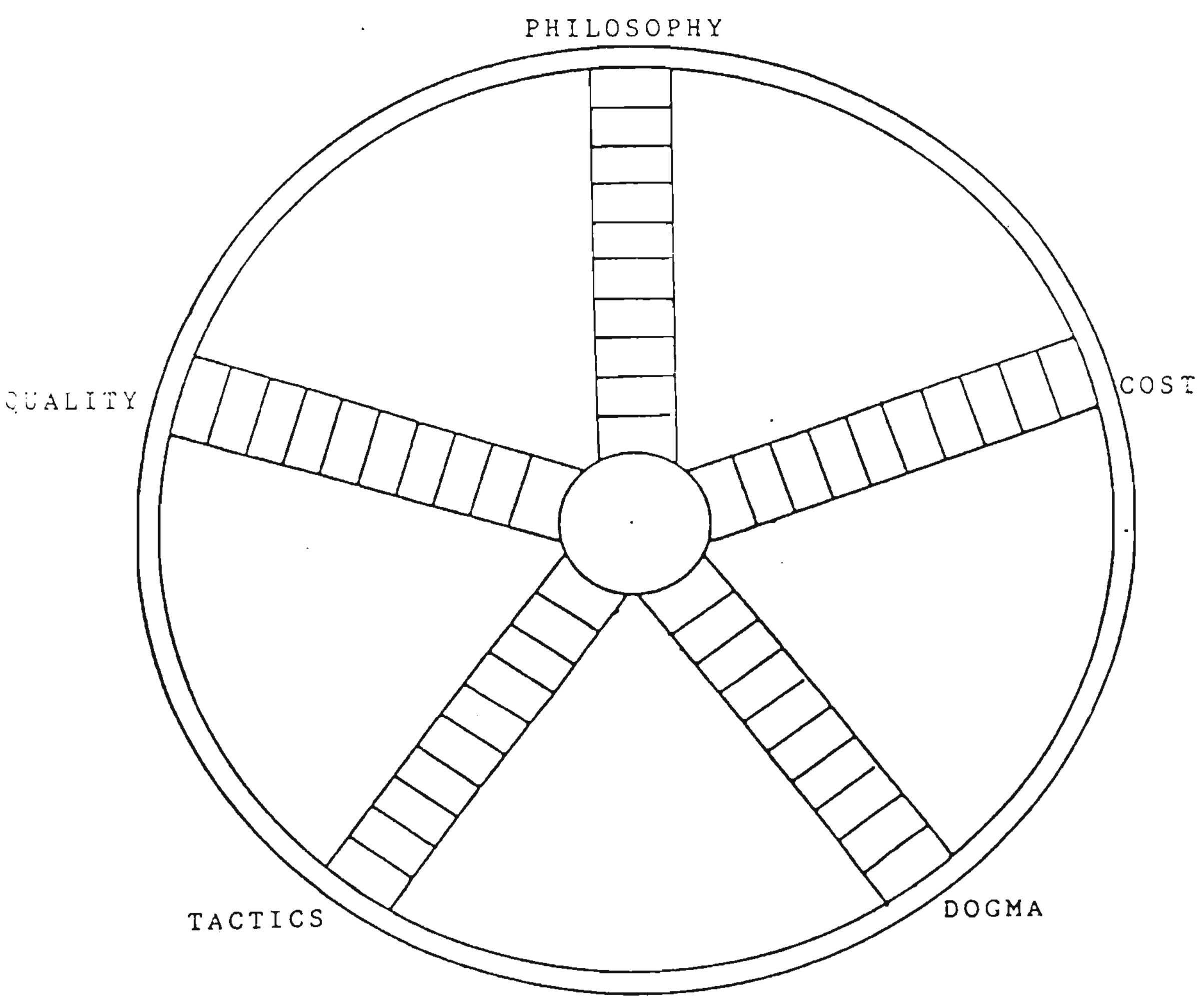
1. INTRODUCTION

Those of us who export cutflowers have tended to re-invent the wheel. So, you will not be surprised to learn that my export wheel (Fig.1) is less than perfect and the ride a little bumpy. It has 5 elements: Philosophy, Cost Analysis, Quality Analysis, Tactics and Dogma. The tyre is often punctured by the rough road of Murphy's Law ("If anything can possibly go wrong, then it most certainly will!").

FIG.1.-THE EXPORT WHEEL - ONE EXPORTER'S APPROACH



2 PHILOSOPHY

2.1 Why Export ? It could be argued that the main reason to export cutflowers is because production is greater than the domestic market can absorb. The belief that exports will yield a higher return per stem is highly suspect; it stands to reason that freight alone would cancel out any extra profit margin.

2.2 How Serious are We ? Unless one is dedicated to export, it is probably safer to stick to the domestic market. Export is a different ball game ; the ball may be similar, but the rules are different. It is a "long haul" rather than a "quick fix". Export requires one's undivided attention.

2.3 Economies of Scale : For a start, export requires volumes large enough to attract favorable freight rates. Obviously there is a stage of transition from domestic to export orientation but this is a costly phase, best traversed as rapidly as possible.

2.4 Payment Constraints : There are hazards in doing business with someone that one has never met, but the risk can be covered, to some extent, by "non-payment insurance". However,it is not possible to arrange cover for shipments made on consignment, since returns on these are not known in advance. Happily, the risks here are small, auctions in Japan, the Netherlands and Canada, for example, paying reliably and regularly, if not immediately.

2.5 Up-Front Capital Requirements : The fact that returns may take some time "to return" means that one must be able to pay up-front costs, such as freight, for a period of 6-8 weeks before shipments are paid for. Thus, one would need to have about $30,000 in reserve to contemplate exporting 1000kg per week. Nor is it comfortable to have the bank manager breathing down your neck when you should be concentrating on nursing an important shipment through to its destination ! Better to scrape the necessary capital together before you start !

2.6 Forward Planning : Whim alone is a poor basis for contemplating export. Forward planning is required - a year or two perhaps. Packing-shed facilities have to be set up; transport routes identified; agents and export outlets chosen; export boxes made; export permits obtained; capital accumulated; communication systems established; and so on.

2.7 Export/Import Controls : Such regulations are not set up by bureaucrats to make export difficult or impossible. There are good reasons for their existence. Doesn't the community have a vested interest in ensuring that wildflowers are picked to a responsible management plan ? Doesn't every country need to know the value of its exports ? It is far better to make the system work as smoothly as possible than to develop ulcers trying to buck the system .

2.8 <u>Added Value</u> : Some people tend to be surprised how little the grower gets for his product in relation to how much the customer pays at "the other end". But, what would that flower really cost if one had to hawk it around the world and pay a manager to run the plantation ? Doesn't it take time and effort to get an item from farmgate to final customer ? The problem with the "rip-off paranoia" is that it erodes the mutual confidence needed to build up a good distribution team. When the team co-operates, everybody wins !

2.9 <u>Nature of Demand</u> : When we have a nice flower, we tend to think (as with the proverbial mousetrap) that the world will beat a path to our door. Perhaps we should be concentrating not so much on the merits of the flower *per se* as on the niche that it will fill : earlier/later varieties ? bigger/smaller flower heads ? longer stems ? varieties with a longer vase life ? festival-specific varieties ? "Quality", after all, is "what the customer wants" !

2.10 <u>Market Prospects</u> : Given choice of different markets, the closer market has the edge, airfreight being by far the major cost in getting the product to the marketplace (Table 1). Other markets may be preferred because they already know and appreciate the product. Some might be ruled out because there are no reliable carriers to that destination. There are so many factors to be considered. Some lateral thinking is required.

TABLE 1. Relative Importance of each Element of Export Cost in relation to Return to Supplier. The Table shows the decrease that would result from doubling each element of Export Cost. Note the importance of the freight component. Hypothetical shipment of 20 boxes of Protea, Sydney to Tokyo; 15kg/box (40 stems); CIF Tyo : AUD 2.00/stem.

EXPORT COST	RETURN TO SUPPLIER $/stem	% Reduction
Normal Rates *	1.16	0
Double the Insurance	1.15	0.9
Double the Levy	1.15	0.9
Double the Freight Forwarding	1.08	6.9
Double the Commission	1.03	11.2
Double the Freight	0.60	48.3
Double all Costs	0.51	56.0

* Normal Rates		
	Freight	$ 1.65/kg
	Export Commission	FOB value x 10%
	Freight Forwarding	$45/shipment + $1/box
	Non-Payment Insurance	CIF value x 0.5%
	Box Levies	$0.25/box

COST ANALYSIS

To determine whether an export business will result in a profit or a loss requires some close analysis of the associated costs. Suppose we are shipping from a plantation in Queensland to auctions in Japan via Brisbane, Sydney International Airport and Narita International Airport (Tokyo) (Table 2).

TABLE 2.- A TYPICAL EXPORT PATH

*

AUCTION
(e.g.Japan)

*

OVERSEAS ARRIVAL AIRPORT
(e.g. Narita)

*

INTERNATIONAL DEPARTURE AIRPORT
(e.g.Mascot,Sydney)

*

REGIONAL DOMESTIC AIRPORT
(e.g. Brisbane)

*

FARMGATE

*

PLANTATION

Then, the relevant export equations would be as follows :

CIF NARITA = AUCTION RETURN - COSTS (Narita to Auction)....(1)

- Fumigation Fee
- Terminal Charge
- Import Duty
- Customs Clearance
- Customs Overtime
- Inland Transportation
- Auction Commission
- Importer's Commission

FOB SYDNEY = CIF NARITA - COSTS (Sydney to Narita).........(2)

- Airfreight
- Freight Forwarding
- Non-Payment Insurance
- Industry Levy

CIF SYDNEY = FOB SYDNEY - EXPORT AGENT COSTS...............(3)

FOB BRISBANE = CIF SYDNEY - COSTS (Brisbane to Sydney) (4)

EX-FARMGATE = CIF B'BANE - COSTS (Farmgate to B'bane).....(5)

Carrier
Phytosanitary Inspection
Phytosanitary Certificate

EX-PACKING SHED = FARMGATE RETURN - PACKING COSTS.........(6)

Packers' Wages
Packaging Materials
Boxes
Postharvest Treatment
Coolroom Costs

EX-PLANTATION = PACKING-SHED RETURN - PLANTATION COSTS....(7)

Pickers' Wages
Plantation Maintenance

AIRFREIGHT COST = "CHARGEABLE WEIGHT x AIRFREIGHT RATE.....(8)
(Rates increase in steps, usually at 100,250,500 and 1000kg)

CHARGEABLE WEIGHT = PACKED WEIGHT OR CUBIC WEIGHT..........(9)
(Whichever is the Greater)

PACKED WEIGHT = Weight of (BOX + PACKAGING) +
Weight of (STEMS/BOX x STEM WEIGHT).......(10)

CUBIC WEIGHT = BOX VOLUME (in cubic metres) x 167.........(11)
(167 is the volume:weight conversion factor used by the airline)

BOX VOLUME = LENGTH x BREADTH x DEPTH (Outside Dimensions)(12)

STEMS PER BOX : Best determined by Actual Trial...........(13)
(depends on STEM LENGTH, FLOWER HEAD, LEAF BULK and PACKING METHOD - See Fig.3)

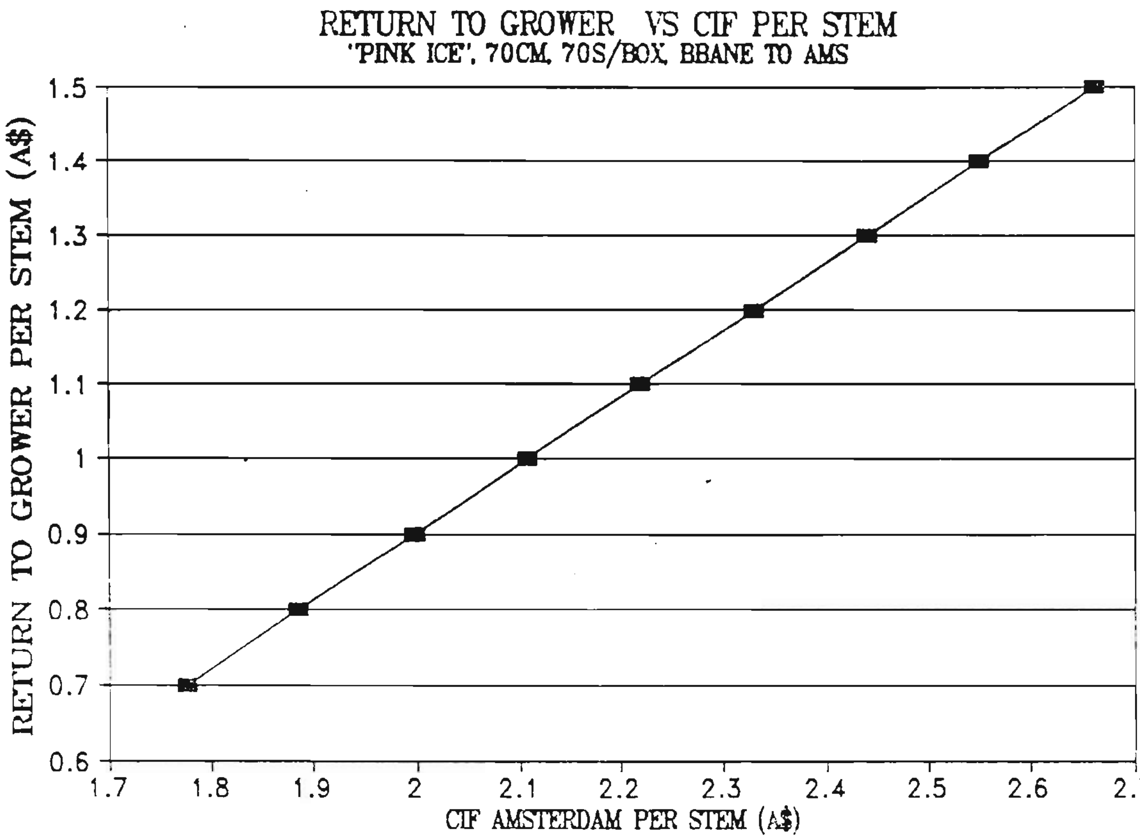


Fig.2 Return to Grower (FOB Brisbane) for 70cm Protea "Pink Ice" exported to Amsterdam. Note that the relationship is a linear one and that the return (FOB B'bane) is approx. half the landed (CIF) price. Where the shipment is sent to auction on consignment, the return could well be less than one third the auction price, since, here, the grower also bears the post-arrival distribution costs

The return to the grower varies with stem length, because longer stems generally fetch higher prices. Where stems are light (as in Serruria or Leucospermum), the return to grower also varies with stems per box, because (a) length determines the number of stems that can be fitted within a given export box (Fig.3); and (b) freight per stem is a function of stems per box.

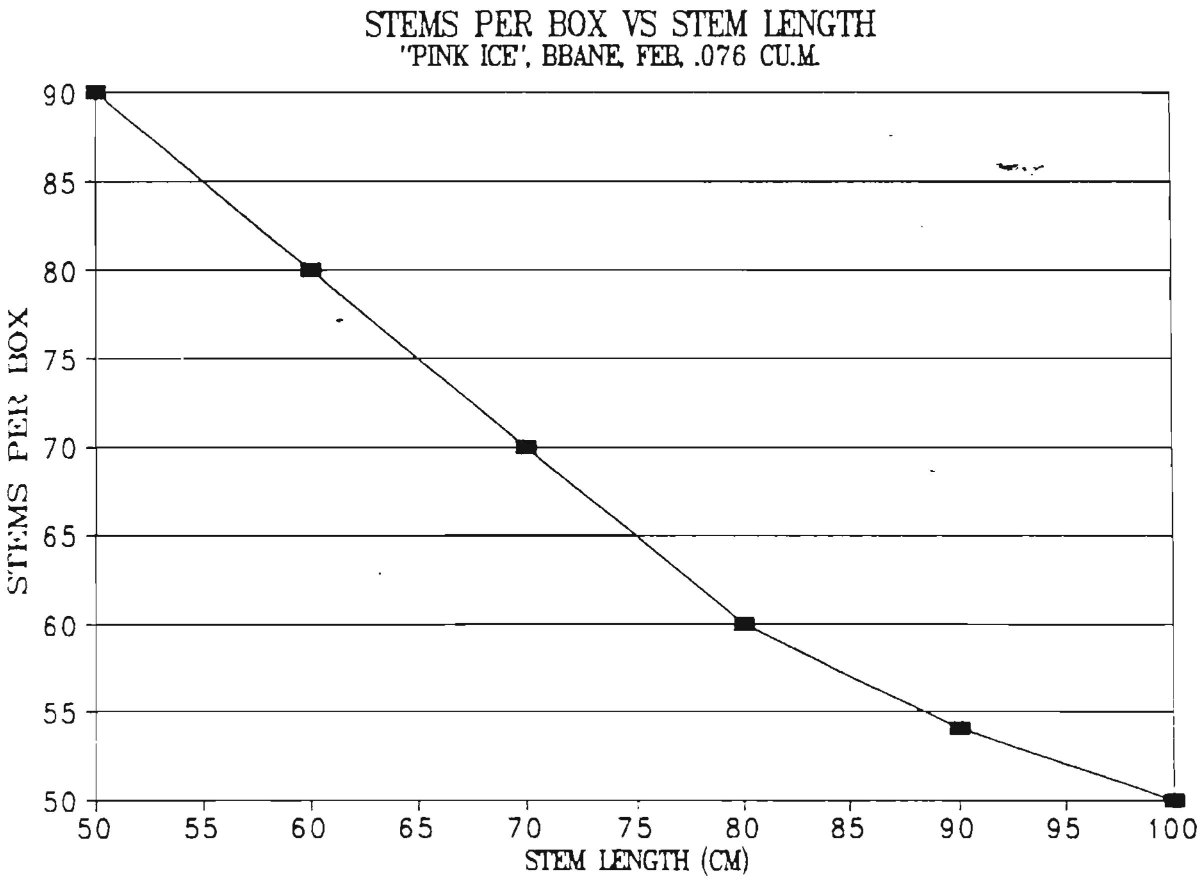


Fig.3 The Number of Stems of Protea "Pink Ice" of different lengths that can fit within an export box of .076 cubic metres (1040 x 390 x 190mm). Note that the relationship is linear for lengths less than 80cm. Since freight on most protea and leucadendron is charged by weight rather than by volume, denser packing, here, does not result in a lower freight per stem. Data from Packing Trials at a Queensland plantation.

Airfreight is such an important part of the overall export cost (Table 1) that it is wise to wait until one can produce 100-250kg per shipment before commencing export (Fig.4). Below 100kg, the profit margin slides abruptly into loss,its rate of fall depending on the overheads.

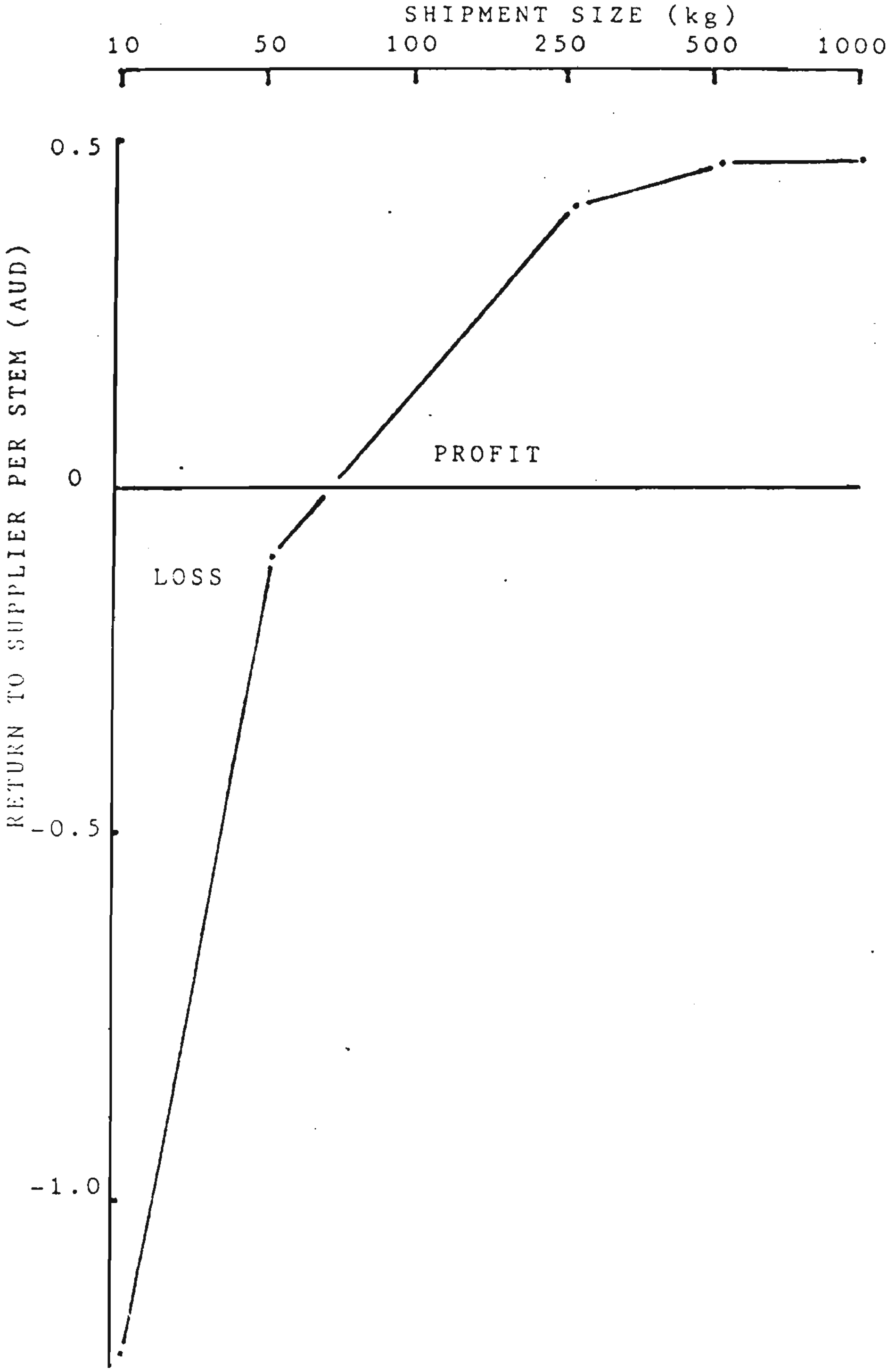


Fig.4 Effect of Shipment Size (kg) on Return per Stem to the Supplier. Data for Protea "Pink Ice", Sydney to Tokyo, CIF Tyo AUD 1.50/stem, Production Cost AUD 0.50/stem. Note that profitability depends on shipment size.

4. QUALITY ANALYSIS

It might be useful, for a change, to evaluate the components of quality in order of their practical importance. My view is that *arrival quality* is the first consideration, rather than *departure quality*. I believe that *pre-cooling* is the most important element in quality control, followed by *speed of delivery*. The quality of the flower at harvest is a necessary requirement,of course, but that amounts to nought if that quality is lost en route to the final customer.

4.1 <u>Precooling</u> : I think that few people understand what precooling really is and why it is so important. Precooling is not (a) postharvest cooling to remove field heat or (b) putting the boxes in the coolroom after they are packed. It is the practice of reducing the *temperature of the flowers* within the export box to the absolute minimum, immediately *prior* to their export journey, in order to cushion them against subsequent overheating and spoilage . Every extra minute at every extra degree of temperature is one more nail in the coffin of arrival quality. *Pre* cooling must be done after the flowers have been packed, therefore "pressure (forced air) cooling" is the only way. The test of whether flowers have been precooled is to measure their temperature with a probe; all else is speculation.

4.2 <u>Speed of Delivery</u> : The shipment must start off cool, arrive cool, and be cool throughout the journey, which, consequently, must be as short as possible. This is not as straightforward as it may seem, because so many factors can cause delay. For example :

* Phytosanitary Inspection
* Lack of freight space
* Offloading
* Missed Connections
* Careless Documentation
* Clearance Bottlenecks
* Fumigation
* Holidays
* Mis-timed Market-Days

In this wild area of uncertainty and chaos, Murphy's Law runs rampant !

4.3 <u>Preharvest Watering</u> : Flowers need to be in good condition at the moment they are picked, to sustain them on their journey. If they are under stress due to, say, prolonged drought, they will, in all probability, arrive at their destination spoiled, no matter how much postharvest attention they might get. In practical terms, this means keeping the water up to the plants until the flowers are picked.

4.4 <u>Daily Picking</u> : Every experienced grower knows that a flower should be picked as early as possible so that it will be at exactly the right stage of maturity when it arrives at its destination. This means that picking must be done on a daily basis to catch the flowers as they "start to smile". Weekly or bi-weekly picking schedules are not frequent enough for the export business, so weekend growers can forget the idea unless they have an on-site manager.

4.5 <u>Culling, Selection and Grading</u> : Culling of defective stems, selecting those that have characteristics attractive to the export market, and grading them for uniformity are basic to quality control. Grading provides the buyer with sure knowledge of the contents of the box, sight unseen. If the invoice says 10 stems per bunch, there must never, *never* be 9, and eleven is not much better either. If the stems are supposed to be 100cm long, then make sure they do not range beyond, say, 95 to 105cm, otherwise it can well be argued that they are second class material, no matter how nice any single stem may be.

4.6 <u>Control of Physical Damage</u> : Some exporters assume that an importer will see the contents of that export box in all its pristine beauty when he lifts the lid. But that box has been handled 30-40 times from packing shed to destination, and none too delicately at that. Those flowers will rattle around and bash their heads against the box, unless they are restrained by a strap or stay. It is pointless to speculate whether a pincushion will return 50 cents or a dollar per stem if its stem is at one end of the box and its head is at the other ! and it is an illusion to believe that flowers will not move because the box is "full". The flowers in that "full box" will settle down and compact before they even reach the airline. Restraint of flowers within the export box is an important element in arrival quality.

4.7 <u>Postharvest Conditioning</u> : I assume that it is now routine for growers to put their flowers in buckets of water,in a well-lit coolroom, as soon as practicable after harvest. The question is : what further conditioning should be done before those stems are packed away in the darkness of the export box ? Whatever the flower, it is likely that it will get hungry on its journey and will therefore benefit from some postharvest pulsing (with sugar) to build up its carbohydrate reserves. Take care with the concentration, since too much is worse than none at all. An appropriate bactericide should, of course, always be added to the pulsing solution, otherwise the stems will clog up with bacteria and will not be capable of revival at their ultimate destination.

4.8 <u>Coolroom Turnover</u> : Some growers accumulate their harvest over a period of several days, even weeks, without labelling the date of the daily pick. The result is that there are flowers of all ages in the coolroom. Those complaints of spoilage that occur from time to time often arise from "old flowers" that have sat far too long in the coolroom. Development and spoilage are delayed at 2-3 degrees Celsius, but they are not suspended. "Get the flowers into the coolroom" is certainly the first step, but the next is "Get them out again !" -A coolroom is not meant to be a cryonic morgue !

4.9 Control of Humidity :

Moisture	+	Heat	+	Time	=	Rotting	=	Spoilage
Lack of Moisture	+	Heat	+	Time	=	Desiccation	=	Spoilage

The objective, therefore, is to control humidity in the export box so that flowers will neither dry out nor rot. At present this is more of an art than a science. CSIRO (Australia) is currently developing plastic liners that will control humidity to within very fine limits (e.g. 90-95%) but, for the moment, one has to choose whether to use absorbent newsprint or polythene, and, if so, how much of it. Waratah ~~and~~ pincushion, for example, lose moisture easily and collapse. Protea and leucadendron do not. Of course, the flowers will dry out, even in the coolroom, unless the cooling system is designed to maintain high humidity..

4.10 Cultivate Cultivars : In selecting a suitable export crop, cultivars should be evaluated first. The chances are that these will be more successful than plants from seedling stock, if only because someone has taken the trouble to select and propagate them. Not only are they likely to have more attractive flowers, but, coming from clonal stock, they will also be more uniform. Uniformity is an important element of export quality.

5.TACTICAL CHOICES

From time to time, in the export business, simple choices have to be made - either this or that. Some of these choices are of critical importance to export success.

5.1 Proximity to Airport ? It is a great advantage, for export, if your plantation is situated within a few hour's drive of a major international airport. You will be able to ensure that your flowers are still cool when they are loaded on the target flight, you will have less problems securing scarce airfreight space, your costs will be lower, and, overall, you will have more flexibility in your operations. For example, I think there are more international flights out of Sydney Airport than out of all other international airports in Australia and New Zealand put together. This does not mean to say that it is impossible to export from remote plantations, but it does mean that you have to be much, *much*, smarter and it could be better for you to work through an export agent close to where the action is.

5.2 Which Crop to Plant ? You will choose a crop for which there is a known demand, one that grows well in your plantation, and one that has a long postharvest life. I have found that auctions are the best indicator of demand, and importers who work through the auctions will tell you what sort of auction prices you could expect for a variety landed in good condition. As to postharvest life, do some tests for yourself : pack a box with your target flower, leave it at room temperature for a week, and then inspect.

5.3 Which Export Box ? That box is the vehicle by which you ensure that arrival quality is as good (or nearly as good) as departure quality. It is also the ultimate purchase unit and, as such, must suit the buyer's pocket. It is counterproductive to pack in big boxes if that generates buyer resistance at the other end. Smaller boxes tend to be stronger and their flowers arrive in better condition. There are economies to he had in using a standard kind of box if it comes close to your ideal. All export boxes should be in 2 parts, base and top, to give added wall strength, and there should be ventilation holes at each end for forced air cooling and fumigation. Importers prefer contents details to be written on the ends, because boxes are stacked end-outwards on the pallet. All else, is largely a matter of cosmetics.

5.4 Which Customer ? The conventional wisdom is that you should export only to customers who purchase at fixed price. The trouble with that option is that, while most fixed price customers are happy to pay the agreed price for so long as they are making an adequate profit margin, when things get tough they ask for prices to be lowered. Also, when most imports go to auction, one is either cutting oneself off from the bulk of the demand by selling to fixed price buyers or if your fixed price buyer also sells your shipment through the auction, then the price that you receive is adjusted for his margin. On the other hand, if your customer is a retailer, rather than a wholesaler, then there is scope for he and you to eliminate the wholesale margin to your mutual advantage.

5.5 Which Supplier ? Many exporters need to supplement their production with that from other growers in order to bulk up and achieve economies of scale, e.g. to reduce such costs as inspection and forwarding that are charged per shipment rather than per box. This means that one has to choose one's suppliers carefully The formula that I use is this : suppliers must (a) produce top quality flowers (b) have a coolroom, fumigation room and fax machine (c) pack to export specifications (d) be responsible for their own phytosanitary inspection and (e) take a personal interest in the shipment to its final destination. If the supplier is just delivering the flowers and leaving the rest to you, he is not an exporter at all, merely a domestic supplier, and is therefore unlikely to appreciate what export quality entails.

5.6 Which Exporter ? It is not always easy for a grower to reconcile the conflicting priorities of plantation management and shipment management, and, in such situations, he might do well to export through an export agent. In this case, he needs to evaluate the service that the agent provides against the commission charged (usually 10% to 15% of the FOB value of the shipment). A good export agent will earn his commission by his wise choice of customers, freight forwarders, and carriers, and in doing the forward planning, pre-shipment organization and post-shipment monitoring that is needed to keep potential disasters at bay.

5.7 <u>Which Freight Forwarder ?</u> Clearly, if one is in the cutflower business, one needs to use a specialist in export perishables. That shipment of yours may have to wait a day or two before freight space becomes available and, a freight forwarder without a coolroom, loses you a day or two in postharvest life. Secondly, that freight forwarder must be available to service the target flight, no matter when. No room for nine to fivers here ! Thirdly, your freight forwarder must be reliable and conscientious. Fourthly, he should have enough clout with the airline to persuade them to make reimbursement for losses due to their own negligence.

5.8 <u>Which Airline ?</u> The choice of the airline that you use depends on (a) whether they run direct flights to your target destination (b) whether they have freight space to spare (c) whether they are prepared to offer discount freight rates (the usual IATA rates are prohibitive) (d) whether the days that they fly suit you and your customer (e) whether they have a good transhipment record (f) whether they have a good reputation for reliability and service. Of course, all airlines would prefer to carry passengers rather than freight, and, if they must take freight, then they would prefer that it not be perishable. Very few, if any, specialize in perishables.

5.9 <u>Which Shipment Day ?</u> The rationale for this choice should be derived from the point of sale. Importers usually wish to get their hands on a shipment on a particular day of the week, and one should try, so far as possible, to cater to that demand. For example, if the shipment is to go to auction, there are special auction days. There may be particular festivals, holidays, or events that your customer wishes to allow for, either by supplying flowers or by avoiding airport bottlenecks. At the point of despatch, there are similar constraints, for example in arranging phytosanitary inspection by government inspectors who march to the sound of a different drum.

5.10 <u>Which Flight ?</u> The choices here are based on (a) whether the flight is direct (same aircraft all the way) (b) whether that particular flight has plenty of airfreight space. Some airlines operate "full freighter services" where it is easier to secure space when space is short. In our imperfect society, it helps to choose flights departing Mon-Fri (better still Tue-Fri), but with a good freight forwarder, sometimes weekend flights are a feasible option.

6. DOGMA

Some may prefer to follow a set formula, no questions asked. Here are "Ten Export Commandmants"; follow them if you wish ! ?

* Decide, at the outset, whether your main interest is in growing flowers or exporting them ; if growing is your interest then use an export agent.
* If you have only a passing interest in export, then stick to the domestic market; export requires your undivided attention.
* Do not expect to get better export prices per stem than from domestic outlets ! The point of export is to maximize returns per season, not returns per stem.
* Plan your export strategy, the year before the season starts, not the week before.
* Do not try to export without coolroom or fumigation room unless you are interested in exporting money.
* Unless you are there for the experience rather than the money, do not start to export until you can supply 10-20 boxes per shipment.
* Invest in a fax machine; time is money where perishables are concerned !.
* Do not bypass Government regulations.; try to understand why they exist and develop the simplest possible routine to satisfy them.
* Pay close attention to detail.; "She'll be right Jack!" is a recipe for disaster.
* If you do not have confidence in your suppliers, your agents or your customers, then change them immediately! Bitching gets you nowhere.

7. MURPHY'S LAWS OF EXPORT
(with some latitude ,admittedly, for the Laws of Chance)

7.1 Murphy's Law of Supply and Demand : " The Demand for your flowers is greatest before and after your flowering season; your peak coincides with the seasonal glut."

7.2 Murphy's Backsides Law : "If freight space is tight, there is a 100% probability that backsides will be looked on more favorably than cutflowers."

7.3 Murphy's Law of Offloading : "If the flight is overloaded, there is a 100% probability that cutflowers will be off-loaded first."

7.4 Murphy's Transhipment Law : "If there is a change of flight, there is 1 chance in 2 that your flowers will arrive before they perish; if there are 2 changes of flight, the chances are 1 in 3."

7.5 Murphy's T.L.C. Law : "Tender Loving Care falls to Absolute Zero when the shipment is lodged with the airline (ANY Airline)."

7.6 <u>Murphy's Topside Law</u> : "If there is a Top, a Bottom, 2 Sides and 2 Ends to an Export Box, the chances are 1 in 6 that the box will be stacked the right way up."

7.7 <u>Murphy's Law of Concussion</u> : "If any flower is free to move within an export box, there is a 100% chance that it will arrive with concussion."

7.8 <u>Murphy's Law of Migratory Insects</u> : "There is a 100% probability that live insects found in your shipment migrated from the adjacent shipment - and vice-versa !"

7.9 <u>Murphy's Law of Transcendental Magic</u> : "The Value that is Added to to an export flower en route to the Final Customer, appears by Magic, without any visible human aid."

7.10 <u>Murphy's Law of Communications</u> : "If you haven't had an answer to your fax enquiry within 48 hours then they do not exist; if you haven't replied to a fax enquiry within 48 hours, then YOU do not exist."

And the very best of good luck to you all !

Austraflora Exports

12 McGuinness Drive, Robertson, N.S.W. 2577, Australia. Tel.: (048) 851 394, Fax: (048) 851 334.
International Fax: 61 48 851 334

David Tranter comes from a pioneering dairy- farming family in far North Queensland. Mud and slush immunized him against farming for 40 years, during which time he practised as a research scientist with CSIRO, far out of sight of the nearest land. Early retirement found him settled on a rich, wet hillside overlooking the coastal plain south of Sydney, growing protea, and other equally vulnerable species. Having travelled widely in his professional life, he developed an interest in exporting the crops of more successful growers in Queensland, New South Wales Victoria and South Australia. At present, he is shipping to Europe,North America and Japan. He is a member of the Australian Protea Growers' Association and Flower Export Council of Australia and is retiring Editor of the Journal of the International Protea Association.

INTERNATIONAL PROTEA ASSOCIATION

SIXTH BIENNIAL CONFERENCE

Session:- Exporting, Marketing and Promotion

Title:- The Flower Levy

Author:- Philip Watkins, Technical Director, Sunglow Flowers Pty Ltd.

THE FLOWER LEVY

Introduction:

Flower consumption in Western Australia in the early 1980's was around A$5 per capita. In the mid 1980's this had increased to A$12 per capita and by the early 1990's it is estimated at A$25 per capita. This consumption is still low compared with Europe at around A$100 per capita. It is also estimated that 90% of sales in WA are to 30% of the population.

There are also interesting differences in market segmentation by intended use: gifts, home, commercial and special occasions. Special occasions account for 65% of sales in Western Australia while only 15% are for use in the home. In Europe, flowers for the home represent almost 40% of sales.

This analysis suggests there is a large opportunity to increase flower sales by promotion. In January 1991 a flower promotion committee was established under the umbrella of the Greenhouse Rosegrowers Association of WA. This committee aimed to bring together all facets of the floricultural industry to develop a strategy for promotion of flowers on the Western Australian market. Committee membership includes growers (roses, carnations, other exotics, proteaceae, natives), wholesalers, florists and exporters with the WA Agriculture Department providing secretariat support.

The Committee's goal is to increase sales of all types of cut-flowers both to existing regular buyers and to the more numerous very infrequent buyer.

Promotion Strategy 1991-92

For its initial promotion campaign, the Committee decided to target the home consumption and gift segments of the market believing this to be the area of greatest potential for fairly quick results. Due to the high proportion of consumers in the very infrequent purchase category, the campaign could make use of mass-media. Indeed a strategy based on in-store and point-of-sale promotion was specifically rejected as being overly focused on "the converted" i.e. our existing regular buyers. The 1991/92 strategy is to target the 70% of the population who rarely buy flowers rather than to encourage the 30% who do regularly buy to buy more. We hope, of course, to achieve both but we decided to seek a medium and a message suited to the 70% of non-buyers as a modest improvement in this area promises a significant increase in the value of the industry.

The message we want to get across is "Buy Flowers Today" similar to the "What no potato" marketing strategy which was aimed initially at getting people to put potato back on their plate instead of rice and pasta and has now shifted focus to diversify uses of potato and hence increase sales.

A professional advertising agency was briefed to develop a campaign based on the above strategy. The agency was selected on the basis of its experience in promoting fresh perishable products. As expected by the Committee, the agency limited its options to only those media which were visual and in colour. Television was eliminated on the basis of cost. Colour magazines or colour inserts in newspapers were eliminated on the basis of the very brief time period a consumer is exposed to such advertising and the relatively high costs.

The recommended strategy was outdoor advertising, primarily billboards with bus-backs as additional support if the budget could be stretched this far. It was decided that a spring campaign using billboards be mounted and to have a reasonable impact a minimum of 20 billboards was required.

The billboards have to achieve three things:

1. get people thinking about flowers

2. tell people flowers are available

3. tell people there is a reward for buying and giving flowers.

The slogan "Brighten Someone's Day with Flowers" was adopted for this purpose.

The committee also decided to have 2000 wall posters printed for distribution to florists and growers and for sale to the public. The posters will provide a visual link to and reinforcement of the billboard campaign at the point of sale. In addition it was felt important to give sponsors of the campaign something tangible to cement their on-going support and to convince them that the campaign is really going to happen.

Budget and the Flower Levy

Promotion campaigns can use several media at different costs. TV costs about $30,000/week, radio $10,000/week, colour magazines $2500/half page per issue, billboards $450/month. To mount a promotion campaign with 20 billboards for one month a budget of at least $25,000 is required being rental of sites of $9,000 and production costs of $16,000. The production cost is largely a fixed cost whether 20 or 40 billboards are involved.

To raise this money a levy system for the industry was required. The levy had to be appropriate for growers, wholesalers, florists and allied trades. The levy formula for growers was set as follows:

Gross turnover in WA in $	Levy payable as % of gross turnover
0/50,000	1 %
50,000-100,000	0.75%
100,000-500,000	0.50%
500,000 +	0.25%

A wholesaler's levy of 0.1% of turnover was adopted and a florists levy of $100. Donations of cash or kind are being solicited from allied trades.

Achievement to date

By July 10 1991, a total of $35,500 has been pledged of which over $16,000 had been received. The Committee has produced 2,000 posters and has booked 25 billboard sites. Further sites will be booked depending on funds actually received as we move closer to launch date. The campaign is booked to run in earnest from October 23 1991.

The levy is voluntary but has been broadly supported by the industry despite the very difficult economic conditions prevailing in Australia.

Market Research

The Committee considers it essential to monitor the impact of the campaign to guide future decision-making. Curtin University's floriculture program have agreed to undertake the necessary market research. A random sample of florists will be surveyed to collect sales data for the months Sept-January for 1990/91 and 1991/92. The prior year data will enable us to establish a seasonal pattern against which to assess the campaign's impact and the data for the two years for the two months prior to the start of the campaign will allow us to isolate the impact of the present recession.

The Committee is also considering commissioning some consumer market research but we are conscious that the levy has been adopted by sponsors on the basis that it will fund a campaign, not research. So alternative sources of funding will need to be found if this is to be done and the Committee will have to give further consideration to the likely value of such research.

The Future

If the campaign is successful, it is expected that the levy system will remain in place to fund further campaigns which will become progressively more refined as to message, medium and target market. It is in this fine-tuning stage that consumer market research has value.

However, given the relatively low per capita expenditure in WA, a broad-brush approach is likely to be cost-effective for some years yet. The present slogan was developed, in part, with an eye to its adaptability for further use or modification in the future.

Under Government legislation it is possible for primary producer groups to introduce a compulsory industry-wide levy to fund promotion and research. Moves in this direction have been widely mooted in the industry but the Committee has refrained from involvement in this debate

We understand that Flower Grower groups in other parts of Australia are keenly interested in the outcome of the campaign and we will certainly be sharing our experience and results with them. An expanding market Australia-wide is in all our interests.

SPECIES RESOURCE

SOUTH WESTERN AUSTRALIA: BOTANICAL EXPLORATION, PROTEACEAE AND PLANT TAXONOMY

Neville Marchant
Department of Conservation and Land Management, PO Box 104 Como Western Australia 6152

Knowledge about the Western Australian flora has been gained since the seventeenth century when English and Dutch navigators visited the west coast. The first plants known to have been collected from Western Australia were obtained seventy three years before the east coast of Australia was botanically explored by Joseph Banks.

Dampier

William Dampier visited Western Australia twice. In 1688 he described the flora of part of the far north of the State and in 1699 he visited Shark Bay and made plant collections there and further north on islands and the mainland in the north west of the state. The collections of Dampier and the observations he made on the vegetation are only of historic interest and added only a little knowledge of the flora of arid parts of Western Australia.

Dutch Exploration

The Dutch were the first visitors to the species rich south western corner of Western Australia. Their contribution too was rather limited; New Holland was far too barren in comparison with the East Indies to the north.

In 1697 Willem de Vlamingh in the ship *Geelvinck* arrived off the southern part c the west coast near present day Fremantle and a landing party crossed the narrow neck of land between the Indian Ocean and the Swan River. In a report they commented on their experience with the toxicity of the only species of cycad of the south west, *Macrozamia riedlei*, and it seems likely that they collected some samples of the local flora.

In 1768 the botanist Burmann described two plants new to science. He regarded them as species of the fern genus *Polypodium*, believing them to have come from Java (Burmann 1768). These were later recognised as a phyllodineous species of *Acacia* and *Synaphea*, a species of Proteaceae endemic to the Perth region. It is likely that these specimens were collected by the landing party from the *Geelvinck*.

English and French Exploration

English and French expeditions were to dominate the exploration of western Australia from 1791 to settlement in 1826.

Menzies

In 1791 Captain Vancouver discovered the safe anchorage of King George the Third Sound. The Surgeon botanist Archibald Menzies, sailing with Vancouver, became the first person to make extensive collections of plant material in the south west. His collections of dried specimens were sent to Joseph Banks and included seeds of *Banksia* and fruits of other Proteaceae which were the first seeds of this family to reach Kew from the western part of New Holland. Some seeds were distributed to nurserymen and many were matured to flowering and used by Bentham to describe species in *Flora Australiensis*, Bentham (1863-78). Menzies collected numerous species of *Banksia* including the widespread *B. menziesii*.

Labillardiere

The first of four French expeditions to visit Western Australia was led by Admiral D'Entrecasteaux whose flagship "La Recherche" carried the naturalist Labillardiere. In 1792 Labillardiere collected on the south coast near Esperance Bay. He later presented an account of the flora in *Novae Hollandiae Plantarum Specimen*, published in 1804, describing for example, the new genus *Adenanthos* and species such as *Banksia repens* and *Dryandra nivea* (as *Josephinia*).

Leschenault

The second French expedition was commanded by Nicholas Baudin who visited various points of the WA coast enabling the botanist Leschenault to collect widely. The expedition visited Geographe Bay and Shark Bay in 1801 and King Georges Sound in 1803. The genus *Chamelaucium* (Myrtaceae), named by the French Botanist Desfontaines, was described from material collected at King George Sound by Leschenault. Although he didn't publish any account of the flora himself, Leschenault made his collections available to other botanists. The Albany Pitcher Plant, *Cephalotus follicularis* for example, was described by Labillardiere, probably from King George Sound specimens gathered by Leschenault.

Gaudichaud and Lesson

The third French expedition to Western Australia was led by Louis de Freycinet and enabled the botanist Charles Gaudichaud to collect in the vicinity of Shark Bay. The last expedition, under Dumont D'Urville, visited King George Sound in 1826 and the zoologist Lesson collected specimens of plants and animals from the sound.

Brown

Ten years after Menzies made his collections, King George Sound was visited by Robert Brown on board the *Investigator* under the command of Mathew Flinders.

For three weeks of December 1801, Brown, under instructions from Joseph Banks, studied the flora of the Sound and its environs. For 19 of his 27 day stay, Brown botanised in the area, walking many kilometres to the west and the north and collecting hundreds of specimens, including *Banksia occidentalis*.

The next Western Australian anchorage of the *Investigator* was at Lucky Bay which was entered in January 1802. Some of this area, now known as Esperance, Cape Le Grand National Park and the Recherche Archipelago, had been botanised by Labillardiere ten years earlier. Brown was to revisit Middle Island in the Recherche Archipelago in 1803 after circumnavigating the Australian continent.

Brown collected approximately 3,900 plant species in Australia; he was to publish the first flora of Australia, the *Prodromus Florae Novae Hollandiae et Insular van Diemen* in 1810. This contained the new genera *Dryandra*, *Synaphea* and *Franklandia* as well as many new species in other genera.

In 1809 a work entitled *On the Cultivation of the Plants Belonging to the Natural Order of Proteéae* was published by the gardener J. Knight; the botanical descriptions were prepared by R A Salisbury. Salisbury "scooped" Brown by seven months and first established the names of many genera and species of Proteaceae.

In late 1830 Robert Brown published the only supplement to the *Prodromus*. This contained descriptions of new Proteaceae some of which had been collected in WA by Baxter and Fraser. It included *Banksia goodii*, *B. caleyi* and *B. solandri*.

Baxter

William Baxter was a diligent collector of Proteaceae and other plants of horticultural value from the south coast of WA. Little is known of Baxter except that he was sent to New Holland to collect seeds for horticulturalists. In 1824 he visited Cape Arid, Lucky Bay and King George Sound where he collected nine species of Proteaceae, including *Banksia dryandroides*; which were later described by Robert Brown. In 1828, the second year of the King George Sound settlement, Baxter commenced a five month stay at the Sound, collecting many Proteaceae. Brown commemorated his name with his description of the widespread south coast species *Banksia baxteri*.

Fraser

The Colonial botanist Charles Fraser visited the Swan River in 1827 to report on the suitability of the land for settlement. Sailing to the upper part of the Swan River, where there are clay soils, Fraser and his party walked to the foot of the Darling Range. A number of Proteaceae were collected, including species of *Petrophile*, *Isopogon*, *Hakea* and *Banksia* many of which were new, like *Dryandra bipinnatifida* which was described by Robert Brown in 1830.

Swan River Settlement

The establishment of a settlement at Fremantle and Perth, Swan River, in 1829, provided the opportunity for botanical exploration of the interior of the south west. The Colonial Botanist James Drummond, who arrived with the first settlers, devoted his life to collecting the flora from as far north as the Murchison River and as far east as West Mount Barren. He collected an enormous amount of material which formed the basis for the description of the Western Australian species in Bentham's *Flora Australiensis*.

Preiss

Ludwig Preiss, who visited the colony from 1839 to 1842, also made a substantial contribution to our knowledge of the flora. Preiss travelled widely over the settled areas of the colony, collecting many species including Proteaceae which were mostly described by Meissner. The arborescent monocot *Xanthorrhoea preissii*, and *Hakea preissii* are two of the many species named after Preiss.

Huegel

Karl von Huegel collected near Perth and Fremantle in 1833 and at King George Sound in 1834. Bentham, Meissner and Endlicher studied his collections and his name is commemorated in a number of taxa, including *Conospermum huegelii* and *Grevillea huegelii*.

Recent Botanical History

A number of enthusiastic amateur botanists assisted with the inventory of the States' flora from the first days of settlement. Persons like Forrest, Gilbert, Mangles, Maxwell, Molloy and Oldfield, who were active last century, all made substantial contributions to botany. Plant enthusiasts such as Andrews, Blackall, Diels, Fitzgerald, Goadby, Koch, Morrison and Sargent, like their predecessors, are commemorated by many specific names of Western Australian plant species.

The Western Australian Herbarium

The Western Australian Herbarium was formed in 1928 from an amalgamation of the Forests Department and Bureau of Agriculture herbaria. Charles Gardner became the Government Botanist and until he retired in 1962, he collected a vast number of species of vascular plants from almost all parts of Western Australia.

In 1930 Gardner published his *Enumeratio Plantarum Australiae Occidentale*, the first census of Western Australian vascular plants. This list included 15 genera and 467 species of Proteaceae.

The 1985 census of the vascular plants of Western Australia lists sixteen genera of Proteaceae with a total of 536 species, Green (1985). Most of these occur in the south west of the state which is one of the areas of the world renowned for its species richness.

The Herbarium is the State repository for flora and has nearly 500,000 specimens. It is the centre for studies on the flora of Western Australia and has an active research program to inventory the State's flora and provide the data bases that help conserve its remarkable botanical diversity.

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THE PROTEAS OF TROPICAL AFRICA

By J S Beard

The genus *Protea*, although best known as a member of the Cape flora, in fact extends over most of Africa south of the Sahara. The Cape plants form a tightly-knit group of 69 species (Rourke 1980) beyond which there is a group of 13 in the summer-rainfall area of South Africa. Two of these are tropical species at the southern extremity of their range. North of the Limpopo river a further 30 species are now recognised. These vary from localised to extremely widespread. Some have very small ranges indeed and were for a long time known only from the type collection, while others range over almost the entire area of *Protea* country in the tropics. *P. madiensis* for example ranges from Angola across to Malawi, north into Kenya and Uganda and from there into the the highlands of Ethiopia on the one hand and on the other westward into the furthest limits of West Africa.

The flower heads of tropical proteas are for the most part not as strikingly beautiful as the Cape species. The heads are more "ordinary" with simple coloured bracts, not prolonged into ornamental shapes or decked with long hairs. The most beautiful probably is *P. asymmetrica* from the Inyanga Mts. of Zimbabwe, so called because the heads do not open uniformly all round but from one side first. The tropical species do include the most bizarre of all proteas in flower, *P. rupestris*, where the bud is enclosed in smooth reddish-purple bracts which droop down completely when the head opens, leaving the protruding flowers. Another claim to fame is that the tropicals include the smallest of any protea flowers. Two miniature species vie for this title, *P. heckmanniana* and *P. linearifolia*, both found in mountain grasslands of south-western Tanzania, with heads only 3 cm long.

Several of the tropical species may be trees up to 10m tall, the only real trees in the genus. *P. rupestris* referred to above is a tree of this size. It ranges across Africa south of the Congo basin from Angola to Mozambique, described as a small tree attaining the canopy in stunted *Brachystegia* woodlands of especially poor soils at a high altitude of about 2000 metres (Beard 1963). *P. petiolaris* is a smaller tree of some 5-6 m but with a typical tree habit, an erect truck and ascending branches. It has much the same range as *P. rupestris* extending also to Zimbabwe, and is named from the pseudo-petiolate leaves, so exaggeratedly narrowed at the base as to possess an apparent petiole 2-5 cm long. The largest trees of all are produced by a form of *P. welwitschii* which I discovered on the Morro de Moco in the mountains of western Angola and described as subsp. *mocoensis* (Beard 1963). While it is more commonly shrubby and not exceeding 3 m, numerous trees of at least 10m were observed growing scattered in mountain grasslands associated with new a species discovered there, *Protea flavopilosa*, and *Faurea speciosa* (another genus of Proteaceae).

P. welwitschii is an extremely variable species, varying in leaf size and shape, hairiness of stems and leaves, and size of flower heads which vary from large and solitary to small and clustered in groups of up to 6. In early days therefore many different species were described and to try to bring order out of chaos I reduced no less than 12 of them to synonymy under P. welwitschii (the earliest valid name, which thus has priority) in my revision of 1963. To cater for the diversity I proposed 7 subspecies, but subsequent taxonomic opinion is that even these are not sustainable, and that we have to recognise just one highly variable species (Chisumpa & Brummitt 1987).

Another type of variation in P. welwitschii is in habit. While mostly taking the form of shrubs, tree forms are found as noted above and at the other extreme miniature forms where the plants consist of numerous ephemeral stems arising from an underground rootstock. These occur in grasslands, and are burnt off each year when the grass is burnt, being renewed in the spring. This adoption of both shrub and miniature form occurs also in P. angolensis, another very widespread species. The two forms occur in separate areas, the shrub form in bush and the miniature in grassland usually on the edge of dambos (treeless, swampy valley bottoms), but they are about equally widespread. In this case the two forms, being quite distinct, are recognised as varieties, var. angolensis for the miniature and var. divaricata for the shrub form.

Others of the tropical species are less variable in this respect and are consistently either shrubs or miniature ("suffrutescent") species. Of the 32 tropical species, 15 (almost half) are consistently suffrutescent and may be considered as having evolved to suit the fire-prone habitat of the tropical savanna. Of course the Cape fynbos is regularly burnt too, but not every year. The presence of grass greatly intensifies exposure to burning. The tree habit is considered ancestral, evolving to the shrub habit and this in turn to the suffrutescent form.

Colour of flower head is also variable, from red through pink to white. Many Cape species have either pink or white heads mixed indifferently through the same population, but this is not so marked in the tropical group. Only in P. angolensis perhaps is it a noteworthy feature where both the shrubby and miniature varieties are generally white but the miniature has a pink form found only in N E Zambia and the shrubby variety a brilliant red form rather more widespread in Zambia and Malawi. In general in tropical species bracts and flowers are pink-tinged.

Broadly, the tropical proteas occupy two principal habitats, the one related to that of the Cape species, the other quite distinct from it. The former is vegetated as in the Cape by fynbos or by degraded communities derived from it, the latter by plateau woodland, that vast complex of savanna woodlands of the Brachystegia-Isoberlinia-Julbernardia assemblage which covers so much of Africa south of the Sahara.

In the former case, the Cape _fynbos_ is generally classified like Western Australian _kwongan_ as "mediterranean-type" vegetation adapted to a wet-winter, dry-summer climatic regime, but in fact this concept is false as the component plants do not exhibit any specific adaptations of the required nature, and the _fynbos_ extends from the winter-rainfall western Cape into the constant rainfall zone and then on beyond Grahamstown into the summer-rainfall zone. Here its presence is less obvious because summer rainfall promotes the growth of grass, which becomes dry and inflammable in winter, with the result that fire has largely eliminated the _fynbos_ in favour of grassland. Sufficient relics of it survive to show its former presence and composition, and some fire-resistant members of it persist, forming a shrub-savanna vegetation in combination with the grassland. These often happen to be proteas, and a protea savanna, derived in this way, is a frequent element together with _fynbos_ relics all along the escarpments and mountains of Africa at ever increasing altitude until it achieves recognition as the "ericaceous zone" of East African mountains at an altitude of some 3000 m.

At a lower level than these specifically mountainous areas extend the great plateaux of tropical Africa between altitudes of 1000m to 2000 m, covered with a grassy woodland of leguminous trees. This too is a fire climax, as famous experiments in Zambia have shown that the real climax is semi-evergreen forest ("muhulu") which will develop under fire protection. The _Brachystegia_ woodland ("miombo") is a secondary type maintained by early, light burning. Late season, severe burning creates open grassland. Proteas are inhabitants of the miombo at the higher elevations and on the poorer and rockier soils where the trees are stunted and less competitive with the smaller proteas. This is where the tree proteas are found, and also those others considered to show characters which are primitive in the evolutionary sense. It is here that the ancestral home of African proteas appears to lie.

In Australia the shrubby, sclerophyllous Proteaceae of kwongan and other "heathlands" are believed to be descended from rain forest ancestors, and proteaceous genera are still represented among rain forest trees. This is also the case in Madagascar, where there is a single monotypic genus _Dilobeia_, but not in Africa itself (Johnson & Briggs 1975). The family is not represented, today at least, in African rain forests. It is thought that _Faurea_, another proteaceous genus represented in both tropical Africa and Madagascar, is possible ancestral (Rourke 1973). This is primarily a tree of closed and open hill forests in the drier parts of the tropics, not of rain forest.

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WILDFLOWER DIEBACK
AUSTRALIAN PROTEACEAE IN CRISIS

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Western Australia has an extremely rich flora and the South-West Botanical Province is one of the most important centres of biotic diversity in the world. Unfortunately, deforestation, soil erosion, over-exploitation of natural resources and fungal disease are severely threatening the integrity of the State's biodiversity and its loss is an irreversible process of global concern. Western Australia has 43% of Australia's threatened plant taxa, more than any other State on the continent and more than most other countries. Dieback disease, caused by *Phytophthora* species, is out of control in some areas of the south west, especially in the species rich coastal heathlands, where many of the ecologically important and spectacular species are facing extinction. The family Proteaceae (*Banksia*, *Grevillea*, *Dryandra*, *Hakea* etc., comprising 536 described species) is one of the most diverse plant groups in Western Australia and is highly susceptible to *Phytophthora* - more than 80% of species in the family are susceptible to the fungi.

Despite extensive research we are unable to halt the pathogens onslaught and protected species, once thought secure in national parks and reserves, are now facing extinction in the wild as existing conservation reserves are being decimated by the disease. Wildflower dieback is now the greatest conservation threat facing Western Australia!

The conservation problems that we face are graphically demonstrated in the dieback video:-

Video "Dieback on the South Coast" (9 minutes)
Produced by Tom Hill and Bryan Shearer, Dpt. Conservation and Land Management (CALM)

WHAT IS BEING DONE

In 1989, government departments, universities and industry groups in Western Australia spent more than $3.5 million on dieback detection and prevention and the Department of Conservation and Land Management (CALM) has developed comprehensive hygiene protocols to quarantine the disease. In the past, disease research by CALM and university scientists concentrated on studying the biology of the fungus to develop effective hygiene protocols to contain the pathogen. Current research is directed at:

a) containing the spread of the disease,
b) developing more effective diagnostic techniques (e.g. DNA probes) for detecting the pathogen,
c) eradicating the pathogen from infected sites, and
d) identifying, propagating and cryostoring resistant plant genotypes.

The fungicide phosphorous acid, is proving effective in controlling most types of *Phytophthora* and the compound is cheap and easy to apply in field situations (Shearer et. al., in press). Selection of resistant plant varieties is also possible and *Phytophthora* resistant strains of jarrah (*Eucalyptus marginata*) have been developed within CALM for use in rehabilitation strategies (Stukely, unpublished data *) - this work will be expanded to include threatened plants in the Proteaceae (e.g. *Banksia brownii*). CALM is testing the latest dieback mapping techniques on the south coast using remote sensing, which detects infected water-stressed plants before other symptoms are visible. New molecular biological approaches will be developed to exploit weaknesses in the genetic make-up of the fungi and this genetic manipulation research should lead to the attenuation or eradication of the pathogen from infected sites.

WHAT CAN THE COMMUNITY DO?

The fight against dieback is not hopeless but it is essential that the community combines in the fight against the pathogen. The majority of our National Parks and Conservation Reserves are still healthy, and this will remain the case as long as we stop the spread of dieback into pathogen free

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*Stukely, M. : Department of Conservation and Land management, Como Research Centre.

areas. The greatest single step we can take to stop this killer is to stop its artificial spread.

We need to contain dieback until a cure can be found. People visiting the bush should observe the road closed signs in dieback quarantine areas and stay on hard, well drained roads and tracks when they're out driving. Anyone driving off the road in natural areas should check first with the local CALM office to ensure that they don't become dieback carriers.

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BURN.
A COMPUTER MODEL IN RESOURCE MANAGEMENT OF THE PROTEACEAE.

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INTRODUCTION

Natural ecosystem management, conservation authorities and private horticultural enterprises must make decisions which include consideration of conflicting pressures. Such pressures might include preservation of rare and endangered species; utilization of native species in the cut-flower industry; control of noxious species; prevention of wild-fires; and recreational uses (Aust. Environ. Council 1986). Increasingly, computer analysis and simulation are being used in land use planning. Such techniques cannot supplant considered judgement and experience but may provide a reasonable estimation of management practices.

The model **BURN** is a management tool used to investigate the role of fire and drought in determining the species composition of plant communities and the dynamics of individual plant species. It has potential for use in studies of natural communities or in the organization of artificial plant communities (eg horticultural crops). At present BURN is based upon the population and reproductive features of banksias and dryandras. This group has been chosen because a large body of information exists concerning these plants and they show a great deal of variation in ecology, distributional patterns and morphology. However the model is generalized to allow inclusion of any plant species, eg kangaroo paws, proteas, provided relevant data are available.

The biology, ecology and management of banksias and other Proteaceous species have been discussed by Wrigley & Fagg (1988), Taylor & Hopper (1988), George (1981, 1987) and Burgman & Hopper (1982). These books and various scientific papers (eg Lamont & Barker 1988, Collins & Rebelo 1988) provide background material to the intent and uses of this model. Further information regarding a rationale of the model may be obtained from the authors.

BURN - THE MODEL

The population dynamics model has been written so that it can fulfill three major roles. The first role is as a teaching device for use in educational environments ranging from primary school, through secondary and tertiary situations, to general community applications. Its second role is as a research tool to further our understanding of the biology and evolution of the Australian flora. The third use of the model is as an aid in resource management. The latter use encompasses natural communities as well as horticultural situations. It can function as a guide to species selection and management regimes with regard to cone crop production, supplementary water requirements and the like.

Discussion of Model Variables

BURN is written in the C computing language. It incorporates a number of demographic and environmental variables which may be altered by the user. Familiarity with the biology of the species under analysis is essential for the correct use of the model. It should be noted that the results of this model are illustrations of the predicted dynamics of different species under varying environmental conditions. The data and functions used in the model are based on actual results from a large number of sources (see reference list). The output from the model should not be used in isolation from field experience and the user must be aware that predicted outcomes are not real scenarios but probability statements.

A maximum of 6 species may be incorporated in any one run of the model. This has the considerable advantage of providing comparative information regarding species performances. It emulates the difficulties faced by resource managers in deriving optimal programmes for maintenance of community diversity or targeting individual species for conservation (eg rare flora) or eradication (eg exotic species). The programme can be used in various ways. Long term (300 year) simulations investigate outcomes of particular model configurations (eg extinctions, weed invasion). Multiple short simulations provide probability estimates regarding reproductive output and the effects of different fire intervals. This type of analysis might be useful in determining potential returns from cone crops using different species combinations. Many of the details of the model are beyond the scope of this paper; a user's guide, currently being drafted, provides discussion and equations for all variables.

Fire Response, A(01). Banksias are usually considered to be either fire-tolerant or fire-sensitive. Fire-tolerant species of *Banksia* resprout after fire by lignotuberous (eg *B. menziesii*) or epicormic regrowth (eg *B. grandis*). Many resprouting banksias possess both types of bud system and the nature of the regrowth depends on the intensity of the fire and age (size) of the plant. The populations of all fire tolerant species may also regenerate from seedlings.

Fire-sensitive species are killed by fire, as they lack lignotuberous or epicormic bud systems. The size of the plant (for example in *B. prionotes*) may confer some resistance to fire, particularly if the fire is relatively mild and does not reach the canopy. Fire-sensitive species generally rely upon seed germination for population regeneration. Some species of banksia may include both fire response types (eg *B. ashbyi*, *B. marginata*, *B. violacea*). Information concerning the geographic ranges of such ecotypes is unavailable in most instances.

Fire response determines the manner in which the model treats the species. After a fire, the model determines the fire response type and either destroys all plants in the case of a fire sensitive species or a proportion of plants in the case of a fire-tolerant species. The proportion of plants killed is related to the age and structure of the populations.

Table 1. Species variables used in BURN.

Variable Code	Variable Name	Description
A(01)	fire response	banksias are either killed by fire or are capable of resprouting after fire.
A(02)	flowers per cone	the number of flowers produced per cone
A(03)	follicles per cone	the number of fruits per cone; each follicle is capable of containing two seeds
A(04)	percentage of cones fertile	only some cones produce follicles
A(05)	granivory	seed death due to predation
A(06)	abortion	seed abortion
A(07)	branch rate	rate of increase in the number of branch apices
A(09)	seed viability	proportion of seeds which remain viable each year
A(10)	serotiny	the rate of seed release from the cone
A(12)	juvenile period	the period (in years) between seed germination and production of the first cone
A(13)	lifespan	the potential lifespan of the species
A(14)	initial population	size of the population at the start of the program and after each fire
A(15)	mortality	shape parameter for mortality curve
A(16)	mean annual rainfall	aver ge rainfall experienced over the spec.es range
A(17)	Std. Dev. annual rainfall	standard deviation of the above
AS(S)	species	species name

Juvenile Period, A(12). The juvenile period is the time which elapses between germination and first flowering. Species which are fire-tolerant usually have a longer juvenile period than do fire-sensitive species (a minimum of 5 and 3 years respectively, George 1987). Some species (eg *B. grandis* and *B. tricuspis*) apparently do not flower for up to twenty years after germination (Lamont & van Leeuwen 1988). Fire-tolerant species tend to grow more slowly overall and may allocate more of their resources to lignotuber formation rather than stem and leaf growth.

Demographic Variables, A(15), A(13). Initial post-fire populations consist of large densities of seedlings (and resprouts in some species). With the passage of time these densities decrease due to a range of mortality factors (eg animal grazing, plant competition, drought). Though there have been few long-term studies of the population dynamics of banksias, the fact that plants can be aged due to their pattern of growth means that general mortality patterns can be determined.

The populations of many fire-sensitive species of *Banksia* appear to decline due to plant senescence in the absence of fire. Plant death is sometimes linked to the collapse of large heavy branches (eg *B. cuneata,* Lamont *et al.* 1991) or loss of active apcies (eg *B. coccinea* Witkowski *et al.* 1991). Fire-tolerant species typically exhibit a longer potential lifespan related to their ability to recover from fire damage. Plant mortality and life span variables are used to power a survivorship curve. Plant survivorship nd the effects of fires on population regeneration are controlled by plant density-dependent and density-independent functions.

Branch Rate, A(07). The majority of *Banksia* species possess a pattern of growth which enables individual plants to be aged and the temporal pattern of cone production determined (Lamont 1985). This important observation means that populations can be age-structured and the dynamics of reproduction over time assessed. There are difficulties in ageing some species but in most cases some estimate can be obtained.

Reproductive Variables, A(02), A(03), A(04). All species produce distinctive cones which may bear from 60 to 4000 individual flowers. The majority of flowers do not set fruit, which in banksias are called follicles. The potential number of follicles that a cone may bear is equal to the number of flowers the cone possesses. This potential is never reached in any species. In many species the majority of cones fails to set any follicles. Reasons for the excessive production of flowers as compared with follicles are debatable (see Collins & Rebelo 1988 for recent reviews). It may reflect resource limitations as most follicles are massive and woody structures which involve a heavy resource commitment (Wallace & O'Dowd 1989). Alternatively it may reflect poor fertilization of flowers because of pollinator (mostly birds, insects and small mammals) behaviour (Paton & Turner 1985). The reason for low follicle set probably involves a combination of causes. It is doubtful that the biology of seed set in any *Banksia* species will be resolved quickly given the multiplicity of variables operating and the difficulties inherent in experimental investigation of the group (eg long juvenile period, plant size, problems involved in nutrient and pollination experiments).

Seedbank Dynamics Variables, A(05), A(06), A(09), A(10). Each follicle may contain a maximum of two seeds, though ovule abortion and seed predation usually reduces seed production considerably (Zammit & Hood 1986, Scott 1982). Abortion of seeds may be due to a range of factors. It may represent external environmental stresses operating during seed set (eg drought or nutrient deficiency) or be due to genetic causes (eg *B. coccinea* which always aborts one of the seeds per follicle). In many species seed abortion is linked to damage to the vascular tissues of the cone caused by insect larvae feeding (Scott 1982). Levels of seed abortion are often greater in those species which are fire-tolerant (eg *B. elegans, B. incana*). Granivory includes invertebrate and vertebrate destruction of cones, follicles and seeds. Most seed predation and cone damage occurs in the first year and some data indicate that there is little further damage within the follicles until they either open or decay. Other scientific papers show that granivory increases with age, eg Lamont & Barker (1988). Abortion occurs during seed development and hence is confined to the first year of a seed's existence. Seed viability decreases by a constant proportion with age while the number of seeds released increases. Serotiny is an index of the degree to which a seed store is accumulated. It is directly comparable to similar indices used for soil seed storage.

Rainfall, A(16), A(17). The mean and standard deviation annual rainfall statistics, derived from climatic predictions, are used to determine age-specific mortality as a consequence of flood or drought. This is density-independent mortality.

Fires. Fires in the simulation are of two types. Wildfires arise by the comparison of random numbers to a cumulative normal distribution whose mean is decided upon by the user. Typically the mean is set between 15 to 20 years. A second system of fires is BURNS which is called at the user's discretion. This enables the user to modify (within limits) the dynamics of the simulated community. FIRES can override BURNS should they occur prior to the projected year of the management burn.

Species Database

Species currently incorporated in the model database are listed in Table 2. The list includes the majority of banksias from Western Australia and a smaller number of dryandras. Additions to this database are constanly being made as information is obtained. The inclusion of a species is not limited to the W.A. flora and so a *Protea* could be added and analyzed in conjunction with, say, *B. speciosa* for a flower farm around Esperance.

Table 2. Species presently incorporated in **BURN** database.

Banksia			
B. attenuata	*B. audax*	*B. baueri*	*B. baxteri*
B. blechnifolia	*B. burdettii*	*B. caleyi*	*B. candolleana*
B. chamaephyton	*B. coccinea*	*B. cuneata*	*B. elderana*
B. elegans	*B. gardneri*	*B. grandis*	*B. grossa*
B. hookerana	*B. ilicifolia*	*B. incana*	*B. laevigata*
B. lanata	*B. laricina*	*B. lemanniana*	*B. leptophylla*
B. littoralis	*B. lullfitzii*	*B. media*	*B. menziesii*
B. micrantha	*B. nutans*	*B. occidentalis*	*B. petiolaris*
B. pilostylis	*B. prionotes*	*B. pulchella*	*B. repens*
B. scabrella	*B. sceptrum*	*B. seminuda*	*B. speciosa*
B. sphaerocarpa	*B. telmatiaea*	*B. tricuspis*	*B. violacea*
Dryandra			
D. armata	*D. carduacea*	*D. nivea* (form)	*D. nobilis*
D. praemorsa	*D. proteoides*	*D. quercifolia*	*D. senecifolia*
D. sessilis	*D. stuposa*		

Future enhancements of the model will provide seed harvesting options for population supplementation after fire and to evaluate the effects of flower picking on population viability. Inclusion of interfire establishment, non-normal fire frequency distributions, drought and greenhouse effect modules is planned to more fully explore and emulate the dynamics of individual species and communities.

Example 1. Population dynamics of four species of *Banksia* from Hopetoun.

The species included in this example are all from the south coast of Western Australia. Their attribute settings are presented in Table 3. All four species are killed by fire (response code 0). *Banksia speciosa* produces the largest cones (most flowers), while *B. coccinea* sets the greatest number of follicles per fertile cone. All species, except *B. pulchella*, set follicles on more than 50% of cones produced. Seed mortality ranges from 46% to 75% and is due to both seed abortion (especially *B.

coccinea) and seed predation (especially *B. pulchella*). Branch rate, which determines the rate of cone crop increase, is greatest in *B. baxteri* and least in *B. coccinea*. The climatic statistics indicate that, on average, *B. baxteri* and *B. coccinea* occur in situations which receive more rainfall per year than do *B. pulchella* and *B. speciosa*. An average annual rainfall of 500 mm was selected for this simulation, within the ranges of all species. Average fire interval was 14 years.

Table 3. Biological attributes of four species of *Banksia*. Rainfall statistics are mean±std.dev.

Species	*B. baxteri*	*B coccinea*	*B. pulchella*	*B. speciosa*
Fire response	0	0	0	0
Flowers per cone	224	286	324	1369
Fruits per fertile cone	2.7	23.2	19.0	8.7
Fertile cones (%)	59	50	20	55
Seed aborted (%)	21	56	15	24
Seed eaten (%)	32	19	56	22
Branch rate	1.32	1.13	1.26	1.27
Mortality constant	0.08	0.10	0.10	0.08
Rainfall (mm)	537±118	548±131	514±101	499±118

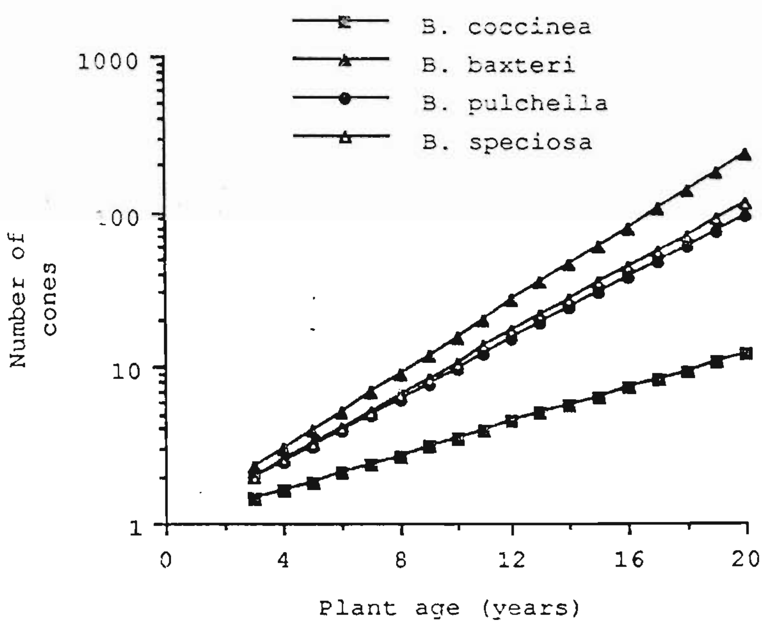

Figure 1. Predicted annual cone production patterns in four species of *Banksia*. Note log scale.

Figure 1 shows the temporal development of the cone crops on individual plants of the four species over twenty years. *Banksia baxteri* produces the largest cone crop of the four species while the cone crop of *B. coccinea*, reflecting the poorly branched form of the species, is the smallest. The amount of seed stored on the plants is a function of cone crop development together with the dynamics of seed set and seed loss. Figure 2 illustrates the temporal development of the seed stores in the four species. Though the

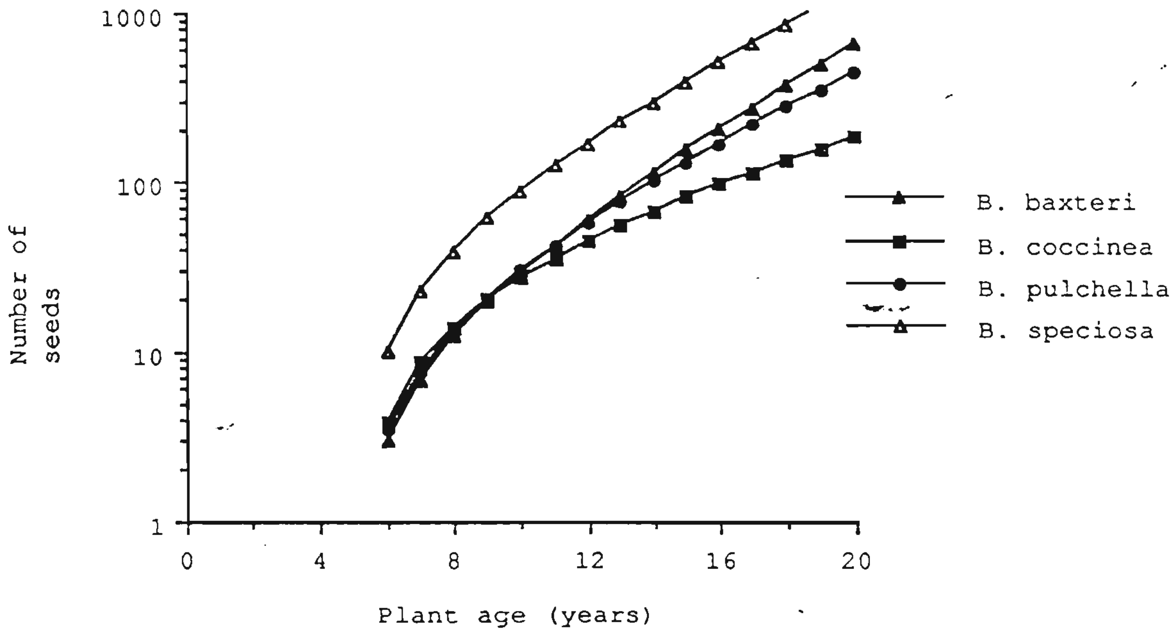

Fig. 2. Predicted seed bank dynamics of four species of *Banksia*. Note log scale.

rate of cone production was greatest in *B. baxteri*, the few follicles set per cone combined with the other reproductive variables lead to the species having a lower rate of seed bank development than *B. speciosa*. *Banksia pulchella* and *B. spceciosa* have similar numbers of seed stored each year, though their reproductive attributes and cone crop dynamics differ. *Banksia coccinea* stores the least amount of seed of all four species

The effects of fire interval on population change are presented in Table 4. In general, frequent fires (interval less than 13 years) lead to a decrease in the population sizes of all four species (a percentage change less than 100). The size of the standard deviations indicates that an increase in population size is possible but unlikely as the average effect is below 100. Fire intervals between 14 and 20 years yield a dynamic equilibrium in population sizes with alterations in the numerical dominance of individual species from fire to fire. Such a fire regime would ensure survivorship of the four species and maintenance of plant community diversity. Fire intervals greater than 20 years may lead to population reductions due to parent plant senescence.

The result of any one simulation is unique. General similarities exist between simulations which have the same initial configurations, eg eventual extinctions, overall mean population sizes, effects of average rainfall and fire regimes etc, but the year by year and generation by generation values differ. Figure 3 reflects this point for *B. baxteri* and *B. coccinea*. This simulation was over a 300 year period during which time 20 fires occurred. Not only were the settings identical in both cases (average annual rainfall of 500m, average fire interval of 14 years) but the sequence of fire intervals was also controlled. The differences between the outcomes are clear, eg in the temporal patterns of species dominance and dynamics; while similarities can also be observed (overall dominance of *B. coccinea*).

Table 4 Effect of fire interval on percentage population change of 4 species of *Banksia*. Data are mean ± standard deviation based on 20 simulations.

	Fire Interval (years)								
Species	11	12	13	14	15	16	17	18	19
B. baxteri	56±26	87±44	91±53	95±40	114±68	114±58	125±70	113±56	113±46
B. coccinea	66±15	83±19	97±29	104±33	107±28	111±41	113±54	114±53	112±48
B. pulchella	55±15	68±20	77±18	94±23	120±67	110±51	115±52	118±65	111±42
B. speciosa	56±25	85±27	90±36	110±40	109±35	115±37	115±59	113±51	113±50

These patterns can be interpreted as being due to the temporal interactions between individual species attributes, their ecological requirements, and the environment. Population declines could be related to short fire intervals or to drought events occurring shortly after fires. Population increases were often related to periods when seed set was high and fire intervals optimal. The model infers that the species richness and dynamics of Western Australian plant communities can be understood in terms of the effect of climate and fire on individual species.

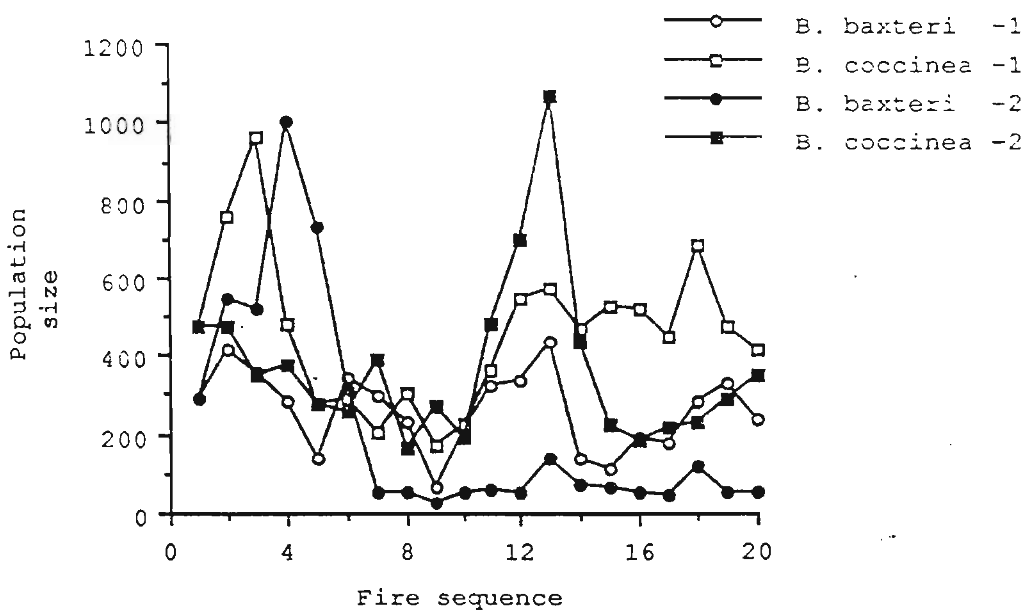

Figure 3. Comparative population dynamics of two *Banksia* species from two simulations using the same rainfall regime and sequence of fire intervals. Open symbols represent the first simulation and filled symbols the second.

The average population sizes (Table 5), together with the population turnover estimates (Table 4), give an indication of the sensitivity and dynamics of the species under particular model settings. *Banksia coccinea* was the overall dominant species in the example though it also showed the greatest variation in plant numbers. *Banksia speciosa* was the least common, and as Fig. 2 indicates, probably would benefit from a longer average fire interval than was experienced. The implications of an analysis of this type are manifold. Provided the user has confidence in the model settings then an assessment of management practices is produced. The impact of any additional pressures (eg cone harvesting, *Phytophthora* infestation) can be ascertained by modification of the model settings and statistical analysis of the differences in outcomes. The model allows long term predictions to be made which would otherwise remain subjective opinions.

Table 5. Predicted average population densities (per ha) of the four *Banksia* species.

Species	*B. baxteri*	*B. coccinea*	*B. pulchella*	*B. speciosa*
Number of plants	229±155	490±259	215±128	118±49

Example 2. Climate and the viability of *Banksia coccinea* populations.

The effect of climate on long term survivorship of *B. coccinea* is presented in Fig. 4. A bioclimatic analysis of *B. coccinea* established that it occurred in areas with an average annual rainfall of 548 mm (Std.Dev 131). **BURN** predicts that when annual rainfall is less than 450 mm the species will die out. This prediction agrees with the isohyet relationships of the current distribution of *B. coccinea* (see Taylor & Hopper 1988, George 1987). The extrapolation from this result is that introduction of *B. coccinea* as a horticultural crop in an area with less than the critical annual rainfall may need to include supplementary watering, at least until the plants are established. It also implies that seed and cone harvesting would probably have similar impacts in areas ranging in average rainfall from 460 to 660 (100 mm either side of the mean rainfall). This inference needs to be treated with caution however as other factors (eg soil type, area occupied by the population) will undoubtedly affect the dynamics of post-fire regeneration.

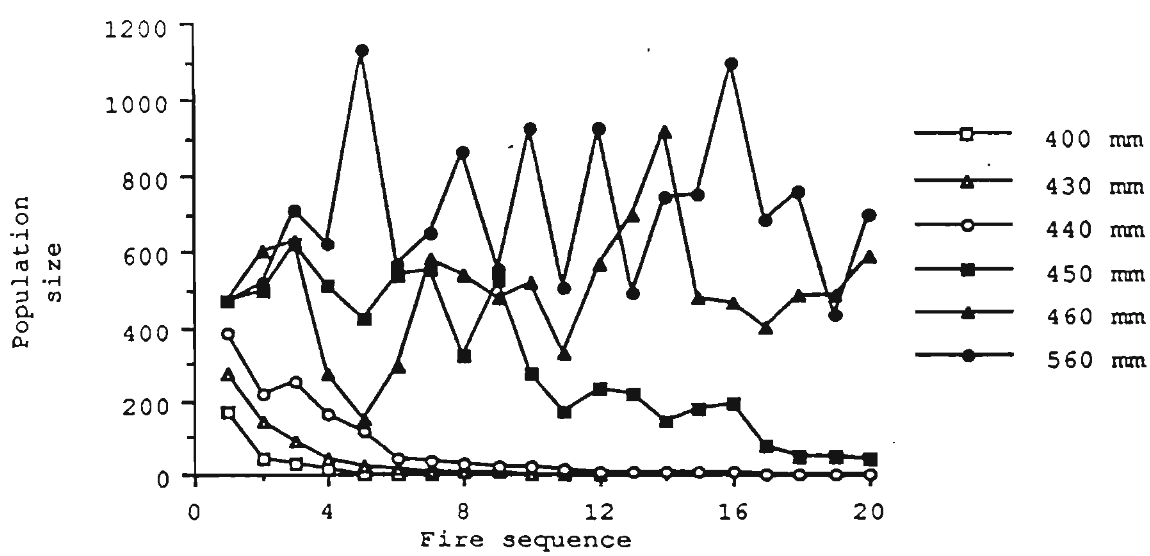

Fig. 4. Population dynamics of *Banksia coccinea* under different climatic conditions

CONCLUSIONS

An ecological model has been developed which provides insight into the biology and management of natural and artificial plant communities. The model is flexible and can include native and exotic species of varying growth forms provided certain information is available. The model has potential for use in education, resource management, horticulture and theoretical biology.

ACKNOWLEDGEMENTS

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UTILIZATION AND CONSERVATION OF *BANKSIA HOOKERIANA*

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INTRODUCTION

In recent years, interest in the conservation of rare and endangered flora has increased dramatically. This has come about due to the decreasing likelihood of survival of many plant species in the wild. This is the result of factors such as land clearing, mining, urban sprawl, pollution, introduced plants and plant diseases (such as *Phytophthora cinnamomi* and other fungal pathogens), lowering of the water table and increased exploitation of natural products. Wildflower picking may even result in local extinction when the species being picked is not allowed to develop a seed bank which will allow it to regenerate after the next wildfire.

The extent of commercial picking from the wild has been escalating in recent years (Burgman & Hopper 1982; George 1984; Joyce & Burton 1989). *Banksia hookeriana* Meissner is a case in point: it is an attractive species that occurs over a limited distribution in dry mediterranean scrub-heath (Fig. 1; George 1981; Taylor & Hopper 1988) and is intensively harvested by bush pickers for the wildflower industry. *Banksia hookeriana* is one of the most important species in the export wildflower trade (Table 1). Since *B. hookeriana* is killed by fire it is dependent on canopy stored seed for regeneration (Enright & Lamont 1989). Seedling recruitment only occurs in the winter - spring period immediately after fire following seed release in response to fire. Reduction in the potential seed store as a result of intensive harvesting could result in insufficient recruitment for parent replacement. *Banksia hookeriana* and other wildflowers which are popular in the wildflower trade, such as *B. coccinea*, grow on deep acidic nutrient-poor sands. However, seeds of these species contain high levels of limiting nutrients, such as nitrogen and phosphorus (Kuo *et al.* 1982), which are essential for seedling establishment in the impoverished soils. Intensive flower picking over a number of years may deplete the nutrient reserves of this ecosystem, as well as impair the ability of these plants to set seed (eg. Low & Lamont 1986; Esler *et al.* 1989; Witkowski 1990). Thus it is important to determine the long-term impact of present harvesting practices on this geographically-restricted species.

In this paper, we report the results of a number of studies on the distribution, phenology, seed-bank dynamics, post-fire seedling establishment and survival, and ecophysiology of *B. hookeriana*. In addition, we present preliminary data on the effects of wildflower picking on bloom production, total canopy seed storage, pre-fire seed dispersal and seed predation. Data were collected from a commercially-picked site, the Beekeepers Road Nature Reserve (No. 39744; 29°49'S, 115°16'E), 300 km north of Perth (near Eneabba), and compared with an unpicked population, of the same age (13 years), and on a similar site in terms of environmental conditions. The climate is dry, warm mediterranean, with a mean annual rainfall of 530 mm, and a pronounced winter maximum (Beard 1976). Mean maximum temperatures in January (hottest month) and mean minimum temperatures in July (coldest month) are 35.8°C and 9.2°C,

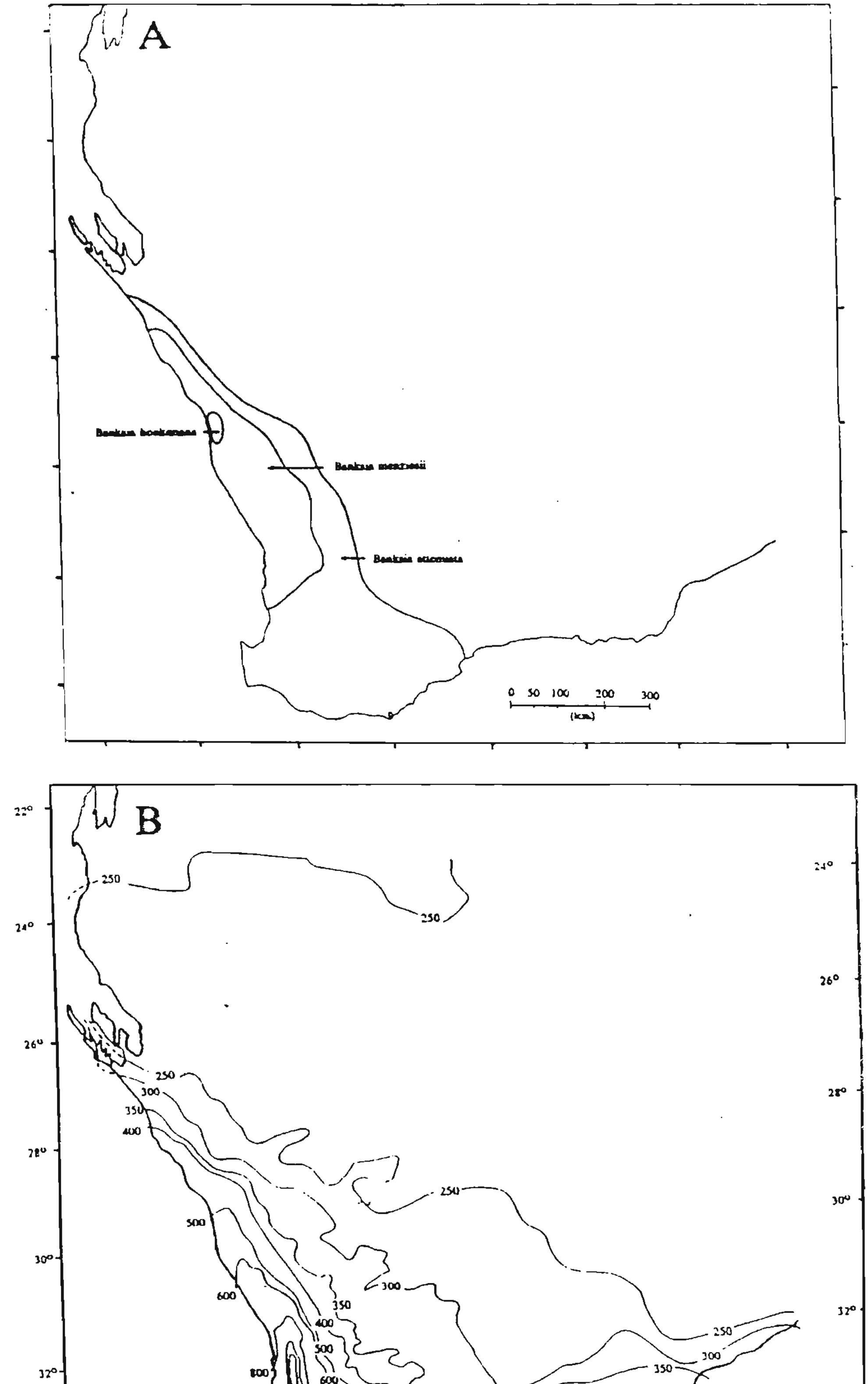

Fig. 1. A) Distribution of *Banksia hookeriana* in comparison with other banksias. B) Rainfall isohyets for S.W. Australia.

Table 1. Features of the Australian wildflower industry in relation to picking of *Banksia hookeriana* blooms. This data is preliminary, and was researched and compiled by F.J. Obbens.

Year	1981	1990
No. of flower pickers (all species)	550[1]	1000[2]
Number of <u>major</u> wholesalers	5[1]	15[2]
Annual harvest of *B. hookeriana* blooms (millions)	-	1.27- 1.42[3]
Blooms sold (% total)		
Exported	80[1]	87[3]
Local	20[1]	13[3,4]
Source of blooms (% total)		
Picked from the wild	90[3]	50[3,4]
Cultivated	10[3]	50[3]

1 Burgman & Hopper (1982).
2 M. O'Donoghue, Department of Conservation and Land Management.
3 Compiled by F. Obbens.
4 Australian National Parks and Wildlife Service.

Table 2. Population details for *Banksia hookeriana* plants from picked and unpicked stands near Eneabba, Western Australia. Results are means±S.D. Density determined on three 20 x 20 m plots and other variables on 20 plants per site. *, $P<0.05$; **, $P<0.01$; ***, $P<0.001$; NS, not significant (t-test).

	Picked	Sig.	Unpicked
Density (plants ha^{-1})			
B. hookeriana	1483±181	*	2100±265
All shrubs	10342±800	NS	12500±1179
Height (m)	1.49±0.14	***	1.78±0.27
Canopy area (m^2)	2.11±1.00	**	3.77±1.86
Canopy volume (m^3)	2.13±1.13	***	4.65±2.71
Openness of canopy (%)	23.9±14.2	***	10.3±6.4

respectively. Rainfall exceeds evaporation only during the months of June to August. The length of the growing season for agricultural plants (Prescott formula) is 4.5 months (Bartlett 1975). *Banksia hookeriana* is restricted to the Eneabba Plain which represents a coastline dating from the Pleistocene (Baxter 1972). It consists chiefly of alluvial/colluvial deposits of gravel, sand and clay which were deposited through the action of wind and streams from the lateritised sandstone plateau to the east. These deposits are dominated by undifferentiated bleached sands underlain by lateritic gravels and clays (Hopkins & Hnatiuk 1981).

Proteaceae, and banksias in particular, have special features which enables one to trace the annual history of bloom production and the extent of picking on a plant. That is, one can determine the age of cones and shoots from the growth pattern of the stems (Lamont 1985). Furthermore, seeds are stored in the canopy (serotiny), and thus the total seed bank available for the next generation can be easily assessed (Lamont 1991).

DISTRIBUTION

Banksia hookeriana is restricted to an area of about 33 x 74 km^2 (E-W x N-S) in the northern sandplains of Western Australia centered on Eneabba, 285 km north of Perth (Taylor & Hopper 1988; Fig. 1). Thus it is very restricted compared with widespread banksias such as *B. attenuata* and *B. menziesii*. It is found in the crest and upper slopes of deep, sandy dunes, and is absent from interdune depressions (Enright & Lamont 1989; Lamont *et al.* 1989). It may hybridize with *B. prionotes*, preferring low points in the landscape, at the ecotone of their distributions. Pollination by new holland and brown honeyeaters, as well as bees has been observed (Taylor & Hopper 1988). *Banksia hookeriana* is locally common with most populations in excess of 100 plants at maturity. It is highly susceptible to dieback disease (McCredie *et al.* 1985).

In an attempt to explain the restricted distribution of *B. hookeriana*, a study was undertaken along a topographic gradient at Mt Adams (Lamont *et al.* 1989). *Banksia hookeriana* was only found in the midslope area where the sands are deepest. Seeds of *B. hookeriana* were planted as a monoculture and as a mixture with *B. attenuata*, *B. menziesii*, *B. leptophylla*, and *B. prionotes* (the other species occurring naturally along the gradient) on the upland, midslope and lowland positions on the gradient (Lamont *et al.* 1989). Seed germination was similar at all sites and *B. hookeriana* seedlings survived in the monoculture plots throughout. However, when grown with the other species, *B. hookeriana* only survived at the midslope site where it occurs naturally. Thus the restriction of *B. hookeriana* to the mid-slope area is due to the combined effects of biotic and abiotic factors. Since the sites where *B. hookeriana* will not be outcompeted by other species are not abundant (deep sands), this could explain its restricted distribution.

PHENOLOGY

Vegetative growth of *B. hookeriana* occurs for nine months of the year (Fig. 2). It is highest during the summer months: greater than 90% of total extension growth and leaf production occurs during the driest and hottest

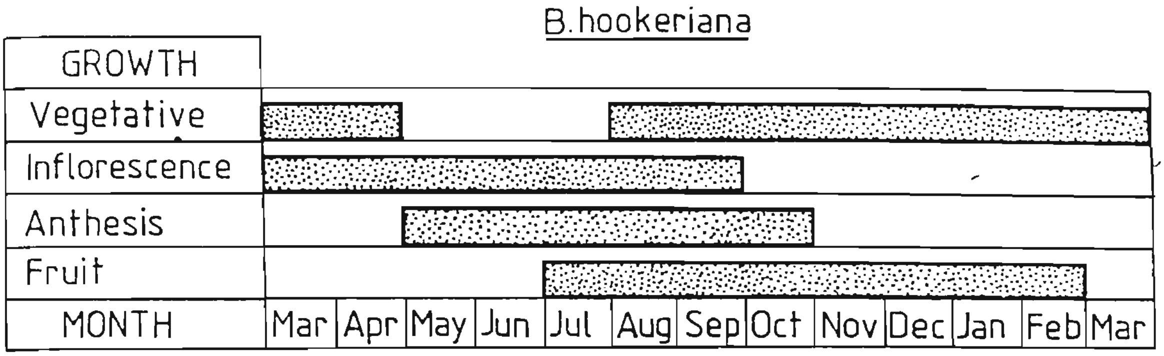

Fig. 2. Phenophases of *Banksia hookeriana* at Eneabba, Western Australia.

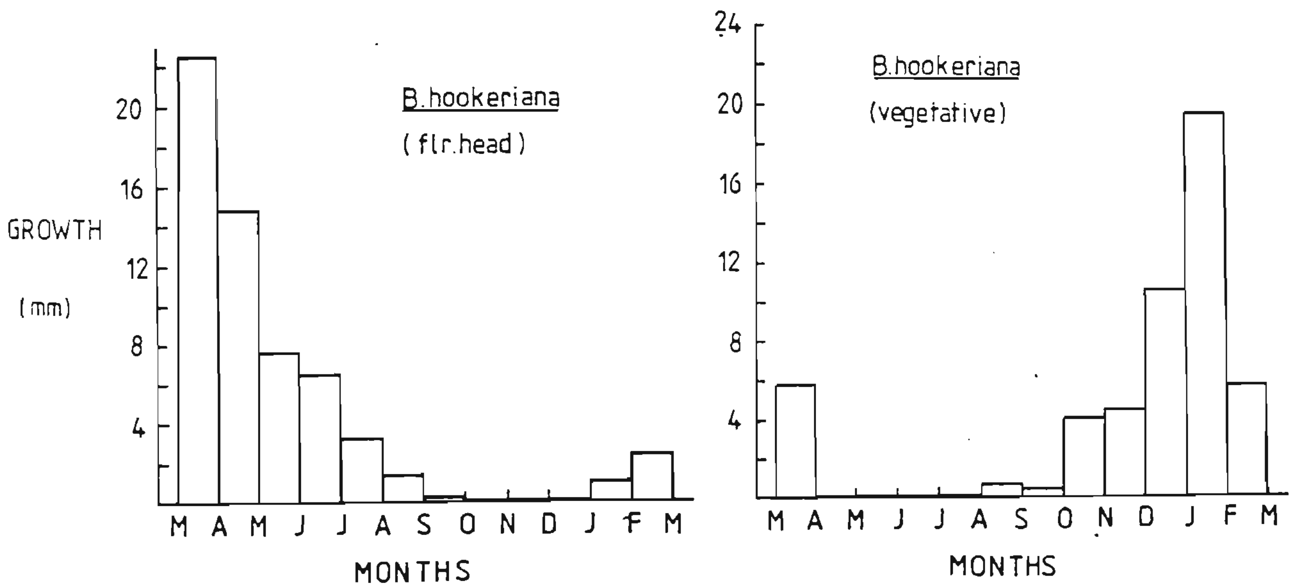

Fig. 3. Flower head and shoot extension of *Banksia hookeriana* at Eneabba, Western Australia.

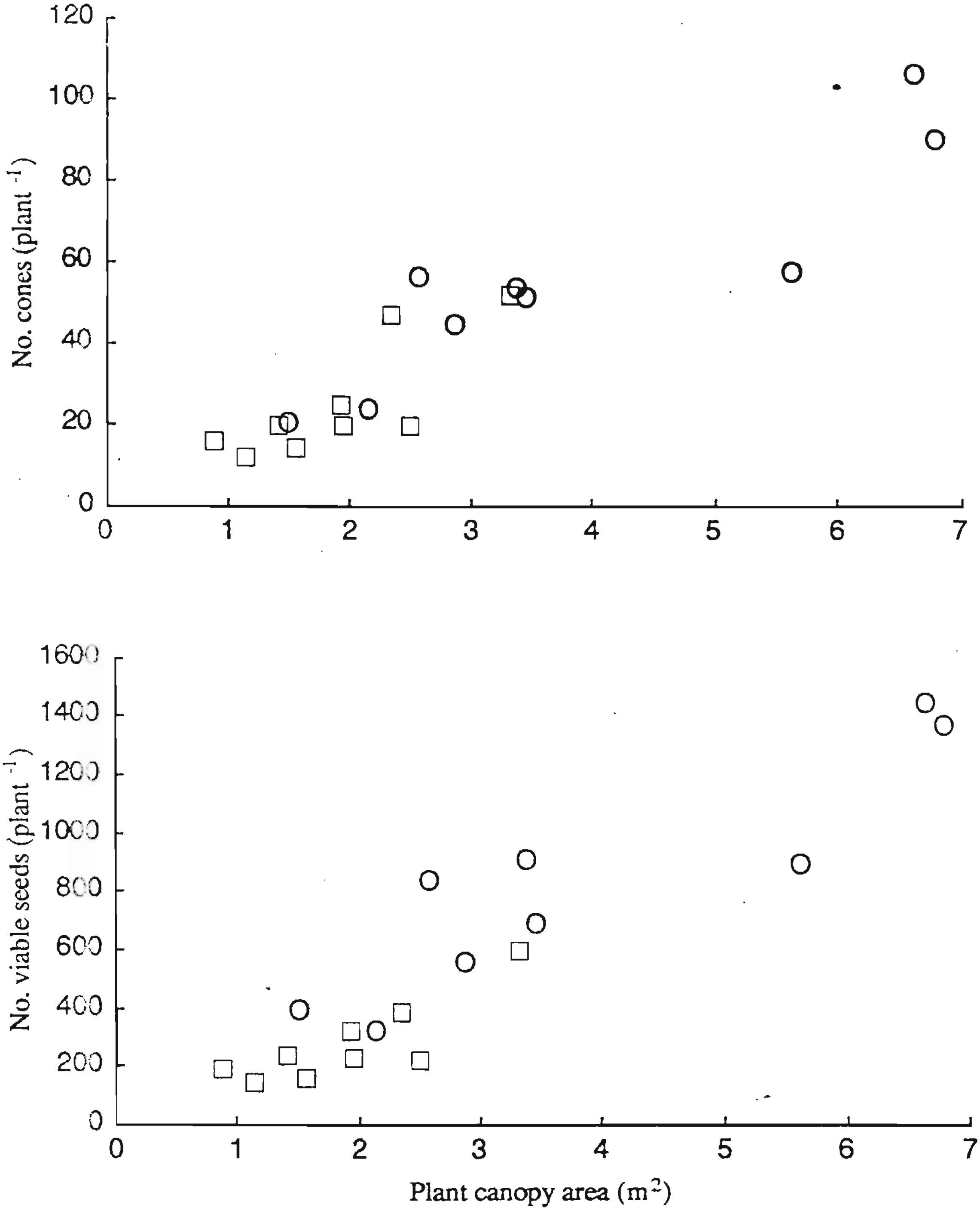

Fig. 4. Numbers of fertile cones and canopy stored viable seeds in relation to canopy area of picked (□) and unpicked (○) populations of *Banksia hookeriana* at Eneabba, Western Australia.

months, and stops over the winter period (Fig. 3) like other banksias in the area. In contrast, inflorescence development occurs over a period of 7 months from January to September, with blooms maturing asynchronously on an individual plant. Blooms opening late in the flowering season are much smaller than those opening at the start of the season. Floral initiation and development in banksias is slow, taking from 6 to 12 months (Fuss & Sedgley 1990). During this time the developing blooms are prone to insect damage, especially by species of borer (Wallace & O'Dowd 1989). Once blooms develop they may be visited by white-tailed black cockatoos, *Calyptorhychus funereus latirostris* (Saunders 1980; Scott 1982; Witkowski *et al.* 1991). Cockatoos remove blooms by chewing them off at the base in their search for moth larvae. Fruits (follicles) develop from July to February. Commercial picking is undertaken from about June to September. Lateral roots extend up to 4.5-10 m from the parent plants (Lamont & Bergl 1991). All lateral branches terminate in clusters of rootlets (proteoid roots). Proteoid roots of all banksias in the stand merge to form a 5-10 mm thick mat at the soil surface. Tap and sinker roots (functionally equivalent to tap roots) penetrate to a depth of over 5 m (Low & Lamont 1990). This prevents the adults from developing significant water deficits over summer - autumn (Lamont & Bergl 1991). Production of surface rootlets commences after the first substantial autumn rains (May) and ceases in late spring (October).

EFFECTS OF PICKING ON BLOOM PRODUCTION

Little is known about the levels of bloom picking from the wild for most plant species (Low & Lamont 1986; Rebelo & Holmes 1988). Bloom picking results in the removal of a large proportion of the most physiologically active tissues on a plant. Levels of picking at the Beekeepers Reserve has been an average of 26% of blooms over the last 8 years. This has resulted in markedly reduced plant size (Table 2). However, levels of picking may vary enormously between individual plant. Blooms are graded and those of low quality receive low prices. Good quality blooms have long straight stems and large undamaged inflorescences and are in demand for export. In general, blooms picked from natural populations are of lower quality than from plantations. Bloom picking was found to reduce the following seasons cone production in two species of *Protea* and *Leucadendron* in the Cape fynbos (Mustart & Cowling 1991). Similarly, bloom picking of *B. hookeriana* also reduces subsequent production (Table 3; Fig. 4). No significant differences in cockatoo cone removal and the numbers of infertile cones per plant were observed between picked and unpicked populations (Table 3).

EFFECTS OF PICKING ON SEED BANK DYNAMICS

The effects of bloom removal on seed bank dynamics is the most important question for the conservation of these species. Pre-fire seed dispersal increases as cones (and thus follicles) become older. Our preliminary data show that picking had no effect on pre-fire seed dispersal (Fig. 5). However, we have observed much higher levels of follicle opening, and thus pre-fire seed dispersal, on severely picked plants. Pre-dispersal seed predation also increases with cone age, and picking results in increased seed loss from granivores (Fig. 5). Percentage seed abortion was higher in the older cones, but is generally not different between picked and unpicked populations of *B. hookeriana*. Percentage seed viability decreases with cone age, and tended to be slightly lower in the picked population (Fig. 5). Total numbers of viable seeds stored increased exponentially with plant age in the unpicked plants,

Table 3. Cone production and fate, as well as total seed store in picked and unpicked populations of *Banksia hookeriana* near Eneabba, Western Australia. Results are means±S.D. for 10 plants per population. *, $P<0.05$; **, $P<0.01$; ***, $P<0.001$; NS, not significant (t-test).

	Picked	Sig.	Unpicked
No. of cones produced $plant^{-1}$	45.2±26.3	NS	68.5±35.7
Fertile cones (%)	64.5±11.3	***	83.6±6.1
Cones picked (%)	25.5±9.0	***	0.9±1.3
Infertile cones (%)	3.4±3.0	NS	6.2±4.8
Cones removed by cockatoos (%)	6.6±4.0	NS	9.2±5.4
Total seed store $plant^{-1}$	345±246	***	853±383

Table 4. Seedling survival over 12 months (June-May) for *Banksia hookeriana* within litter and sand patches after intense (wildfire) and mild (backburn) fires at Mt Adams, Western Australia. Superscripts refer to levels of significance for X^2 analysis between a) control vs thinned (50% of seedlings removed in September) and b) control vs sand, performed on the raw data for each fire type.

	Wildfire			Backburn		
	Litter		Sand	Litter		Sand
	Control	Thinned		Control	Thinned	
Survival (%)	33	58***	80***	7	35***	64***
Sample size	369	66	50	419	84	50

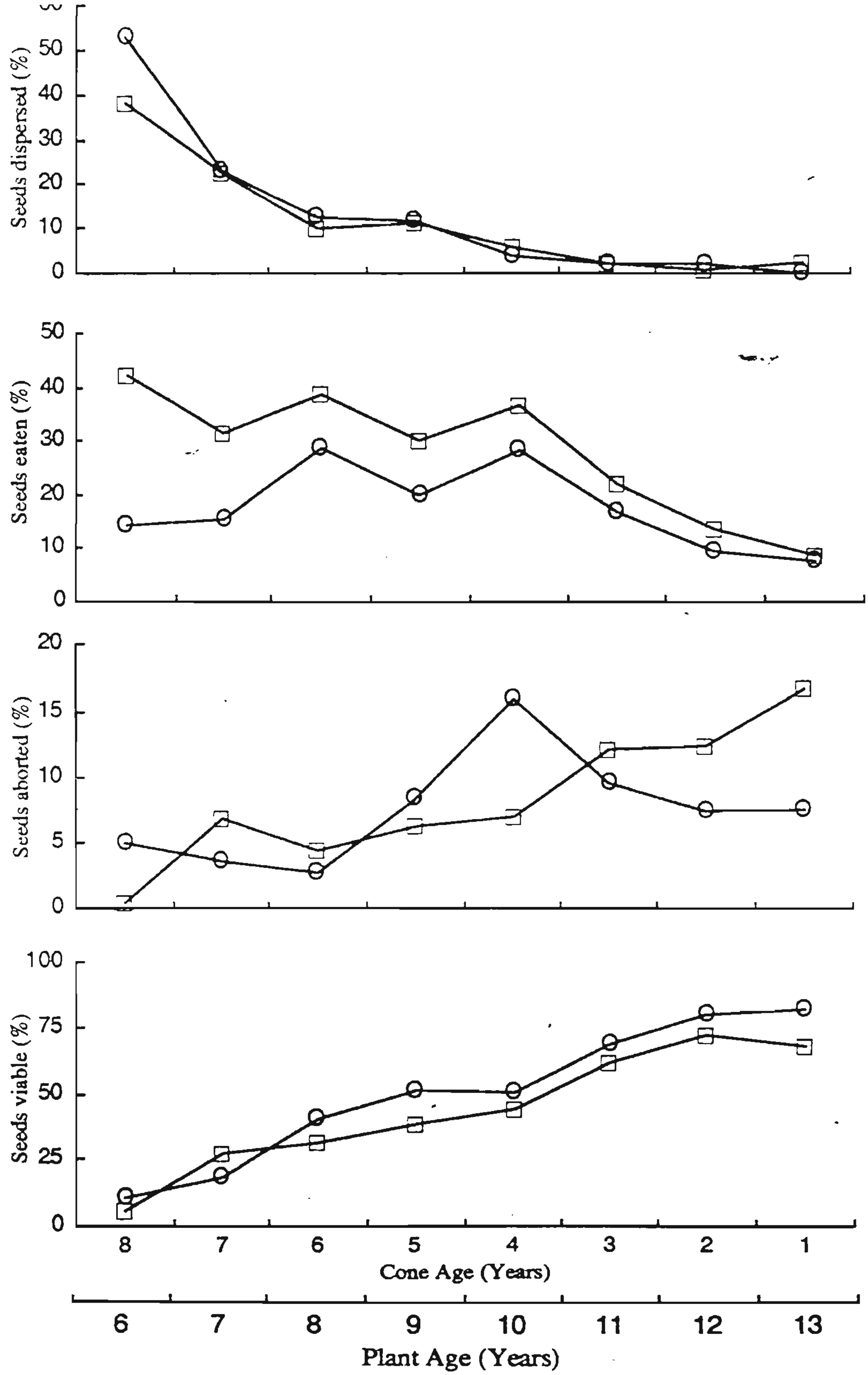

Fig. 5. Percentages of seeds dispersed, eaten, aborted and viable in picked (□) and unpicked (○) populations of *Banksia hookeriana* in relation to cone and plant age at Eneabba, Western Australia. Means of 5 plants per population.

linearly and at a much lower rate in the picked plants (Fig. 6). As a result, total canopy seed storage in unpicked plants was over twice that of picked plants at 13 years of age (Fig. 6; Table 3). This difference would accelerate with older plants. The total numbers of fertile cones and viable seeds per plant were closely related to plant canopy area (Fig. 4). Unpicked plants have much higher canopy areas than picked plants (Table 2). Similar relations between cone numbers and canopy size have been observed for species of *Protea* (Bond *et al.* 1984; Mustart & Cowling 1991), *Leucospermum* (Witkowski 1990) and *Leucadendron* (Mustart & Cowling 1991; Witkowski, Cowling & Davis unpublished). Cone picking also results in a sparser canopy (Table 2), exposing the older cones to more direct sunlight which may result in increased pre-fire seed dispersal.

POST-FIRE SEEDLING SURVIVAL

Fire is central to the management of vegetation in which banksias are conspicuous (Gill & Groves 1981; Cowling *et al.* 1990). A major research challenge is the identification of the critical limits of species to various components of the fire regime (i.e. fire frequency, intensity and season of burn) so that the demise of horticulturally-valuable species can be avoided (Bond *et al.* 1984; Cowling & Lamont 1986). By harvesting flowers, the reproductive potential of a species is lowered.

Half of the canopy-stored seeds of *B. hookeriana* plants (burnt by spring and autumn fires) were released spontaneously within 2 hours, and 95% of seeds were released within the first forty days (Enright & Lamont 1989). However, only 72% of *B. hookeriana* cones were scorched in the spring fire and no seeds were released from these unburned cones by the start of winter. Thus about 100% and 72% of canopy stored seeds were released after autumn and spring fires respectively. Seeds released after spring fires are exposed on the soil surface for longer than those after autumn burns and must also endure the hot dry summer months. Pre-release seed viability has been estimated at 40% when abortion, dispersal and granivory are taken into account (Enright & Lamont 1989). Viability of seeds left on the soil surface was observed to decline rapidly after exposure for more than one summer month and was close to zero after 4 months (Fig. 7; Enright & Lamont 1989). In contrast, the viability of buried seeds declined only slightly over a study period of 6 months. Following winter rains, initial seedling to parent ratios of *B. hookeriana* were on average 37 and 74 after spring and autumn burns respectively. However, by the end of the first summer, seedling mortality had resulted in about equal seedling to parent ratios for both seasons of fire, namely 24 and 23 respectively. That is, seedling mortality during this summer period was 35% and 68% respectively. It appears that season of burn in the absence of weeds (Hobbs & Atkins 1990) is not as critical as once thought.

The post-fire distribution of seedlings of *B. hookeriana* is not random. The post-fire environment consists of a mosaic of litter patches and intervening tracks of sand, the latter covering the largest area. A far greater proportion of seedlings emerge from litter patches than from the sand (Enright & Lamont 1989; Lamont *et al.* 1991). These litter microsites, generally known as 'safe sites', accumulate debris and seeds during the period between the fire and the onset of the winter rains, when seed germination and establishment commences. However, owing to the high seedling density in the

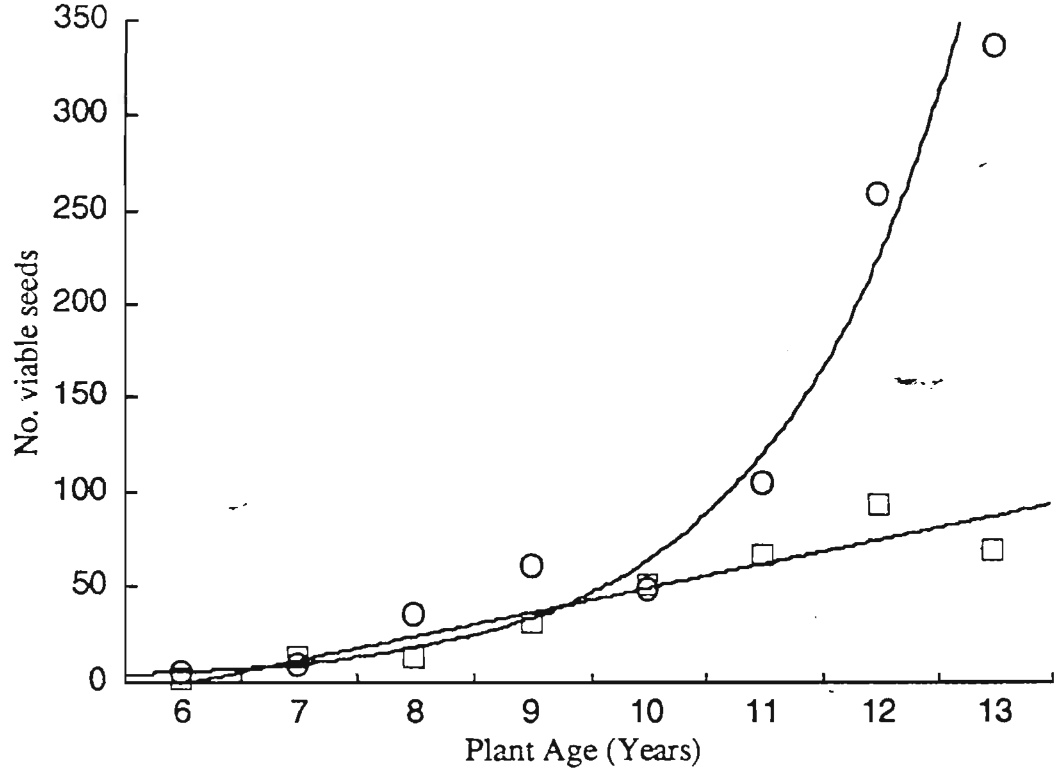

Fig. 6. Numbers of viable seeds stored (S) per crop year in relation to plant age (A) for picked (□) and unpicked (○) populations of *Banksia hookeriana* at Eneabba, Western Australia. $S = -0.76.55 + 12.60A$ ($r^2 = 0.88$) and $S = 0.122e^{0.627A}$ ($r^2 = 0.94$) respectively. Based on 10 plants per population.

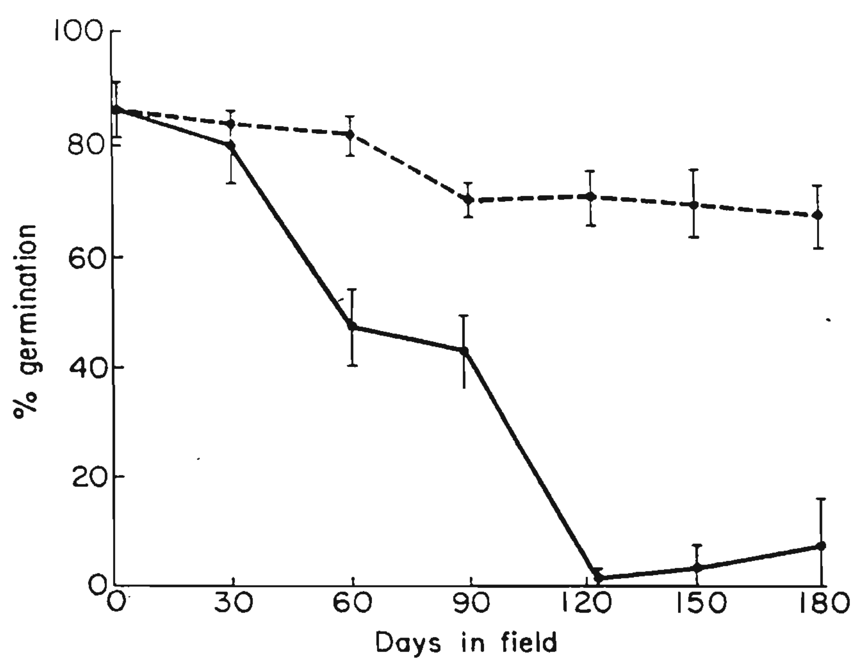

Fig. 7. Viability of *Banksia hookeriana* seeds at a site near Eneabba, Western Australia following varying periods of exposure at the soil surface (———), or buried (– – – –). Data for 'control' seeds (kept in the laboratory) are presented as exposed for zero days. Vertical bars are ± 1 S.E.

litter patches (e.g. 139±74 m^{-2} and 284±166 m^{-2} for *B. hookeriana* and total seedlings respectively after a wildfire; Lamont *et al.* 1991), competition for moisture becomes intense during the first summer drought and seedling mortality is much higher than for seedlings growing in the sand, after both intense and mild fires (Table 4; Lamont *et al.* 1991). Thinning of seedling numbers in the litter patches results in the eventual density of juveniles becoming similar in both patch types.

MINESITE REHABILITATION

RMC Mineral Sands Ltd mines for heavy minerals within a Flora Reserve 280 km north of Perth, Western Australia. Legislation requires that these areas be returned to reserve status, and the revegetation program needs to replace 80% of the local native flora. Due to the fact that large areas of this land were previously dominated by banksias (Hnatiuk & Hopkins 1981), and account for 80% of the aerial biomass of scrub heath on deep sand (Low & Lamont 1990), replacement of banksias is essential for the restoration of the original community structure and composition. Survival and growth of first year seedlings of *B. hookeriana* is lower in rehabilitated mine sites than in natural areas which closely represent the pre-mining environment (Enright & Lamont 1991). This is largely due to poor development of the root system in the rehabilitated site compared with the natural sites. Taproots stop at the topsoil/tailings boundary, about 0.05-0.15 m deep, while they reach 2 m at the natural sites within 12 months. This was reflected by much lower pre-dawn xylem pressure potentials and stomatal conductances and higher leaf temperatures, indicating greater water stress. Seedlings in natural sites obtained most of their water below 0.5 m in depth. In the rehabilitated minesite, the modified soil structure impeded root penetration, resulting in increased moisture stress, reduced growth and ultimately increased seedling mortality. The mining program is now being reexamined to determine if coarser tailings suitable for banksias can be returned on top of the finer tailings.

GENERAL DISCUSSION AND CONCLUSION

Intensive flower picking has a major effect on subsequent flower and seed production. As a result, the numbers of seeds available for the next generation is greatly reduced. However, in view of the marked density dependant death of seedlings that occurs after fire, the impact of bloom picking on the restoration of *B. hookeriana* populations is not yet clear.

Insufficient land available for various landuses ultimately results in compromises, such as between the use of catchment areas for water production and as conservation reserves (eg. Van Wilgen & Lamb 1986). We have discussed the conservation of *B. hookeriana* because over the years we have collected a large body of information on this species. However, other banksias such as *B. coccinea*, are also widely picked and have a very uncertain conservation status (Burgman & Hopper 1982; Witkowski *et al.* 1991). Furthermore, other species, such as *B. goodii*, *B. tricuspis* and *B. cuneata* are gazetted rare species, and it is an offence to damage these plants. Continual monitoring of these species, together with further research on their ecology is required. Only proclamation of more conservation reserves where vulnerable species are abundant will guarantee their long-term survival in the wild.

The addition of nutrients to proteaceous plants in the field has been shown to result in increased bloom production in *Leucospermum* (Witkowski 1990; Witkowski *et al.* 1990), and increased seed set in banksias (Stock *et al.* 1989; Wallace & O'Dowd 1989). Concern has been expressed about the possibility of depletion of ecosystem nutrient reserves by bloom picking over an extended period of time in the nutrient-poor Australian heathlands and the Cape fynbos. No evidence of this has yet been found (eg. Esler *et al.* 1989), although we expect the results of our current work on *B. hookeriana* to be significant in this regard.

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FLOWERING IN BANKSIAS

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INTRODUCTION

The future success of banksias in the horticultural industries of cut flowers, potted plants and amenity planting is dependent on the development of suitable cultural management techniques and new and improved cultivars. However the research work required to make these developments is both costly and time consuming, and therefore careful planning is essential. This paper presents the results of research which has some direct benefit to industry and will assist in the planning of future research. The work was conducted on *Banksia coccinea* and *B. menziesii*, to investigate (1) the relationship between vegetative and reproductive growth cycles for the development of plantation management practices and strategies; and (2) the breeding system of these species to establish the limitations which may be faced in breeding programmes.

PLANT MATERIAL

All experiments were conducted using plants established from seed and planted out in 1983 on commercial cut flower plantations in the Blewitt Springs area of South Australia. The plants received routine plantation management, including limited drip-irrigation to supplement rainfall, annual fertilising in autumn (March-May) with complete mineral Mix (Top Australia Ltd), and biannually with low phosphorous Osmocote Controlled Release Fertiliser (Sierra). Weeds were controlled by mowing between rows and by either whipper-snipping or spraying with Round-Up (Monsanto), at the minimum dosage, around the base of plants. Harvesting of blooms served as the only form of pruning prior to the experimental period.

(1) GROWTH CYCLES

Shoot growth and the time of floral initiation were investigated in relation to flowering of both *B. coccinea* and *B. menziesii*.

In the short term this will assist in the development of cultural practices such as pruning, as well as the planning of future research to understand the controls of flowering. The experiment was conducted from March-April 1988 until August 1989. Measurements of shoot growth, including basal shoot diameter and shoot length were made on six plants of each species. These data and the presence of developing inflorescences were recorded at monthly intervals for every shoot on the *B. menziesii* plants (average 50.3 shoots per plant) and every second shoot for the *B. coccinea* plants (average 69.7 shoots per plant). At completion of the experimental period the shoots were categorised based on the number of years growth from an axillary bud before producing a bloom. Also at monthly intervals, shoots which were not visibly floral were harvested from other bushes, the apices dissected and observed under a scanning electron microscope to determine the time of floral initiation.

SHOOT GROWTH

B. coccinea

Some shoots of *B. coccinea* flowered in their first year of growth (Table 1). However if harvested, these blooms would be of little value on the fresh cut flower market due to the shortness of their stems. The majority of blooms were produced on second year wood. These shoots attained a length suitable for cut flower production and were sufficiently sturdy to support the developing bloom. Those shoots which had not produced a bloom after two years growth were significantly shorter and thinner than shoots in either of the other two categories. By looking retrospectively at the growth of shoots in this category it is unlikely that they would produce a bloom if they remained on the plant. It is therefore proposed that shoots of *B. coccinea* with a basal diameter of 4.5mm or less after just one years growth be removed. Thicker shoots which are bent or damaged should be headed back to leave several nodes from which new shoots can develop. Heading back should also be practised when harvesting blooms.

Table 1. Shoot growth of *B. coccinea* (Adapted from Fuss *et al.* 1991).

Shoot category	Proportion of shoots per tree	Total length (cm) in year 1	Total length (cm) in year 2	Basal diameter (mm) in year 1	Basal diameter (mm) in year 2
Bloom in year 1	29%	33.9	-	6.8	-
Bloom in year 2	42%	20.2	50.9	4.4	9.1
No bloom after 2 years	29%	17.0	43.5	4.2	7.0

B. menziesii

On *B. menziesii* a proportion of the blooms which were initiated on both first and second year wood aborted during the early stages of development (Table 2). Shoots in this category were of intermediate length and diameter when compared to similar aged shoots which produced an inflorescence and those which did not. Although the highest proportion of blooms were produced on shoots in their second year, one year old shoots that flowered were extremely vigorous. There was plant to plant variation in the proportion of shoots flowering in their first year, which creates the opportunity to select for plants with this trait. As with *B. coccinea*, shoots that did not produce a bloom after two years growth were weaker than other shoots and have a low probability of ever flowering.

Table 2. Shoot growth of *B. menziesii* (Adapted from Fuss *et al.* 1991).

Shoot category	Proportion of shoots per tree	Total length (cm) in year 1	Total length (cm) in year 2	Basal diameter (mm) in year 1	Basal diameter (mm) in year 2
Bloom in year 1	9%	40.0	-	8.8	-
Aborted bloom in year 1	9%	17.8	-	4.7	-
Bloom in year 2	45%	26.8	47.7	6.0	12.6
Aborted bloom in year 2	18%	19.0	34.8	4.5	7.9
No bloom after 2 years	19%	13.5	28.2	4.0	6.4

It is proposed that the proportion of shoots on *B. menziesii* plants which are unlikely to produce a saleable bloom within two years could be reduced by removing shoots which did not attain a minimal basal diameter of 6.0mm in their first year. The same principle of heading back as described for *B. coccinea* applies to *B. menziesii*.

TIME OF FLORAL INITIATION

Floral initiation marks the transition of a shoot from the vegetative phase of leaf production to the floral or reproductive state. For both *B. coccinea* and *B. menziesii* floral initiation was recorded in spring, but the subsequent rate of development of the inflorescence differed between the two species (Table 3) (Fuss and Sedgley 1990). Development was more rapid in *B. menziesii*, taking only 8 months to reach peak anthesis, while in *B. coccinea* development took 12 months.

Table 3. Peak month of floral initiation, bud appearance and anthesis in *B. coccinea* and *B. menziesii*. The range of months over which these stages occur, and the season, are given in parenthesis. The bloom would normally be harvested at anthesis.

Floral initiation	Bud Appearance	Anthesis
B. menziesii		
October (October-November) (spring)	February (November-July) (late spring-winter)	May (February-September) (late summer-early spring)
B. coccinea		
November (November) (late spring)	May (May-September) (late autumn-early spring)	October (July-November) (winter-spring)

This has important application in the scheduling of pruning. In *B. menziesii* there are several months between peak bloom production, and floral initiation of the following year's crop in which to prune. However in *B. coccinea* inflorescences for the following year are initiated while the bushes are flowering. For this reason it is inportant that pruning of *B. coccinea* is conducted in conjunction with the harvesting of blooms. Even so, some late blooms may need to be sacrificed to ensure good production the following year. Delaying pruning until after the completion of flowering may result in the removal of potential flowering shoots or in lateral buds being insufficiently developed to produce an inflorescence in the following season.

(2) BREEDING SYSTEM

Plant breeding is essential for the development of new and improved cultivars which are crucial to the long term success of any horticultural crop. However the extremely low level of seed set in *Banskia*, and indeed in many of the other proteaceous genera, is likely to limit the productivity of breeding programmes. For this reason the breeding system of *B. coccinea* and *B. menziesii* was investigated using the controlled hand pollination method developed by Fuss and Sedgley (1991a).

Initially the time of stigma receptivity was measured by the number of pollen grains which germinated on the stigma in a 24 hour period. Banksias are known to be protandrous, and in *B. coccinea* and *B. menziesii* stigma receptivity was found increase from the time of flower opening to a peak at 3 days post-anthesis (Fuss and Sedgley 1991a,b). In *B. menziesii* this correlated with the maximum width of the stigmatic groove as observed by scanning electron microscopy, while in *B. coccinea* peak production of stigma exudate was recorded 6 days after anthesis. Thus to optimise the chance of seed set all hand pollinations should be conducted at peak receptivity.

Self incompatibility was investigated in both species by recording the level of seed set following hand pollinations with self and cross pollen. Fewer follicles developed per infructescence following self pollination of both species (Table 4) (Fuss and Sedgley 1991a,b). Follicles developed on all inflorescences of *B. coccinea*, but in *B. menziesii* follicles developed on 80% of the inflorescences receiving cross pollen and on only 33% of those self pollinated.

Table 4. Mean infructescence set and number of follicles set per fertile infructescence following hand self pollination (SP) and cross pollination (CP) of *B. coccinea* and *B. menziesii* inflorescences (± standard errror).

	% infructescence set		Number of follicles following:	
	SP	CP	SP	CP
B. coccinea	100	100	27.9 ±2.8	40.7 ±4.0
B. menziesii	33	80	1.3 ±1.3	6.0 ±2.8

In *B. coccinea* a 5 x 5 diallel experiment was conducted to investigate self incompatibility and the results measured by studying pollen tube growth (Fuss and Sedgley 1991b). In general self pollinations resulted in poorer pollen tube growth than crosses. However under both pollinating regimes pollen tube growth was often arrested in the upper half of the style, suggesting that a partial self incompatibility mechanism may be operating. Significant specific and general combining abilty as well as significant reciprocal effects were observed showing that some combinations of plants are likely to be more rewarding in a breeding programme with regard to seed set.

CONCLUSIONS

Strategies for the pruning of *B. coccinea* and *B. menziesii* have been developed but further work is required to determine the optimal number nodes of to be left when heading back shoots, to create a balance of vegetative and potentially reproductive growth to maximise the production of quality blooms. In addition the methods described relate specifically *B. coccinea* and *B. menziesii* under the cultural and environmental conditions of Blewitt Springs and need to be tested under different conditions.

The research on floral initiation has shown that it occurs under the conditions of increasing daylength and increasing temperature for *B. coccinea* and *B. menziesii*. This provides a basis for further research into understanding the control of flowering in these species. In the future this may result in growers being able to manipulate the time of flowering to target specific marketing periods, as practiced on traditional flower crops such as chrysanthemum.

Research into the breeding system of banksias will have application for improvement of the crop via plant breeding.

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BIOGRAPHICAL PROFILE

DR. A.M. FUSS

At the end of 1990 I submitted my thesis titled "The floral biology of banksias in relation to crop production and management" to complete post-graduate studies at the University of Adelaide, South Australia. I have since taken up a position as a research officer in the Horticulture Division of the Western Australian Department of Agriculture. My responsibilities include the development of a breeding and selection programme on Australian native plants primarily for cut flower production, but also for potted plants and amenity planting.

PRODUCTION OF *PHYTOPHTHORA* TOLERANT ROOTSTOCKS:
I. SCREENING PROTEAS FOR RESISTANCE TO *PHYTOPHTHORA CINNAMOMI*

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INTRODUCTION

The proteas in commercial cultivation in Australia originate predominately from the winter rainfall area of the Cape region in South Africa. In Australia, proteas are grown in both winter (New South Wales, South Australia, Victoria, Tasmania, Western Australia) and summer (Queensland) rainfall areas. Irrigation is usually applied during dry summer periods, a practice which favours the growth and spread of the root and collar-rot fungus, *Phytophthora cinnamomi*, which is widespread in Australian soils (Grose, 1986). Although there are no figures published on the extent of plant losses attributable to this disease, *P. cinnamomi* is seen as the major limitation to the successful expansion of protea production in Australia (Forsberg, 1989). Chemical control of this disease has not proven satisfactory, particularly under warm wet conditions conducive to active growth of the pathogen (Marks and Smith, 1988). For the industry to survive in the long term, plants resistant to, or tolerant of the disease, are required.

Screening of many of the commercially important proteas, for resistance to *P. cinnamomi*, has been carried out in South Africa (von Broembsen and Brits, 1985). From this work, species of the *Protea* genus were considered to be relatively tolerant of the disease, while those of the *Leucospermum* and *Leucadendron* genera were considered to be highly susceptible to infection by *Phytophthora*. However, some of the *Protea* spp., classified as resistant in von Broembsen and Brits (1985) inoculation studies, are known to be susceptible in the field in Australia (Greenhalgh, 1981; Forsberg *pers comm*). This may be due to higher levels of inoculum or different types (A1, South Africa; A2, Australia, Forseberg, 1988) of the pathogen in Australian soils, or to the effect of other environmental stress factors.

Little notice has been taken of the potential for resistance in proteas from the summer rainfall areas of South Africa, as these have no place in current commercial floriculture. However, they exist in warm , wet conditions conducive to the growth of *P. cinnamomi* and might be expected to have some tolerance of the pathogen in order to survive. Only one summer rainfall species, *Protea caffra*, was included in von Broembsen and Brits' study and this was found to be resistant to *Phytophthora*. Such material could be used as rootstocks to confer resistance to the *Phytophthora* susceptible proteas in commercial cultivation. This technique is already being used in Australia with *Banksia* and *Grevillea* (Cho, 1981; Dixon *et al.*,1984; McCredie *et al.*, 1985 a,b,c; Hodges *pers comm*), indigenous genera of the same family as proteas, the Proteaceae.

The objectives of the following study were to:

(1) produce rootstocks tolerant of, or resistant to *P. cinnamomi*, for use with susceptible protea species of commercial significance to Australia

(2) to confer tolerance/resistance which is persistent under field conditions without adversely affecting the production characteristics of the susceptible species.

Collection of seed for screening began in 1987. Material was obtained from private and Government agencies, mainly from South Africa. During 1988 and 1989 in excess of 60 species/cultivars from the three main genera, *Leucadendron*, *Leucospermum* and *Protea* were obtained and propagated. Six to 9 month old plants were then exposed to *P. cinnamomi* and the level of root infection and mortality rate recorded for each species.

MATERIALS AND METHODS

Preparation of *Phytophthora cinnamomi* inoculum

Stock cultures were prepared from an isolate (A2 mating type) obtained from an infected plant of *Protea cynaroides* (L.) L. Preparation of the inoculum followed the method described by von Broembsen and Brits (1985). This resulted in approximately 8 colony forming units (cfu) ml^{-1}.

Preparation of plant material

Seed was disinfected by heat-treating at 50°C for 30 mins. and dusting with Thiram (Benic 1986), before germinating in paper-lined trays at alternating temperatures of 20°C/10°C for 12h/12h (Brits *pers. comm.*). Germinated seedlings were planted singly into 15 cm diameter pots containing a steamed, modified University of California (UC) potting mix. Plants were grown in a glasshouse for 6 to 9 months, dependent upon growth rate, before exposure to *P. cinnamomi*.

Five plants of each species to be tested were placed in a controlled environment cabinet operating at day/night temperatures of 26/19°C and a 12h photoperiod. Fifty ml of *P. cinnamomi* inoculum was added to the UC mix in each pot, giving a dose rate of approximately 400 propagules $plant^{-1}$. Plants were watered using an automated drip system which maintained the mix in each pot continuously moist.

Two months after inoculation with *P. cinnamomi*, two 1 cm diameter cores, one adjacent to the plant stem and one at the pot perimeter, were removed from each pot. Potting mix cores were washed in deionised water through a 1 mm sieve and the root fragments extracted. Root samples, 5-10 mm long were surface sterilised in 70% ethanol, rinsed in sterile deionised water, blotted dry between sterilised tissue paper and a random selection of 10 segments embedded in $P_{10}VPH$ + Tachigaren agar (Tsao and Guy 1977). The plates were then incubated at 25°C for 72 h and the number of root pieces exhibiting infection by *P. cinnamomi* recorded.

Following the removal of core samples, all pots were transferred to an area outside where they were protected from rain, but maintained under well watered conditions using an automated drip system. Dates of plant deaths were recorded for each species and the minimum time to death of three of the five plants (LT_{60}) determined. At death, plants were resampled to confirm the presence of *P. cinnamomi* in the roots. Reinoculation of surviving plants was carried out at 6 monthly intervals. Testing was discontinued 20 months after the first inoculation with *P. cinnamomi*.

RESULTS

Disease response classification

No source of resistance to *P. cinnamomi* was found, in that root infection occurred in all 62 species/cultivars of protea tested. Based on the LT_{60} data, each was assigned a disease response class (Table 1). A species/cultivar was considered 'highly susceptible' to *P. cinnamomi* if 3 of 5 plants died within 90 d of exposure to the pathogen. For LT_{60}'s between 90 and 180 d, the classification assigned was 'susceptible', while those between 180 and 365 d were rated as 'moderately tolerant'. Species/cultivars were considered to be 'tolerant' of infection by *P. cinnamomi* if 3 of 5 infected plants survived for more than 365 d. Plants in this latter class had been

PROTEA SPECIES/CULTIVAR		RESPONSE CLASS			
		Days from inoculation with *Phytophthora cinnamomi* to death of 3 of 5 plants tested			
		0-90 days	-180 days	-365 days	>365 days
		HIGHLY SUSCEPTIBLE	SUSCEPTIBLE	MODERATELY TOLERANT	TOLERANT
Protea	*aristata*'				•[1]
	aurea			▒	▒
	burchellii	▒			
	compacta (pink)	▒	▒	▒	
	compacta (white)			▒	▒
	coronata			▒	▒
	cynaroides				•
	eximia			▒	▒
	'Ivy'				•
	lacticolor			▒	▒
	laetans			▒	▒
	lanceolata			▒	▒
	laurifolia	▒	▒	▒	▒
	magnifica			▒	▒
	neriifolia (Ruitersbos)				•
	neriifolia (local selection)				•
	'Pink Ice' (cuttings)				•
	pudens				•
	repens			▒	▒
	roupelliae				•
	scabra				•
	stokeoi	▒			
	subvestita	▒			
	susannae				•
Leucadendron	*arcuatum*			▒	▒
	chamelaea				▒
	conicum	▒	▒	▒	▒
	discolor		▒		
	eucalyptifolium				•
	flexuosum		▒	▒	
	floridum			▒	▒
	gandogeri			▒	▒
	laureolum	▒	▒	▒	
	nobile		▒	▒	
	orientale	▒	▒		
	procerum	▒			
	salicifolium			▒	▒
	salicifolium (local selection)	▒	▒	▒	▒
	spissifolium	▒	▒		
	spissifolium ssp. *natalense*	▒	▒	▒	
	spissifolium ssp. *phillipsii*		▒	▒	
	'Sylvan Red' (cuttings)	▒			
	uligonosum	▒	▒	▒	
	xanthoconus				•
Leucospermum	*bolusii*	▒	▒		
	conocarpodendron ssp. *concocarpodendron*	▒			
	conocarpodendron ssp. *viridum*	▒			
	cordifolium	▒			
	cuneiforme	▒	▒		
	erubescens	▒	▒		
	formosum	▒			
	glabrum	▒			
	glabrum x lineare	▒			
	oleifolium	▒	▒		
	muirii	▒			
	patersonii	▒			
	reflexum		▒		
	saxorum	▒	▒		
	'Scarlet ribbon'	▒			
	tottum		▒		
	vestitum	▒	▒		
Serruria	*florida*	▒			

[1] 6-9 month old plants grown from seed unless otherwise stated.
[1a] No plants deaths occurred in these species during the 20 month test period.

subjected to 3 pot inoculations with the pathogen by the cessation of testing.

Generic differences

The *Protea* genus was more tolerant of infection by *P. cinnamomi* than the *Leucadendron* genus, with susceptibility being greatest in the *Leucospermum* genus and in *Serruria florida* (Table 1). Within some species, considerable variation occurred in response to infection by *P. cinnamomi*. For example, in *P. laurifolia*, where plant death occurred as early as 43 days and as late as >365 days after exposure to the pathogen (Table 1), similarly *L. conicum* (68 days, >365 days).

Protea species Of the 24 *Protea* species tested, *P. burchellii, P. stokeoi* and *P. subvestita* were found to be highly susceptible, the pink flowering form of *P. compacta* moderately tolerant and the remaining 20 species tolerant of infection by *P. cinnamomi*. For 10 of the species in the latter class, no plant deaths were recorded during the trial period (Table 1).

Leucadendron species The majority of the *Leucadendron* species tested were of the moderately tolerant (6 species) or tolerant (9 species) response type (Table 1). Two species, *L. procerum* and *L.* 'Sylvan Red' were classified as highly susceptible and 3 species (*L. discolor, L. orientale, L. spissifolium*) as susceptible. Absence of plant mortality during the trial period was recorded in only 2 species, *L. eucalyptifolium, and L. xanthoconus*.

Leucospermum species and Serruria florida No tolerance of infection by *P. cinnamomi* was detected in the 17 *Leucospermum* species/cultivars tested, 8 being classified as susceptible, and the remaining 9 species and *Serruria florida*, as highly susceptible (Table 1).

DISCUSSION

Rootstock classification

Species for which no plant deaths were recorded during the screening period were given the status of primary rootstock material. These included *P. aristata, P.* 'Ivy', *P. neriifolia, P.* 'Pink Ice', *P. pudens, P. roupelliae* and *P. sussanae* in the *Protea* genus and *L. eucalyptifolium* and *L. xanthoconus*, in the *Leucadendron* genus. Use of *P. aristata* and *P. pudens*, also in this group, were considered to be limited due to their relatively small seedling stem diameter, which could not support thick stemmed scion species. Similarly, species with unsuitable growth habit, such as a lignotuber (*P. cynaroides*), or lack of graftable stems (*P. scabra*), were considered unsuitable.

The remainder of the species in the *Phytophthora* tolerant class, *P. aurea, P. coronata, P. eximia, P. lacticolor* and *P. lanceolata, L. floridum, L. gandogeri* and *L. salicifolium*, were considered to be secondary sources of rootstock material. *P. magnifica* and *P. compacta*, also in this group, were rejected on the basis of poor plant growth following infection with *Phytophthora*.

Of the *Leucospermum* species tested, *L. reflexum, L. tottum* and *L. vestitum* were considered to have some potential as rootstocks. In addition, if the problem of continuous shoot production from the lignotuber could be overcome in *L. saxosum*, this species, with its particular adaptation to summer rainfall climates, was thought to be of use.

Current and future research

Grafting compatibility studies These studies commenced during 1989 and are being undertaken at the Nanju Protea Nursery, Ravensbourne, in conjunction with the owner, Judy Moffatt. At the time of writing this paper, compatibility of 28 species/cultivars of the *Protea* genus have been tested, involving 132 rootstock-scion combinations in both intra and inter-generic grafts. Thirty combinations have been tested for the *Leucadendron* genus, 50 for the *Leucospermum* genus and 11 with *Serruria florida*, including some inter-gen ric combinations for each genus. Further testing will be undertaken as suitable material becomes available.

<u>Field testing of grafted material</u> Field testing commenced in July 1990. Four plants of each rootstock-scion combination are being planted on a commercial protea grower's property near Brisbane. The soil on this property is known to be infected with *P. cinnamomi* and should thus provide a good testing site for the grafted material. The grafted plants will be monitored for 3 years to ensure that the graft unions do not break down over time and that acceptable levels of flower production are sustained. The source of failure of grafted plants to survive in the field will be recorded (e.g. whether due to scion or rootstock death) and all such plants sampled to determine if *Phytophthora* is present. The plants will be maintained (irrigated, pruned, sprayed for pests and diseases etc.) according to the management practices carried out on the property. In the third year flower numbers will be recorded for each scion-rootstock combination. Where a single species has been grafted onto more than one species of rootstock, this will enable comparison to be made of the rootstock contribution to flower production.

Results from the field trial should be available in 1993 and provide the basis for the commercial production of grafted protea plants with *Phytophthora* tolerant rootstocks.

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Physiology of flowering, particularly the influence of photoperiod and temperature on floral initiation and flowerbud development. Prior to 1987 worked on agricultural crops (soybean, pigeonpea); since 1987, floricultural crops (protea, grevillea, gypsophilla). Current projects on proteas include an investigation of factors influencing time of flowering in selected species of the *Protea* genus; production of *Phytophthora* tolerant rootstocks; biological and chemical control of *Phytophthora cinnamomi*; nutrient requirements of *Serruria florida* in hydroponic cultivation.

RESEARCH AND DEVELOPMENT

it is clear that fungicidal applications as a mop-up operation need to be carried out following planting.

Field control. Disease hazard is low when disease-free plants are planted at sites free of pathogens. The main effort then becomes one of quarantine rather than containment. Strict guidelines need then to be observed to prevent introduction into the site of infected plants or propagules of the pathogen subsequent to planting. This is certainly a difficult situation, especially in W.A. because of the widespread presence of *Phytophthora* spp. in the state. In instances where plantings have to be carried out at sites with resident inoculum of a pathogen, disinfection may be the only option. Pre-plant fumigation may be considered if it is cost-effective.

Solarization has been found to be effective in controlling *P. cinnamomi* in South Africa (Barbercheck & Von Broembsen, 1986). Solarization of field soil in W.A. failed to eliminate *P. cryptogea* (Kaewruang *et al*.1989a) while solarization of infested soil in plastic bags was however effective in exterminating this pathogen (Kaewruang *et al*., 1989b).

Extensive and regular treatment of soil with fungicides such as metalaxyl to control *Phytophthora* root-rots is expensive, potentially phytotoxic to Proteas and/or may create resistance of the pathogen to the chemical. Fosetyl-Al (or phosphonate) has recently received considerable attention as a potentially useful chemical in controlling root-rots caused by oomycetes (Cohen & Coffey, 1986). This fungicide is known to mediate its activity through the host and not through its activity on the microflora of the soil or rhizosphere (Wongwathanarat & Sivasithamparam, 1991). Fosetyl-Al provides little or no control of root-rot of tomato caused by *P. parasitica* when applied to the plants after inoculation with a suspension of zoospores (Davis, 1989). Efficacy of this fungicide decreased as the interval between final application and inoculation with *P. parasitica* increased. Davis (1989) showed that the concentration of the fungicide in the plant needed to be maintained over long period of time with multiple applications to control the disease. Hopefully future work will indicate the suitability of this fungicide for large scale field use.

Resistance of host. Although sources of resistance to root-rots exist in Proteaceae (Dixon *et al*.1984; McCredie *et al*.1985a; Cho 1985; Von Broembsen & Brits 1985) there is poor exploitation of these sources. We found that among Banksias the most floristically desirable species, especially those originating from the coastal sandy regions of W.A., are highly susceptible to *P. cinnamomi* (McCredie *et al*. 1985a). There is, however, the potential to use root-rot resistant eastern Australian species such as *B. integrifolia* as root-stock material for the grafting of disease susceptible W.A. taxa (McCredie *et al*. 1985b).

Biological control. Bio-control of root-rots in general is an area of research which is currently enjoying a great and enthusiastic revival (Cook & Baker 1983). It is quite likely that in future there will be considerable pressure especially in horticultural industries to resort to biological control as an alternative to chemical control of diseases. *Phytophthora* spp. are known to be sensitive to microbial antagonism (Malajczuk 1979), which is possibly the main basis of disease suppression observed with the application of organic mulch in avocado orchards (Cook & Baker 1983).

Application of single organisms for control of root diseases have been attempted with only rare successes (Cook & Baker 1983). Currently attempts are being made (Turnbull *et al*. 1991) to use *Pseudomonas cepacia* to control *P. cinnamomi*. *Enterobacter aerogenes* was found to be as effective as metalaxyl or Fosetyl-Al in the control of crown and root-rots of apple caused by *P. cactorum* (Utkhede and Smith 1991).

Integrated disease management (IDM) undoubtedly holds the greatest promise in the control of soil-borne plant pathogens. In a recent study (Dixon *et al.* 1990) we showed that a combination of organic mulch, a mildly effective fungicide (Previcur®) and a herbicide (Chlorthal dimethyl) caused a significant reduction of *Phytophthora* root rot of banksias in pots. Similar strategies need to be tested in the field to determine the feasibility of IDM for disease problems with proteas.

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ADAPTATIONS OF S.W. AUSTRALIAN MEMBERS OF THE PROTEACEAE; ALLOCATION OF RESOURCES DURING EARLY GROWTH

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Introduction

There are 16 genera and about 550 species of Proteaceae in Western Australia, many of these endemic to the State. The greatest concentration of species is in the south-west where they grow in habitats ranging from forest to low heath and often comprise dominant members of their respective plant communities, *e.g.* the *Banksia* woodlands of the Swan Coastal Plain (Speck, 1958; Dodd and Griffin, 1989). Their richest development, however, tends to be in the heathlands (kwongan) of the South West Botanical Province which are generally characterised by poor soils of low nutrient availability and a dry, harsh climate in which fires are frequent (Speck, 1958).

Heathlands are most extensively developed on 'sand-plains' soils (George *et al*, 1979) which are geographically unique in presenting extremely large, flat and relatively uniform expanses of deeply weathered and leached soil materials of exceptionally low fertility (Mulchahy, 1973). For example soil sampled from the deep grey leached sands near Badgingarra (30° 20' S, 115° 30' E) showed macronutrient levels (μg per gram of soil dry matter, top 400 mm of soil) for phosphorus of 5.2, nitrogen, 107.8, calcium, 69.5, potassium, 12.5, and magnesium, 20.8 (Pate and Dell, 1984). These areas also experience relatively low levels of winter rainfall (200-600 mm per annum) and hot, dry summers (George *et al.*, 1979; Beard, 1983). Moreover, the deep, leached sands which support this vegetation have an extremely low water holding capacity. For example, measurements by Dodd (1985) on soils in *Banksia* woodlands (similar to those of heathlands) found that volumetric water content remained below 0.1 $cm^3 . cm^{-3}$ throughout the unsaturated profile of soil above the water table, while gravimetric soil moisture content at 100-200 mm depth varied from less than one percent in late summer to a maximum of around five percent in winter. As a consequence, virtually no water is available from the top few metres of soil during the summer months. However, the presence of groundwater, usually at several metres depth, provides a potentially unlimited water supply for deep rooted, phreatophytic species (Dodd, 1985; Dodd and Heddle, 1989). Finally, the dryness of this region, and the pattern and seasonality of wind, rain and thunderstorms, together with the accumulation of flammable vegetation, make plant communities in this region highly prone to widescale intensive fires.

With environmental constraints of the type mentioned above, south-west Australian members of the family Proteaceae must display features enabling them to tolerate three major classes of stress, namely:

1) low levels of nutrients,
2) low rainfall and summer drought and
3) disturbance by fire.

There have been a number of studies on the mechanisms by which plant species survive such stresses and indeed plants from the family Proteaceae have featured prominantly in such studies. However, most investigators have dealt with adaptations relating to mature plants, despite the strong possibility that the seedling stage and subsequent juvenile growth are likely to be phases of the life cycle critically susceptible to stress. One reason for this is that the small size and immature morphological state of an individual may equip it less effectively to cope with stress than in the case of older plants. A second reason is that during early phases of plant development unusually high deployment of resources may be directed towards mechanisms relating to survival and, accordingly at the expense of other plant functions such as growth.

The aim of the following paper then is to briefly describe the mechanisms which enable mature individuals of species of the family Proteaceae to cope with the three environmental stresses mentioned above. The paper then reports in more detail on two studies (Stock *et al.*, 1990; Bowen, 1991) which deal with the early establishment phase of proteaceous species, particularly in terms of their patterns of resource allocation and the relevance of these to the eventual response of older plants to stress.

1) Coping with Low Levels of Nutrients

According to Lamont (1981), the capacity for an established plant to survive in conditions of low soil nutrients depends on (a) an ability to utilise relatively inaccessible sources of nutrients, (b) efficient internal cycling, and/or (c) minimal loss of nutrients to the environment. One feature, relating to heading (a) above and typical of many members of the family Proteaceae, is the development of proteoid (cluster) roots which enable a species, apparently without microbial assistance, to enhance its uptake of key limiting nutrients such as phosphorus and nitrogen (Bowen, 1981; Lamont, 1983, 1986). This feature was first described for the family Proteaceae in Australia by Purnell (1960) and has since been shown to apply to all Australasian genera of this family with the exception of *Persoonia* (Lamont, 1984). Proteoid roots are clusters of rootlets occurring in dense longitudinal rows which collectively present at least a five times greater surface area per unit volume of soil than does a 'normal' root. They therefore provide a greater area for absorption and may also facilitate and prolong nutrient release from entrapped soil particles. Being concentrated in the uppermost 0.1 m of soil, they also exploit regions of actively decomposing litter where nutrients are likely to be particularly concentrated (Lamont, 1984). Their formation is strongly reliant on the presence of adequate soil moisture and is initiated soon after the onset of the Mediterranean winter. Their growth continues until late spring but they normally fail to survive the summer. Significantly, their formation is most pronounced under low nutrient conditions and inhibited by oversupply of nutrients (Lamont, 1983).

Features specifically relating to headings (b) and (c) above are, firstly, that most proteaceous species retain their leaves as functional units for more than one year and, in certain large-leaved *Banksias* spp., for up to five years (J.S. Pate, unpublished). This may reduce to a minimum the considerable nutrient losses which one would normally associate with the more frequent shedding of leaves as typically occurs in many other south-west Australian species (Pate *et al.*, 1984). Secondly, despite the nutrient deficient conditions in which most proteaceous species grow, many members of this family have the ability to produce large seeds stocked with a remarkably concentrated and well-balanced set of energy reserves and essential nutrients (Kuo *et al.*, 1982; Pate *et al.*, 1986; Stock *et al.*, 1989). For example, the seeds of 70 species from 30 genera of Proteaceae surveyed by Pate *et al.* (1986) all showed high concentrations of oil but no starch in their seed dry matter. Lipid reserves together with protein constituted approximately 60 to 80 percent of embryo dry weight. Unusually high concentrations of phosphorus and magnesium were also present in the seeds, and, in certain cases also of calcium and potassium (Fig. 1). Electron probe microanalysis showed that the bulk of this mineral nutrient reserve was located in insoluble form and principally as phytate in various taxonomically-specific types of crystalline or globoid inclusions within the protein bodies of the seed. Concentrated in this manner nutrient levels in seed dry matter were 50 to 100 times greater then that in other areas of the plant such as woody fruits, leaves and stems. Furthermore, when compared with 76 non-proteaceous Australian species, levels of mineral elements in seed dry matter of Proteaceae were found to be several times higher than that generally recorded for seeds of other species from similar habitats (Fig. 1). Another more subtle feature, apparently displayed only by Proteaceae, was the presence of extremely high levels of arginine in the soluble reserves and storage proteins of the seeds. Presence of this basic, high N-containing amino acid was shown to enhance greatly the N available per unit weight of protein, in comparison, say, with storage protein of more normal composition (Pate *et al.*, 1986; Stock *et al.*, 1991). Also of significance, was the fact that small-seeded proteaceous species tended to have their seed dry matter significantly more enriched with minerals than did large-seeded species. Pate *et al.* (1986) proposed that the presence of high concentrations of mineral nutrients in seeds of proteaceous species may be a general response to environmental stress, especially the oligotrophic nature of the soils in which Proteaceae typically occur. They further suggested that large energy reserves, predominantly as oil, might be especially important to large-seeded species with hypogeal or cryptogeal patterns of germination, as are commonly encountered for example in forest habitats. In this case, seedlings are likely to be more adversely affected by shade than by mineral deficiency, and may therefore have to reach a considerable size using their seed energy reserves before being sufficiently well illuminated to photosynthesize adequately (see also Foster, 1986). On the other hand, most small-seeded species of Proteaceae show epigeal germination and are typical of well illuminated, open habitats on nutrient-deficient soils, where mineral reserves of the seed may assume greater importance than energy reserves or oil.

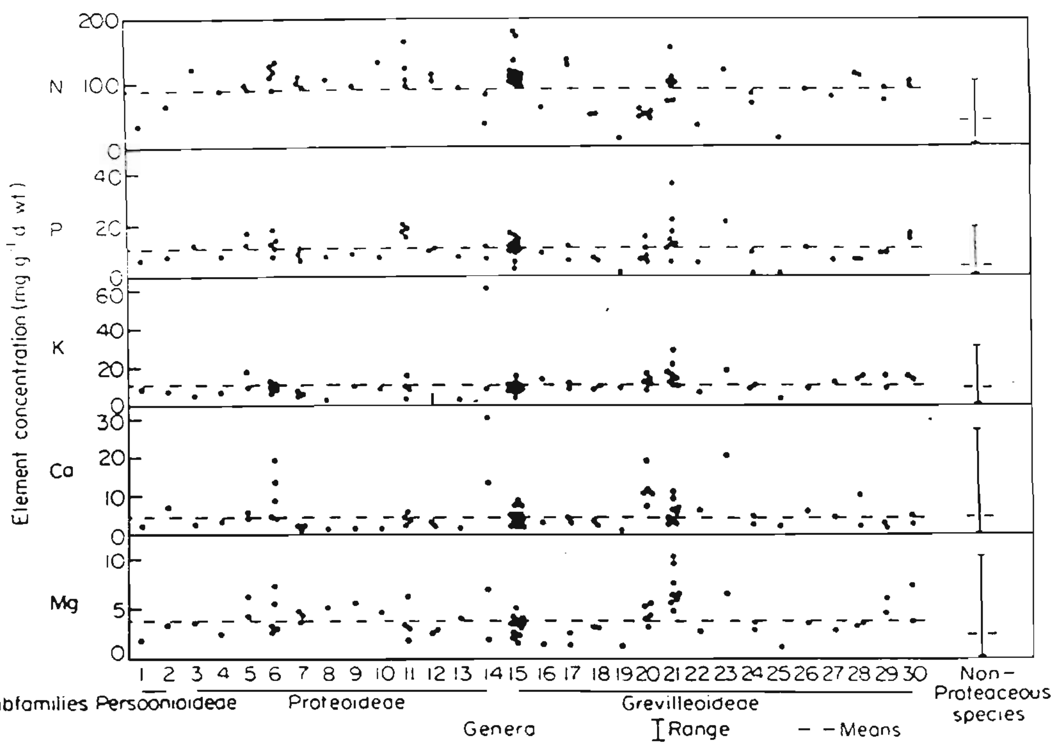

Fig. 1. Element concentrations in embryo dry matter of 70 species of 30 genera of Proteaceaea. The sub-families to which the species belong are indicated and the genera numbered according to Pate *et al* (1986). A dotted line through the data for each relement depicts the mean concentration for the species sampled. For purposes of comparison the mean and range of nutrient concentrations are given for a sample of 76 non-proteaceous species to the right of the figure. Taken from Pate *et al* (1986).

Seeds of high nutritional quality are therefore likely to have resulted from selective influences associated with seedling establishment in grossly nutrient-poor soils. Testing this hypothesis further, Stock *et al.* (1990) investigated the seedling development of five bradysporous members of the Proteaceae (three from South Africa and two from Australia) under nutrient-deficient conditions. The seedlings of all five species showed a pronounced capacity to survive continuous nutrient starvation, to the extent that seedlings of each species, irrespective of initial seed mass, survived for at least 300 days without any visible signs of deficiency. However, the ultimate size of the seedling at the end of this 'starvation' period was still strongly correlated with seed size (Fig. 2A). According to Stock *et al.* (1990) this capacity to survive under extremely adverse conditions may be characteristic of many Proteaceae and result from any of a number of features of the seedling biology of members of this family. For instance, they demonstrated that morphological changes during seedling development such as shoot:root ratio and production of proteoid roots showed consistent patterns among all species investigated. During the early phases of seedling development (days 40 to 120) mobilization of internal reserves first sponsored rapid growth of shoots so that the shoot:root ratio of all species at this time was of the order of 2.0. However, as internal resources became severely depleted, this ratio was progressively reduced to approximately 1.0, particularly as a result of prolific production of proteoid roots from day 100 onwards, presumably in response to protracted nutrient starvation (Fig. 2B).

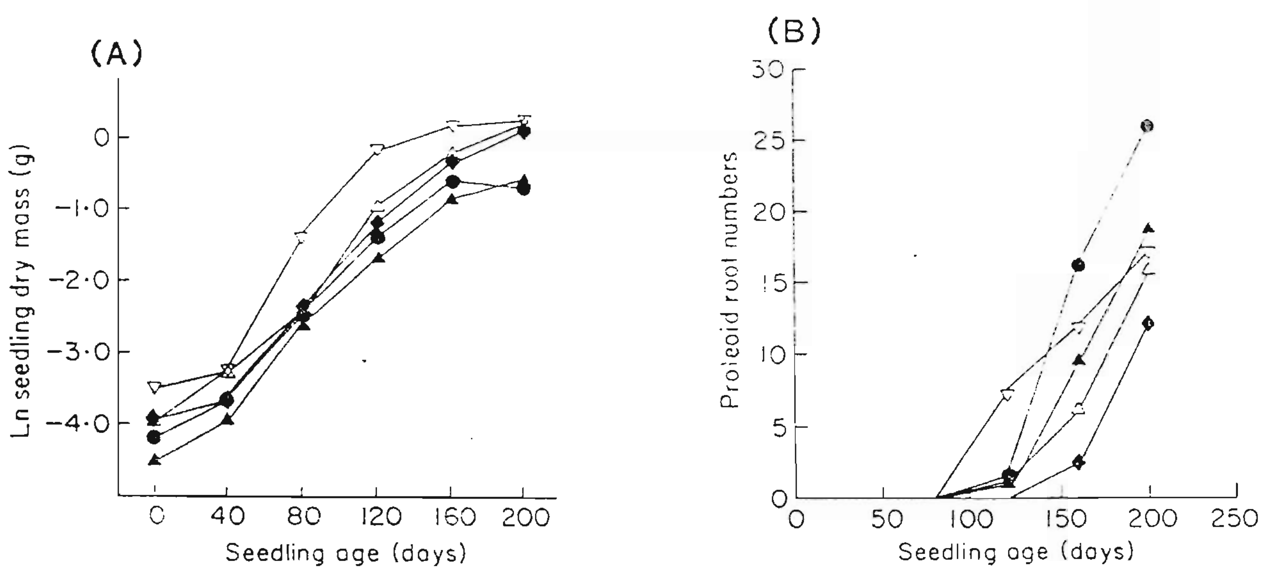

Fig. 2. Time course of (A) log dry mass accumulation and (B) proteoid root number of five species of Proteaceae originating from different sixed seeds when grown under extreme nutrient-deficient conditions: (∇) *Hakea sericea;* (♦) *Banksia laricina;* (▲) *Protea lorifolia;* (•) *Protea cynaroides;* (Δ) *Leucadendron laureolum.* Taken from Stock et al (1990).

Most species from the family Proteaceae rely on fire for germination of new individuals, so that successful recruitment of seedlings between fire tends to be extremely rare. In general, germination takes place during late winter/early spring following a summer or autumn burn. Post-fire conditions provide a favourable environment for young seedlings in terms of reduced competition and increased availability of nutrients in the soil (Stock and Lewis, 1986). However, any nitrogen or phosphorus available after fire is not likely to be readily accessible to the young seedling, firstly because of the loss of nitrogen due to thermal volatisation during the fire and, secondly, because the typical tap root system of the young seedling is likely to allow only limited capacity for lateral uptake of immobile elements, such as phosphorous concentrated in surface regions of the soil profile. As shown in the pot culture study of Stock *et al.* (1990), initiation of proteoid roots does not commence until about 100 days after germination, and in the natural environment this may indeed be delayed until the onset of the second wet winter season, ie. even up to 250 days after germination. It thus appears that development of nutrient acquiring cluster-roots comes strictly secondary to the development of a deeply penetrating root system in time.

In summary then, selective channelling of nutrients into seeds by a parent plant can be viewed as a mechanism for maximising the chances of seedlings surviving in nutrient-poor environments. Clearly, this must be at the expense of utilising these nutrients for other functions within the vegetative parts of the parent plant itself, especially when a specific resource is critically limiting. Specialised modes of enhancing nutrient uptake, such as by proteoid roots are therefore of major importance in the survival of members of the family Proteaceae, for both the established individual and ultimately, for the early growth and survival of its offspring.

2) Coping with Low Levels of Water

In order for established plants to survive conditions of low and ineffective rainfall during the long summer months members of the family Proteaceae exhibit a range of features which enable them to increase their supply of water and reduce water loss through transpiration. This is especially important since most of the Proteaceae in Australia exhibit a late spring/summer pattern of growth. This characteristic probably reflects persistent ancestral growth patterns since it is generally concluded that the Proteaceae originally evolved under conditions of summer rainfall and probably from progenitors inhabiting marginal habitats in tropical regions typical of Australia during the Paleocene/Eocene period (Martin, 1981).

Most present-day Proteaceae exhibit xeromorphic features such as sclerophyllous leaves embracing a variety of sizes and forms, extensive root systems and various physiological specialisations such as mid-day stomatal closure which reduce water loss from foliage. Furthermore, many Proteaceae are deep-rooted and thus able to tap water from ground water sources (Dodd *et al.*, 1984). Plants with the latter capacity generally continue to exhibit relatively low levels of water stress during the dry summer months (Dodd, 1985), enabling them to succeed in much drier regions than were probably typical of the ancestral species (Rundel, 1977; George, 1984).

Nevertheless, a germinating seedling can still be critically vulnerable to dry conditions especially before it develops the capacity to draw from ground water sources. Furthermore, if growing in an exposed habitat, it will not benefit to the same extent from self shading as in larger mature individuals of the species. As mentioned above, most species of Proteaceae growing in south west Australia are stimulated to germinate following fire. The majority of natural fires occur in late summer or autumn, however, germination in most species is delayed until the wet winter or early spring following the fire (Cowling and Lamont, 1986). Germination during the wet winter season, together with the fact that post-fire environments have reduced competition and therefore an increase in moisture status means that seedlings are germinating at an optimal time of water availability (Wellington, 1984). However, the onset of the dry summer months, approximately six months after germination, poses a real threat to young seedlings and this is indeed the period in which the first major phase of mortality of seedlings is most likely to take place (Enright and Lamont, 1989).

Clearly, therefore, priority exists among proteaceous seedlings to locate a reliable long term source of water as quickly as possible following germination. One would therefore predict that a significant quantity of reserves from the cotyledons and photosynthates from young leaves would be directed initially towards extension of a main tap root down to the water table. A recent study by Bowen (1991), has shown this to be the case for six species of Proteaceae investigated in natural habitat conditions. All were shown to have extended their taproot some 2.5 to 3.0 metres and to have reached moist soil layers at or close to the water table within the first year of growth. This proved to be the case for all six species despite the fact that three were obligate seeders and showed resource allocation patterns strongly favouring the production of shoot dry matter. Since many species of Proteaceae are phreatophytic, access to the water table is clearly paramount during early stages of seedling growth, even if this occurs at the expense of other activities such as growth of cluster roots and expansion of photosynthetic shoot systems.

3) Coping with Fire

The long association of fire with a range of vegetation types including Proteaceae has led to the evolution of specific adaptations to this environmental agency, even to the extent that certain species are now markedly dependent on fire for their successful reproduction and seedling establishment (Gill, 1977, 1981; Frost, 1984; Keeley, 1986). As a result, even intense fires in fire-prone environments such as south-west Australia are followed by an extremely rapid and prolific renewal of vegetation (Recher and Christensen, 1981; Christensen *et al.*, 1981). As in other families (Bell *et al.*, 1984.; Pate *et al.*, 1990), the two main strategies utilised by plants from the family Proteaceae when regenerating after fire are that of the obligate seeder and resprouter. Seeder species are invariably killed by even the mildest fire, and must therefore rely exclusively on germination of seeds from stored seed banks to maintain the species within a particular locality. Conversely, resprouter species normally survive fire, although their above-ground parts may be extensively damaged in the process. They subsequently regenerate from buds located in below-ground root stocks or, in adults of larger arboreal species, from epicormic buds on trunks and main branches.

It is logical that the resprouter and seeder modes of recovery should involve highly contrasting patterns of resource allocation in respect of energy and nutrients for maintenance, growth and reproduction. In obligate seeders, on the one hand, allotment of resources to growth and reproduction and ultimately to the establishment of a seed-bank before the occurrence of fire is clearly likely to be more important say, than committing limiting resources to long-term storage. On the other hand, for resprouter species, a pattern of allocation of resources to suitably-protected energy reserves and to the development of dormant buds enabling rapid regrowth of shoots after fire would be of greater importance than maintenance of high rates of shoot growth or reproduction in the interval between fires.

Aspects of the seeder and resprouter mode of recovery have been investigated to varying extents by a number of authors and for a number of plant species, especially in relation to patterns of adult growth and resource deployment in reproduction (Gill, 1977, 1981; Recher and Christensen, 1981; Frost, 1984; Keeley, 1986). However, studies comparing resource allocation and growth in juvenile plants displaying these two strategies are rare, despite the fact that the respective characteristics of the strategies are likely to be initiated early in the life of a species and possibly long before reproductive maturity has been achieved. In recognition of this deficiency in knowledge, a study on the growth and deployment of resources in both resprouters and seeders was undertaken in juvenile members of the family Proteaceae (Bowen, 1991). Six closely related, cohabiting species (three seeders and three resprouters listed in Fig. 3) were compared in terms of their patterns of growth, biomass allocation and deployment and storage of nutrients over the period between six months and three years after germination. The information from this study was then related to the eventual response to fire of adult individuals of the species. The basic differences observed between the two modes of regeneration were as summarised in the empirically-based models in Figures 3 and 4, each series of models describing quantitatively allocation of dry matter (Fig. 3) or carbon (Fig.4) to shoot and root growth and deposition of starch in shoots and roots (Fig. 3). The resprouter species showed slower growth rates, a larger proportion of their biomass below ground and substantially greater concentrations of starch in their roots than the seeder species (Fig. 3). Moreover the greater proportion of below ground biomass in the resprouter resulted in a larger proportion of the carbon from its net photosynthesis being directed towards the root system where a surprisingly large proportion was lost in root respiration (Fig. 4).

The development in resprouter species of Proteaceae of below ground biomass in the form of a tap root and/or lignotuber provides a protected organ replete with storage reserves from which new shoots can readily arise, and thus provides a foundation for the ability of such species to survive fire. Attainment of reproductive maturity in a resprouter is clearly of secondary importance to the development of below ground biomass since the very ability to survive fire ensures an extended lifespan and thereby minimises the requirement for replacement by seedling recruitment in comparison, say, with the obligate seeder. In addition, it is of greater importance for resources to be directed to improving the capacity of the individual to survive a fire than to early achievement of reproductive maturity.

Conversely, the models (Figs. 3 & 4) clearly demonstrate that seeder species of Proteaceae generally commit a much smaller proportion of their overall biomass into roots than do resprouters and do not store significant quantities of starch in their roots. Seeders are therefore able to invest proportionally more of their photosynthetic return directly into the production of further photosynthetically active shoots which in turn will contribute energy for further shoot growth and ultimately permit much earlier attainment of reproductive capacity than in a comparable resprouter. It follows then, that obligate seeder species within the family Proteaceae are potentially well equipped for rapid maximisation of seed production, thereby establishing an effective seed bank before the advent of the next fire.

It is interesting to note that no consistent differences were observed in concentrations of nitrogen, phosphorus and macronutrient elements in shoot or root dry matter between the eight juvenile resprouter and seeder species studied (Bowen, 1991). This was also found to be the case in a broader

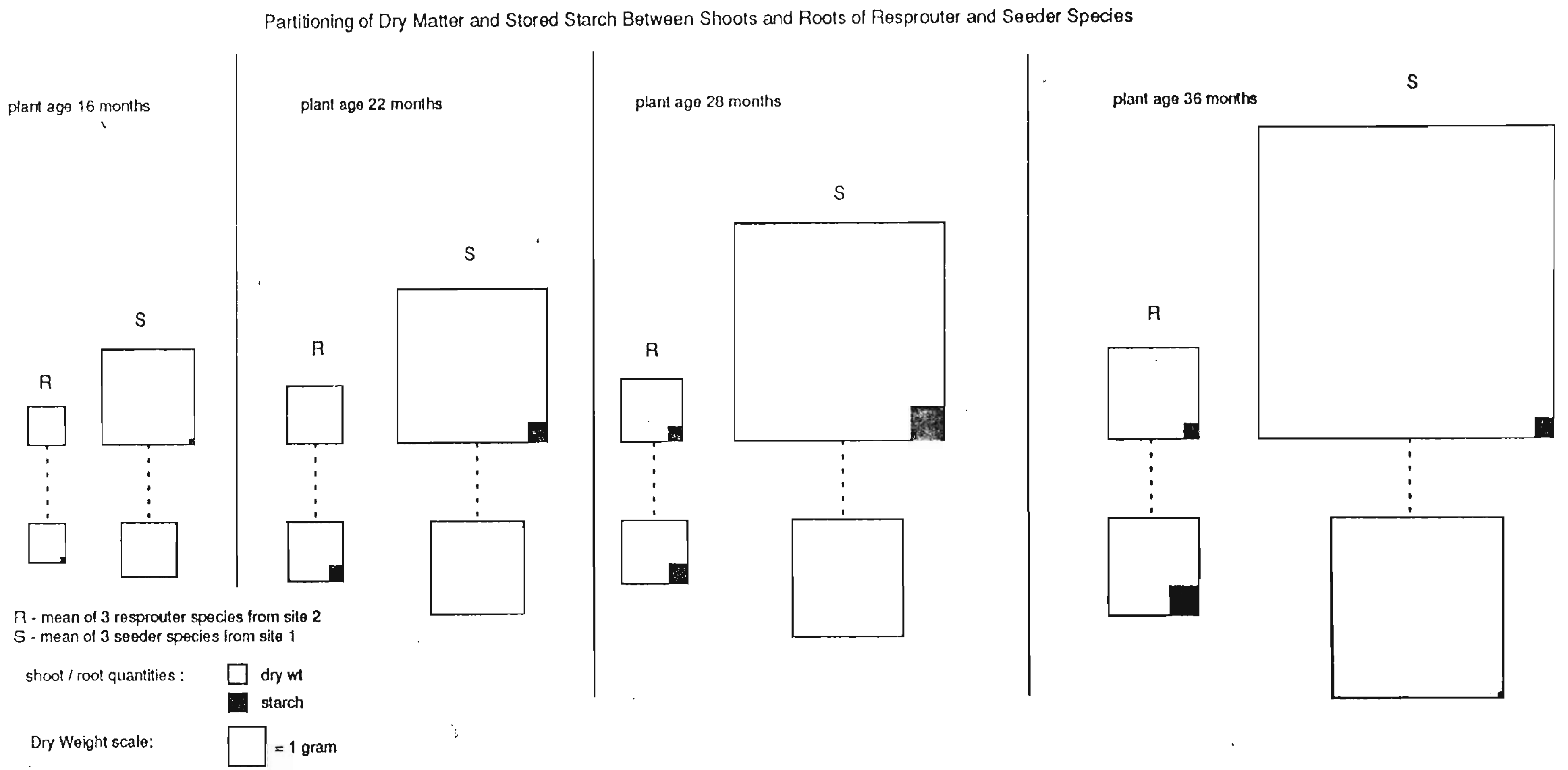

Figure 3. Pictorial representations of partitioning of dry matter and stored starch between shoot and root at four stages of juvenile growth for the combined resprouter (R) and seeder (S) study species (Resprouters = *Banksia attenuata*, *Conospermum triplinervium* and *Stirlingia latifolia*. Seederd = *Banksia prionotes*, *Conospermum incurvum* and *Adenanthos cygnorum*). Plant ages were 16 months, 22 months, 28 months and 36 months. Taken from Bowen (1991).

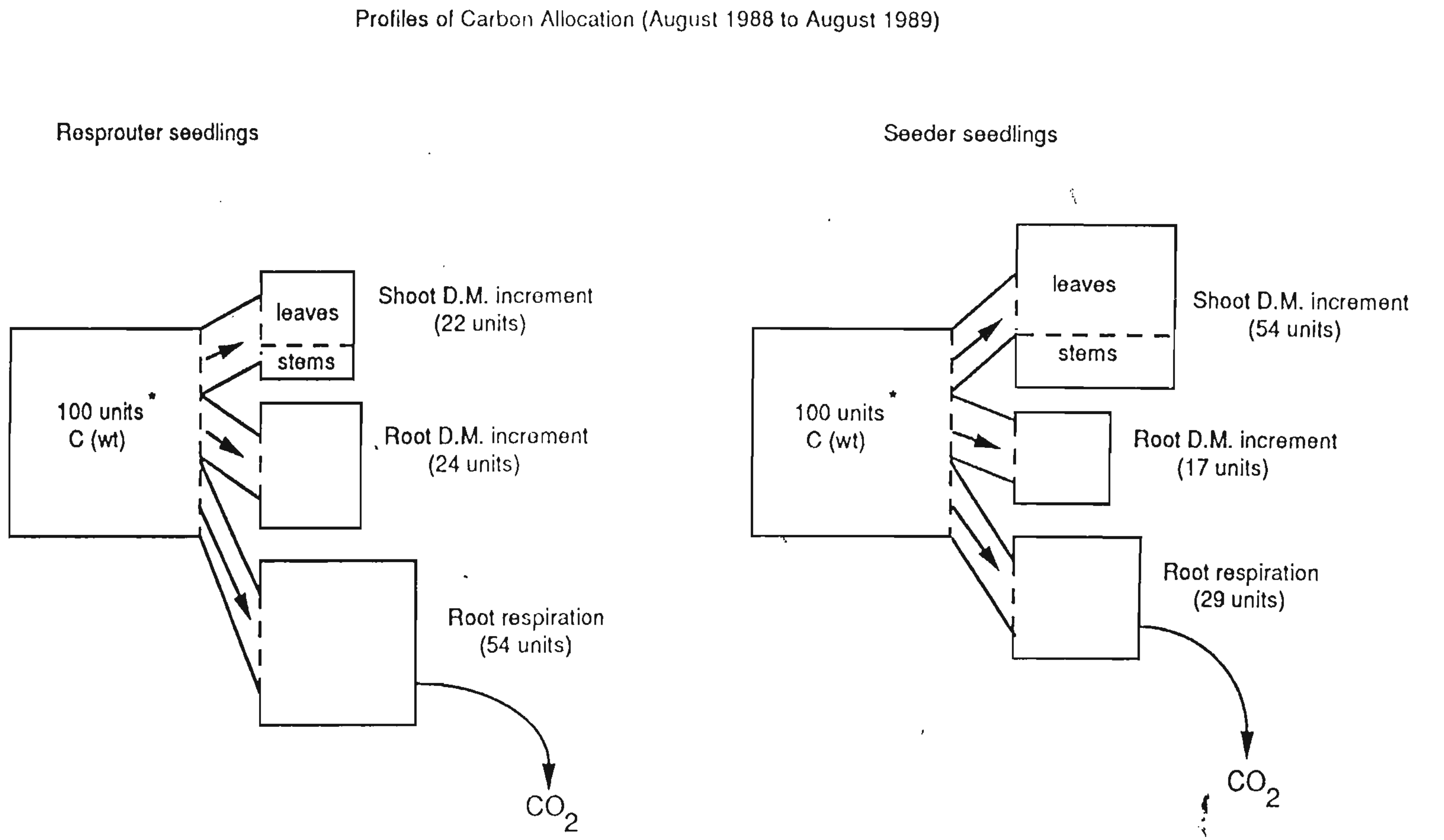

Figure 4. Pictorial representation of the pattern of carbon allocation over a 12 month period for the combined juvenile resprouter and seeder study species listed in Figure 3. Data are expressed in terms of net gain from the atmosphere by the shoot of 100 units by weight carbon. D.M. = dry matter. Taken from Bowen (1991).

study which included plants from a number of plant families in south-west Australia (Pate et al., 1990). Resprouters, in particular, do not preferentially store any of these nutrients even though relatively large amounts of both nitrogen and phosphorus would be immediately required for shoot growth after fire. Such nutrients however, are likely to be readily available after fire in the ashbed and since seeders would have succumbed and would no longer be competing for nutrients, resprouters would be expected to have a virtually unrestricted supply of nutrients, at least in the first few months of the post-fire period. Indeed they might well benefit from nutrients emanating from the decomposing roots of any species killed by fire. In addition, the storage of these nutrients would inevitably take up space within the root of the resprouter, and it is reasonable to suggest that this would be better deployed for storage of starch, thereby providing a ready source of energy and carbon for growth of new foliage. Obviously, storage of such nutrients in juvenile seeder species would be selected against unless such reserves were later shown to enhance the reproductive performance of the species.

From the above results it is clear that the presence of starch in the roots of resprouters but not seeders is likely to be a major feature differentiating the two groups of species. To test this hypothesis, a broader survey was instigated by Bowen (1991) encompassing a wide range of juvenile species from thirteen genera of Australian Proteaceae including 53 resprouter and 50 seeder species. The study aimed to determine the proportion of different classes of root tissue utilised for storage and to determine general patterns of starch distribution within the roots of different genera and species. The distribution and concentration of starch (expressed as a starch score) was determined for each species by examination of cross sections of the main tap root. Storage parenchyma, with or without starch, was present in one of three locations *viz.* between the periderm and the stele ('cortex'), in ray tissue, and in parenchyma associated with the xylem (xylem parenchyma). Not surprisingly, resprouters were found to have considerably larger concentrations of starch in their roots and to have significantly elevated proportions of their root tissue devoted to parenchyma available for starch storage. Nine of the genera studied contained species representing both strategies *viz. Banksia, Dryandra, Grevillea* and *Hakea* in the Grevilleoideae and *Adenanthos, Conospermum, Isopogon, Petrophile* and *Stirlingia* in the Proteoideae. A number of different patterns of starch distribution were evident within and between these genera but in every instance a substantially greater storage area was manifest in roots of resprouters than of seeders (Table 1). On a taxonomic level, broad trends were observed differentiating the genera into their two tribes. Thus, resprouters within Grevilleoideae tended to store their starch in both cortex and ray tissue and their larger storage area mostly resulted from increased area of ray tissue. A notable exception was *Grevillea*, in which resprouters showed an increase in the area of cortex tissue (Table 1). Conversely, within resprouters of the Proteoideae, starch storage and increased area of potential storage tissue was observed in both the cortex and ray tissue or in cortex alone, with the exception of *Isopogon*, which developed a larger area of ray tissue in resprouter than seeder species (Table 1). Yet, again the differences between seeder and resprouter expressed by members of the family Proteaceae were very similar to those expressed generally among other families of plants of south-west Australian habitats (Pate et al., 1990.

Conclusion

Most species of plants have qualitatively similar resource requirements for growth and reproduction, however, they differ quantitatively in the way in which they partition these resources to various plant functions. One particular resource is likely to be generally limiting at any one time so that allocation profiles of it would be expected to be tightly regulated, and to be engineered in such a manner as to maximise survival rate within the species. As a result trade-offs will inevitably occur in which allocation of limiting resources to one trait may be overtly linked to detrimental change in another. Clearly for members of the family Proteaceae found growing in the harsh environmental conditions of south-west Australia, mechanisms of survival are dependant on a number of definite and heritable patterns of allocation of limiting resources, many of which are initiated or influenced early in plant life when mortality is high.

Table 1. Mean values of potential storage area and starch scores for roots of 2 to 4 year old seedlings of seeder (S) and resprouter (R) species from selected genera from the family Proteaceae. Taken from Bowen (1991).

Genera	Mode	#	Cortex Parenchyma % area [1]	Cortex Parenchyma Rating [2]	Score [3]	Ray Parenchyma % area [1]	Ray Parenchyma Rating [2]	Score [3]	Total % Storage area [1] (cortex +ray)	Total Starch score [3] (cortex+ ray+XP)
Adenanthos	S	2	31.4	0.0	0.0	5.7	1.5	1.1	37.1	1.1
	R	3	37.7	3.0	11.9	22.7	3.3	8.0	60.4	20.6
Banksia	S	16	27.8	0.3	1.0	10.9	0.8	0.8	38.6	1.8
	R	10	27.9	1.0	3.0	22.6	3.6	8.6	50.6	12.0
Conospermum	S	4	59.8	0.0	0.0	5.0	0.8	0.4	64.8	0.4
	R	2	75.6	4.0	30.3	4.7	1.0	0.5	80.3	30.7
Dryandra	S	6	26.8	0.0	0.0	7.2	0.7	0.6	33.9	0.6
	R	4	30.9	2.2	7.5	12.7	5.3	5.7	43.7	13.7
Grevillea	S	3	34.7	1.7	5.9	13.4	3.3	5.3	48.1	11.5
	R	8	40.5	3.4	14.1	14.2	5.8	8.3	54.7	22.8
Hakea	S	10	38.4	1.2	5.0	7.7	3.5	3.4	46.1	8.5
	R	7	35.4	2.2	9.3	16.7	5.8	10.0	52.1	20.4
Isopogon	S	3	34.1	0.7	2.7	7.8	4.0	3.0	41.8	5.9
	R	4	34.1	3.0	10.0	26.3	4.8	13.9	60.4	24.9
Petrophile	S	4	32.1	0.2	0.8	3.6	1.5	0.6	35.8	1.4
	R	3	47.1	2.3	13.2	12.0	5.3	7.0	59.1	22.4
Stirlingia	S	1	62.3	0.0	0.0	4.9	0.0	0.0	67.2	0.0
	R	1	80.4	5.0	40.2	5.1	1.0	0.5	85.5	40.7

1. Expressed as percentage of total transactional area of root section occupied by tissue/region in question.
2. Visual rating of starch grain density on a 0-10 scoring system, with ratings from 0 for starch totally absent to 10 for cells fully packed with starch.
3. Derived as % area x visual rating/10. On this basis a score of 100 for the whole section would denote all cells fully devoted to starch storage.

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ADAPTATIONS OF S.W. AUSTRALIAN MEMBERS OF THE PROTEACEAE; ALLOCATION OF RESOURCES DURING EARLY GROWTH

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ASSESSING THE PHOSPHORUS STATUS OF PROTEAS USING PLANT ANALYSIS

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MAJOR FINDINGS

* Controlled release fertilisers used in the production proteaceous plants should have no more than 2% P availab over a 5-6 month period (i.e. 10 g P/m^3/month).

Optimum growth and quality of the test plants were obtain with 2%P. Higher levels of P gave no additional benefit. A cultivars developed P toxicity symptoms at 4% P.

* Controlled release fertilisers without P should not used with soilless media.

Growth of roots of all cutivars and the tops of *Protea* `pi ice' were significantly reduced by the omission of P from t fertiliser program. Strong visual symptoms of P deficien were produced by *Protea* `Pink ice'.

* Tissue analysis standards were developed for assessi the P status of 3 commercial protea species. Until furth work is done, these standards may serve as models for t interpretation of plant test results for other proteaceo plants.

INTRODUCTION

Many plants within the Proteaceae family have a low tolerance phosphorus and will develop severe leaf symptoms and someti die when given fertiliser rates considered normal for ot cultivated plants (Nichols et al 1979, Thomas 1980, Nichols Beardsell 1981). The significance of this problem has increa with the widespread adoption of soilless growing media container production (Nichols et al 1979). Even a small amc cf soil in a mix has been shown to reduce the availability c for plant uptake and so reduce the likelihood of toxic (Nichols et al 1979).

The most common symptoms of P toxicity are a dark, initia water soaked necrosis of older leaves usually commencing f the tips and a yellow chlorosis of newer growth resembling symptom for iron deficiency. These symptoms are qu consistent across genera but may be confused with root inj symptoms produced in response to soil physical problems disease. The presence of leaf symptoms is, therefore, conclusive proof of P toxicity. Also leaf symptoms are of little use as a warning of sub-clinical deficiencies or toxicities as plants produce clear visual symptoms only in the final stages of decline. By this time, growth and quality have been irreversibly affected.

An earlier warning of nutritional problems can be obtained from plant and soil testing. These techniques provide information on the current nutrient status of the plant and soil and are used mainly to confirm disorders diagnosed from symptoms, anticipate when nutrients could limit growth and to fine-tune fertiliser programs. Plant and soil testing has not been widely used by protea growers, presumably, because reliable interpretive standards have not been available.

The primary purpose for undertaking the glasshouse trials described in this paper was to develop a plant test for assessing the P status of Proteas. The studies major objectives were to identify a suitable sample tissue and to formulate tissue standards.

MATERIALS AND METHODS

Rooted cuttings of *Protea nerifolia* `Satin mink', *P. nerifolia* `Pink ice' and *Leucodendron* `Harvest' were transplanted into 2.5 L pots containing a 2.4:4:1 sand: pine bark: peat medium. The pH (1:1.5 water) of the growing medium was adjusted to 6.5 with dolomite.

A combination of Osmocote 18:0:9.3 5-6 months (3 kg/m^3) and Osmocote 0:18:0 5-6 months was dibbled into the pots, giving the following treatments: 18:0:9.3, 18:1:9.3, 18:2:9.3, 18:3:9.3, 18:4:9.3, 18:5:9.3, 18:6:9.3 and 18:8:9.3. The treatments were replicated 5 times, and each trial was fully randomised.

Trace elements were given in the irrigation water which was provided by drippers either daily or twice weekly depending on the weather. Pots were leached by hand at regular intervals to reduce the build-up of nutrient salts in the medium.

Symptoms of phosphorus toxicity were produced by *Protea* `Satin mink' very early in the trial and it became necessary to harvest after just 3 months because several plants were close to death. The other cultivars were grown for 5 months before harvest.

At harvest, plant tops were dried and weighed and the roots were examined and scored for size. Samples of recently matured leaves, old leaves and stems were collected for chemical analysis.

Visual symptoms were described and photographed. Phosphorus toxicity symptoms were scored for severity on two occasions during the trial.

Plant tissue and water analyses were conducted using methods modified after Leece and Short (1967).

RESULTS AND DISCUSSION

Toxicity symptoms

Phosphorus toxicity symptoms were produced by all cultivars at the highest rates of P.

Leucodendron 'Harvest'. Initially developed a reddening of mature leaves in the upper third of the shoot. After this, the older leaves became pale and the foliage looked dull and unhealthy. Later, leaves mid-way up the shoot dried out from the tips, turning grey/green and then a tan colour. Many of these older leaves were eventually shed.

Protea nerifolia 'Satin mink'. Developed a grey/green discolouration of segments of the oldest leaves, commencing from the margins about mid-way along the blade. This tissue turned dark brown and the symptom spread until eventually the whole blade was affected. As the condition of the plant worsened, leaves progressively higher up the shoot also burned. In the final stages, the newest leaves became chlorotic and many older leaves were shed. Young leaves that were green but had not hardened off developed an orange/yellow chlorosis commencing from the margins and spreading towards the mid rib. A narrow region of green tissue usually remained around the main veins. The tips of these leaves eventually turned dark brown and died.

Protea nerifolia 'Pink ice'. Produced similar symptoms to those described for *Protea* 'Satin mink' except that the newest leaves were less chlorotic.

Deficiency symptoms

Protea 'Pink ice'. Developed a pronounced reddening of newer leaves in the nil P treatment. Ironically, a similar symptom, perhaps also a deficiency response, is considered a sign of health by some growers of Australian native plants.

The other cultivars in the trial failed to produce deficiency symptoms. In the case of *Protea* 'Satin mink', this may have been because there was insufficient time for the condition to develop fully.

Sensitivity to phosphorus

From symptoms (Fig. 1), *Protea* 'Satin mink' was judged to be the most sensitive to P, followed by *Protea* 'Pink ice', with *Leucodendron* 'Harvest' the most P tolerant. This ranking agrees well with the experience of commercial growers.

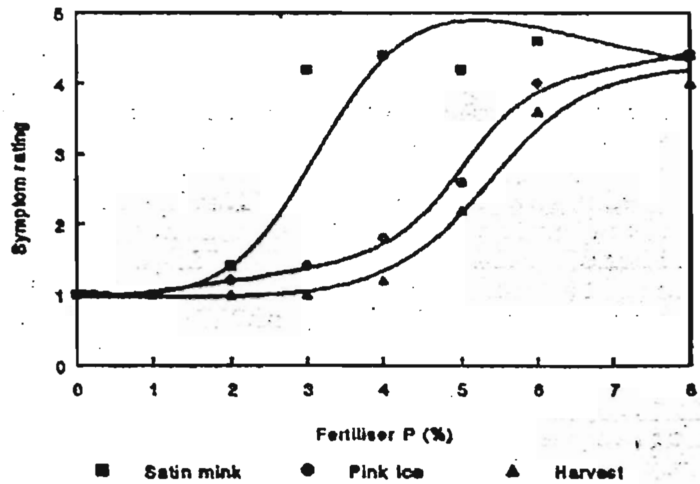

Figure 1. Effect of phosphorus treatment on the severity of phosphorus toxicity symptoms on leaves. A rating of 1 implies no symptoms.

Effect of phosphorus on top growth

Growth of tops by *Protea* `Pink ice' and *Leucodendron* `Harvest' was improved at low rates of P but was depressed at the highest rates (Fig. 2). The reduction in growth due to deficiency was very significant and in the case of *Protea* `Pink ice' was as large as that due to toxicity. Ironically, controlled release fertilisers with zero P are used widely for the production of proteaceous plants specifically to avoid losses due to toxicity.

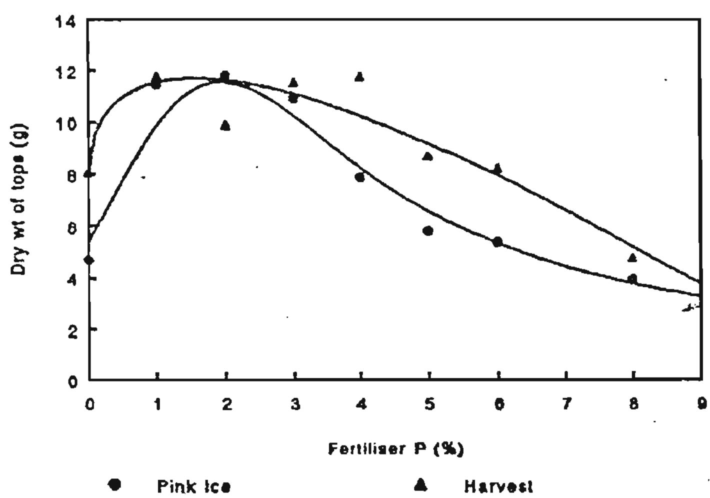

Figure 2. Effect of phosphorus treatment on the dry weight of plant tops.

Information is not available for *Protea* `Satin mink' because the trial was terminated before adequate growth had been made. However, the growth of this cultivar would certainly have been restricted by the chlorosis and leaf shedding that occurred at the highest rates of P.

Effect of phosphorus on root development

Root growth, assessed visually at harvest, declined for all cultivars as P supply was decreased (Fig. 3). Plant top growth was also reduced but whether the responses are related causally is not known. The similarity between the leaf symptoms of root disease and P toxicity in proteaceous plants certainly suggests that root injury is involved in P induced plant death. Iron deficiency and other nutrient imbalances that have been linked causally with P toxicity may only be secondary problems, attributable to poor root function. This would explain why plants affected by P toxicity do not recover when given a nutrient supplement such as a trace element spray.

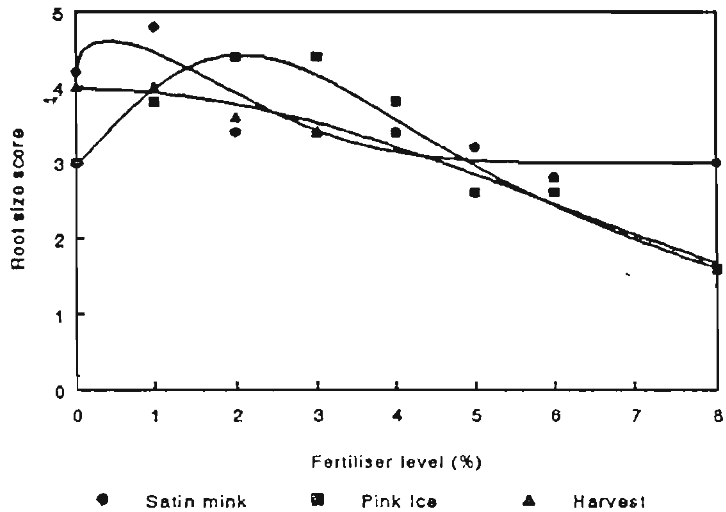

Figure 3. Effect of phosphorus treatment on the development of roots.

Root development was also inhibited in the nil P treatment for all plants except *Leucodendron* `Harvest'. Since *Leucodendron* `Harvest' was the only cultivar to produce proteoid roots it is possible that this adaptation enabled it to get sufficient P for root growth.

Plant tissue analysis

Concentrations of phosphorus in stems, recently matured leaves and old leaves increased with each increment of fertiliser P added, making all tissues suitable indicators of supply (Figs 4-6). Phosphorus concentrations were almost always highest in the oldest leaves. Tolerance of P was related to plant capacity to exclude P from recently matured leaves which was achieved by preferentially accumulating P in the oldest leaves and stems. In view of this mechanism, pruning of shoots or leaves from plants suffering P toxicity would only reduce the capacity of plants to recover.

Tissue P concentrations were signicantly correlated with growth of tops. An interesting feature of the relationship (Fig. 7 is typical) was the relatively narrow range for optimum growth compared with other cultivated plants.

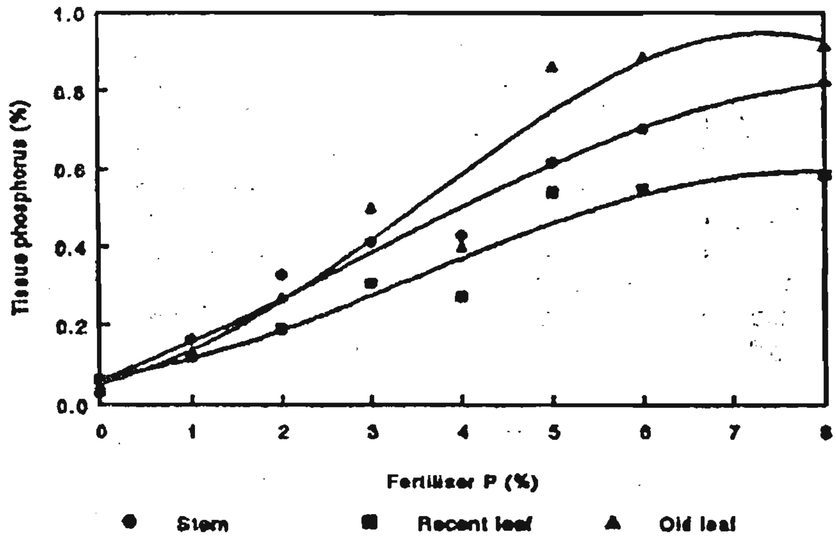

Figure 4. Effect of phosphorus treatment on the concentration of phosphorus in stem and leaves of *Leucodendron* 'Harvest'.

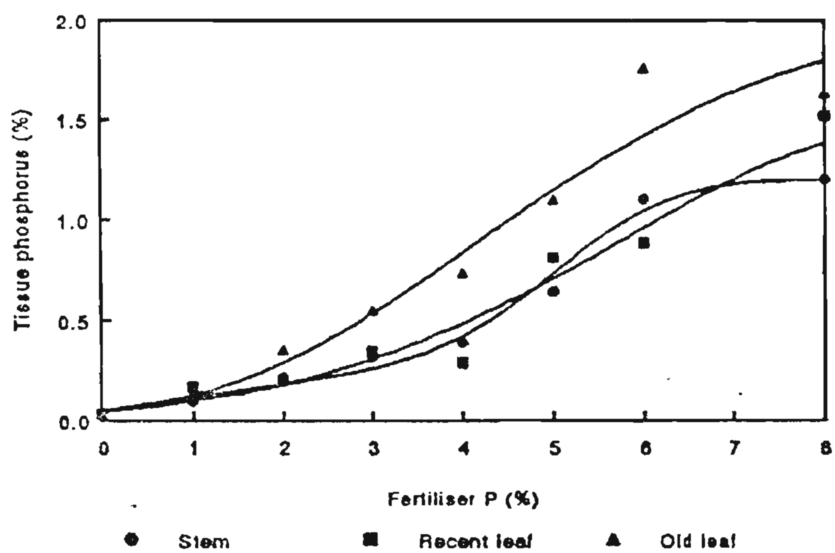

Figure 5. Effect of phosphorus treatment on the concentration of phosphorus in stems and leaves of *Protea 'Pink ice'*.

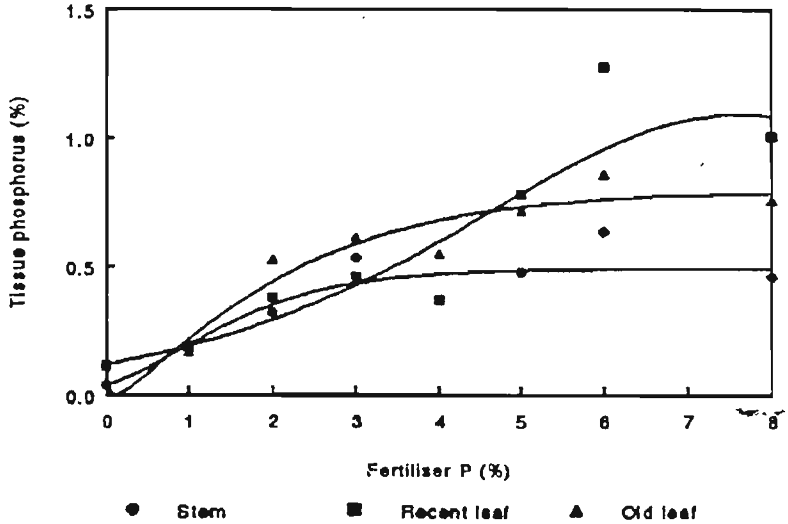

Figure 6. Effect of phosphorus treatment on the concentration of phosphorus in stem and leaves of *Protea* 'Satin mink'.

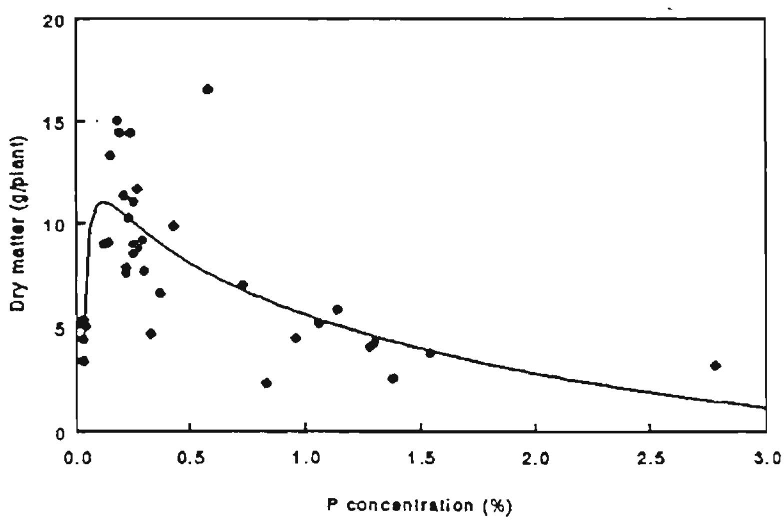

Figure 7. The relationship between the growth of tops and the concentration of phosphorus in recently mature leaves of *Protea* 'Pink ice'.

The tissue P concentrations associated with acceptable growth and with the presence or absence of symptoms are the basis of the tissue standards provided in Table 1.

Table 1. Standards for assessing the phosphorus status of *P.* `Satin mink', *P.* `Pink ice' and *L.* `Harvest' using plant analysis.

Nutrient range	Stems	Recently matured leaves	Old leaves
P. `Satin mink'			
Low/Deficient	<0.19	<0.19	<0.21
Desirable	0.19 - 0.35	0.19 - 0.29	0.21 - 0.44
High	0.35 - 0.4	0.29 - 0.36	0.44 - 0.53
Toxic	>0.4	>0.36	>0.53
P. `Pink ice'			
Low/Deficient	<0.06	<0.06	<0.16
Desirable	0.06 - 0.29	0.06 - 0.27	0.16 - 0.46
High	0.29 - 0.52	0.27 - 0.57	0.46 - 0.95
Toxic	>0.52	>0.57	>0.95
L. `Harvest'			
Low/Deficient	<0.05	<0.15	<0.14
Desirable	0.05 - 0.34	0.15 - 0.42	0.14 - 0.49
High	0.34 - 0.6	0.42 - 0.45	0.49 - 0.73
Toxic	>0.6	>0.45	>0.73

Acknowledgements

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BIOGRAPHICAL PROFILE - DR G.C. CRESSWELL

Dr Cresswell obtained his PhD from the University of New England in 1981 for work on the nutrition of plant communities native to eastern Australia. He joined the NSW Department of Agriculture in 1980 and for 8 years was responsible for running the plant testing service and for providing technical information on nutrition to advisers and researchers. In this role, he gained considerable experience in the recognition of nutritional problems in most crops but his major expertise is with disorders in fruiting and ornamental plants. His research activities have been largely concerned with the improvement of diagnostic procedures. Dr Cresswell is currently collaborating with Mr Ron Weir (formerly with the Department) in the production of a series of books on the identification of nutritional disorders in crops.

UNDERSTANDING AND CONTROLLING LEAF BLACKENING IN PROTEA LEAVES: THE USE OF HIGH CONCENTRATIONS OF SUCROSE.

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ABSTRACT

It is thought that leaf blackening in cut Protea blooms is caused by a depletion of carbohydrates from the leaves by the flowerhead. Cut _Protea cynaroides_ and _Protea neriifolia_ were pulsed with high concentrations of sucrose for 24 hours at 1°C before 28 days dry storage at 1°C. A pre-storage pulse with 20% sucrose significantly inhibited blackening during storage in both _P. cynaroides_ and _P. neriifolia_. Inhibition of blackening continued during vase life assessment of the flowers themselves at 20°C in _P. cynaroides_, but not in _P. neriifolia_. _P. cynaroides_ flowers were unaffected by sucrose pulsing, but a 20% sucrose pulse extended flower life significantly in _P. neriifolia._ High sucrose pulses may reduce water loss and protect cell membranes from damage during storage, thus indirectly preventing the oxidation of phenols that are thought to be responsible for leaf blackening.

INTRODUCTION

Leaf blackening in the leaves of certain Protea species is a serious postharvest problem. Blackening can be visible within two to three days after harvest in several Protea species, including P. neriifolia, P. magnifica, P. repens, P. cynaroides and P. eximia, depending on both pre- and post-harvest conditions.
In order to design an effective postharvest treatment for blackening we must understand the physiology of the processes involved. Water stress was considered to be responsible (Paull et al., 1980), but it is now thought that a depletion of carbohydrates from the leaves by the flower head is involved (Jacobs and Minaar, 1977; Brink and de Swardt, 1986; Newman et al., 1989).

Under normal growing conditions, carbohydrate, in the form of sucrose, is synthesized during photosynthesis in the leaves and translocated to the flower. When blooms are cut and placed in dimly lit rooms, photosynthesis cannot occur and the carbohydrate supply to the flowers becomes exhausted.

Placing cut Protea flowers under bright light effectively inhibited blackening (Newman et al., 1989). This treatment is effective only if the light is strong enough to facilitate photosynthesis in the Protea leaves (Jones and Clayton-Greene, 1991). Furthermore, blackening can be induced in leaves held under high light if photosynthesis was specifically inhibited by 3-(3,4-dichlorophenyl)-1,1-dimethylurea (DCMU) (Jones and Clayton-Greene, 1991). Preventing the translocation of carbohydrates from the leaves to the flower by girdling the stem also reduced blackening in P. eximia (Newman et al., 1989).

Leaf blackening, therefore, is caused when flowers are placed in low light conditions and photosynthesis ceases. Carbohydrates continue to be stripped from the leaves to feed the flower, resulting in an as yet unknown stress that ends in leaf blackening.

Blackening is thought to involve the oxidation of phenols, possibly by the enzyme polyphenol oxidase (Whitehead and de Swardt, 1981). In healthy cells, phenols are enclosed in the vacuole and polyphenol oxidase (PPO) is located in the chloroplasts and the cytoplasm (Lurie et al., 1989). For oxidation to occur phenols must come in contact with PPO, indicating that membrane leakage from the vacuole and/or the chloroplast must take place. The relationship between this leakage and the carbohydrate stress imposed on Protea leaves by the flower is not known.

Evidence for the involvement of an oxidative process in leaf blackening is seen in the inhibition of blackening by anti-oxidant conditions. The anti-oxidant diphenylamine (DPA), used as a 15 second dip, significantly delayed the onset of blackening in P. neriifolia (Jones and Clayton-Greene, 1991). Furthermore, an oxygen atmosphere of 1% effectively inhibited leaf blackening in P. neriifolia leaves (Jones and Clayton-Greene, 1991), possibly by preventing the oxidation of phenols by PPO.

Low concentrations of sucrose (0.5 to 3%) supplied as a continuous vase solution at 20°C are known to partially inhibit blackening in P. neriifolia (Akamine et al., 1979; Brink and de Swardt, 1986) and P. eximia (Newman et al., 1989), while higher concentrations (between 5 and 10%) induced blackening.

These results indicate that it may be possible to control leaf blackening by inhibiting the oxidation of phenols or by supplying the leaves with sufficient carbohydrate (in the form of sucrose).

This paper investigates the control of blackening in P. cynaroides and P. neriifolia by supplying the leaves with high levels of sucrose.

MATERIALS AND METHODS.

Protea cynaroides and Protea neriifolia flowers were harvested from a local grower and transported to the laboratory in water within 1 hour of harvest. Excess leaves were stripped, and 2 cm was cut from the base of each stem. Flowers were placed in solutions of 0, 2, 5, 10, or 20% sucrose and pulsed for 24 hours at 1°C. All solutions, including the control (0% sucrose), contained 100 ug/L sodium dichloroisocyanurate (SDIC) as a germicide.

After pulsing, flowers were randomly placed into bunches of five and wrapped in two layers of newsprint and 35 uM polyethylene. Bunches were stored at 1°C, 95% relative humidity (RH) for 28 days.

Immediately after storage black leaves were counted on each stem. Black leaves were defined as those with more than 5% of the leaf black. The number of black leaves was counted in each flower daily, and expressed as a percentage of the total number of leaves.

Two centimetres was then cut from the base of each stem, and flowers placed in distilled water containing 100 ug/g SDIC for 24 hours at 1°C. Thereafter, flowers were placed in a constant temperature room set at 20°C, 65% RH, with constant light of 10 uEinsteins m^{-2} s^{-1} for vase life assessment.

Vase life was considered terminated at the first sign of curling and color loss in the flower heads. Storage trials were repeated three times with P. cynaroides and twice with P. neriifolia.

RESULTS AND DISCUSSION

Protea cynaroides

Pulsing King Protea (P. cynaroides) flowers in 20% sucrose for 24 hours at 1°C effectively inhibited leaf blackening after 28 days storage (Table 1). This inhibition was visible immediately after storage and continued during vase life assessment at 20°C.

A 24 hour pulse in 5% sucrose significantly increased leaf blackening immediately after storage compared with a control pulse of no sucrose (Table 1). At the end of vase life, pre-storage pulses of 2, 5 and 10% sucrose had all significantly increased leaf blackening. Continuous application at 20°C of sugar concentrations between 2 and 10% promoted blackening (Brink and de Swardt, 1986; Paull and Wei Dei, 1989; Newman et al., 1989). Although we cannot directly compare results from a pulse to that of continuous application, there appears to be some significance in the fact that 5% sucrose promoted blackening in both cases.

Trials with sugar pulses ranging in concentration from 20% to 50% indicated that sucrose pulses of 30% or above damaged the leaves of P. cynaroides (data not shown).

Sugar pulsing did not effect overall flower vase life (Table 1). Flower vase life was assessed independently of leaf condition as it indicated the effect of the sugar pulses on the flower head. In this way the effect of sugar pulsing on both the leaves and the flower head can be expressed.

The inhibition of leaf blackening with a 20% sucrose pulse was consistant and repeatable. Leaf damage in Leucadendron 'Silvan Red' induced by long term dry storage at 1°C was also reduced by a 24 hour pulse in 20% sucrose (Jones, 1991). Sucrose significantly reduced desiccation in Silvan Red leaves thus protecting the leaves from damage during storage. It is thought that sucrose acted in a similar manner in King Protea leaves, as well as maintaining membrane integrity within leaf cells, thus preventing the leakage of phenols from the vacuole and subsequent oxidation by PPO. Further trials are necessary, however, to determine the exact manner by which sucrose inhibits leaf blackening in King Protea leaves.

Protea neriifolia

The incidence of blackening in P. neriifolia was higher than P. cynaroides in all treatments both during and after storage (Table 2). P. neriifolia is known to be more susceptible to leaf blackening than P. cynaroides (Paull et al., 1980).

A 24 hour pre-storage pulse with 20% sucrose significantly reduced leaf blackening during 28 days storage at 1°C in P. neriifolia. Lower concentrations of sucrose had no significant effect. Pulsing with higher concentrations of sucrose (30 to 50%) also had no significant effect on leaf blackening or flower vase life (data not shown). Vase life was significantly extended to 4 days by the 20% sucrose pulse (Table 2).

The inhibition of blackening during storage with 20% sucrose did not continue when P.neriifolia leaves were placed at 20°C for vase life assessment. Blackening rapidly developed in all treatments and all leaves were black by the time vase life was ended 2 to 4 days after storage. Although continuous application of 0.5 to 2% sucrose at 20°C delayed blackening in P. neriifolia Brink and de Swardt, 1986), blackening was accelerated in our trials when flowers were pulsed at 1°C in 2, 5, 10, or 20% sucrose solutions for 24 hours and immediately placed at 20°C (Data not shown).

Pulsing with 20% sucrose, therefore, significantly inhibited blackening in P. neriifolia during storage at 1°C, but was not effective at 20°C. Perhaps sucrose partially prevented membrane deterioration at low temperatures only. temperatures.

In conclusion, pulsing P. cynaroides and P. neriifolia in 20% sucrose for 24 hours at 1°C inhibited leaf blackening during 28 days storage at 1°C. This inhibition extended until the end of vase life (assessed at 20°C) in P. cynaroides, but not in P. neriifolia. Further research, including measurements of solution uptake during the 24 hour pulse, and sugar uptake by the leaves themselves, is needed to determine how sucrose inhibits blackening. At this stage it is thought sucrose helps the leaves retain water during storage, and maintains membrane integrity.

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Table 1. The effect of sucrose pulses on leaf blackening and vase life in cut *Protea cynaroides*. Flowers were pulsed for 24 hours at 1°C and stored dry for 28 days at 1°C. Leaf blackening is expressed as a percentage of the total number of leaves with more than 5% of leaf area black. Least significant difference (LSD) was calculated at the 5% level.
* denotes significant difference from controls.

	SUCROSE CONCENTRATION (%)					
	0	2	5	10	20	LSD
Leaf Blackening after storage (%)	5.0	19.4	45.6*	19.2	0	32.9
Leaf Blackening at end of vase life (%)	61.7	93.7*	91.0*	86.8*	23.2*	23.8
Vase Life (Days)	8.4	5.6	7.8	8.2	9.0	3.0

Table 2. The effect of sucrose pulses on leaf blackening and vase life in cut *Protea neriifolia*. Flowers were pulsed for 24 hours at 1°C and stored dry for 28 days at 1°C. Leaf blackening is expressed as a percentage of the total number of leaves with more than 5% of leaf area black. Least significant difference (LSD) was calculated at the 5% level.

* denotes significant difference from controls.

	SUCROSE CONCENTRATION (%)					
	0	2	5	10	20	LSD
Leaf Blackening after storage (%)	83.1	64.0	74.8	68.4	41.1*	41.8
Leaf Blackening at end of vase life (%)	100.0	100.0	100.0	100.0	100.0	0
Vase Life (Days)	2.0	2.0	2.4	2.4	4.0*	1.0

GERMINATION OF ACHENES OF MEMBERS OF PROTEACEAE FOLLOWING PRETREATMENT WITH THE GROWTH REGULATOR PROMALIN (GA4+GA7+BA) AND ITS COMPONENTS

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SUMMARY

Germination experiments indicated that Promalin, a 1:1 mixture of gibberellins GA4 and GA7 and the cytokinin benzyl adenine (BA), significantly enhanced germination of achenes of *Protea compacta, Leucadendron tinctum, L. daphnoides,* and *Leucospermum cordifolium* relative to a distilled water control. GA4+7 alone improved germination in *P. compacta, P. magnifica* and *L. tinctu* ι. BA alone did not improve germination in any of the species studied and had a significantly detrimental effect on germination in *P. compacta, P. magnifica* and *L. cordifolium.* A more detailed study on *P. compacta* achenes indicated that it was the GA4+7 component of Promalin that was apparently active in overcoming the block to germination. A tetrazolium test and an ultrastructural investigation indicated that treatment with BA alone was detrimental to the viability of embryos and the latter became non-viable during incubation. Evidence of a fungal infection in these embryos was also observed.

INTRODUCTION

There is a keen demand for flowers of such genera as *Protea, Leucospermum, Serruria, Mimetes* and *Leucadendron* on the local and overseas markets. The successful exploitation of the latter markets depends on a number of factors, including the ability of exporters to supply the desired quality and quantity of a particular flowers at a given time. To meet the latter objective the industry has had to adapt so that suppliers are not completely dependent on plants grown in the wild, but can depend increasingly on plants cultivated specifically to supply the export market. This cultivation requires the breeding of improved cultivars. Successful breeding programmes are dependent on efficient propagation techniques. Vegetative propagation is important in maintaining cultivars with desirable flowering characteristics and uniform quality of blooms. Propagation from seed, which is important in the breeding of new cultivars, is complicated by the fact that germination of many species occurs sporadically over a period of time or is poor due to a large proportion of dormant seeds in seed samples (Van Staden and Brown, 1977). One of the methods of improving germination is to pretreat seeds in a solution of the commercially-available hormone mixture, Promalin, which consists of equal proportions of gibberellin(GA4+7) and cytokinin (benzyl adenine). Pretreating achenes in Promalin has been shown to improve germination in *Protea compacta* (Mitchell, Van Staden and Brown, 1986) and *Leucospermum cordifolium* (Brown, Van Staden and Jacobs, 1986). In this study the effect of Promalin pretreatment on germination in a number of species of Proteaceae was investigated. The effect on *Protea compacta* achenes was then looked at in greater depth in order to investigate the conclusion of Mitchell *et al* (1986) that GA4 and GA7 are the ingredients of Promalin that are active in breaking dormancy.

MATERIALS AND METHODS

Achenes of the following were used in the present study: *Protea compacta* R.Br., *Protea magnifica* Link, *Leucadendron tinctum* Williams, *Leucadendron daphnoides* Meisn. and *Leucospermum cordifolium* (Salisb.ex Knight) Fourcade. These were obtained from the Department of Forestry, Pretoria and Parsley's Cape Seeds, Somerset West, South Africa. For the hormonal treatments, the achenes were soaked in aqueous solutions of Promalin, gibberellin GA4+7, benzyl adenine (BA), or in distilled water for 24 hours. The hormone solutions were all obtained from Abbott Laboratories, North Chicago (Ill.),USA. Concentrations of 50, 100, 200 and 400 mgl^{-1} were used. The achenes were incubated in Petri dishes containing acid-washed sand (40 - 100 mesh) moistened with distilled water. The dishes were incubated at $10^{o}C$, a temperature that has previously been found to be favourable for germination (Mitchell, 1983). Throughout the 60 day incubation period, the sand was kept moist by the addition of distilled water. Germination was taken as the first sign of protrusion of the radicle. Five replicates of ten achenes each, were used throughout.

The viability of the achenes of *P. compacta* that did not germinate was tested using the tetrazolium test (Moore, 1973) and following the procedure of Brits and Van Niekerk (1976). A 0,1% aqueous solution of 2,3,5-triphenyl tetrazolium chloride was used and the embryos were examined for colouration after 24 hours. When the viability of unincubated achenes was to be determined, the achenes were imbibed in distilled water for 24 hours prior to testing.

The method used for preparation of embryos of *P. compacta* for transmission electron microscopy was that of Van Staden, Gilliland and Brown (1975), except that block-staining with uranyl acetate was included after post-fixation in osmium tetroxide. Sections of approximately 70 nm in thickness were cut using a glass knife on an LKB ultramicrotome. The sections were stained using lead citrate (Reynolds, 1963) and viewed on a Jeol 100CX electron microscope at an accelerating voltage of 80 kV.

RESULTS AND DISCUSSION

Preliminary investigations

The results of a preliminary experiment, in which the germination of achenes of *P. compacta, P. magnifica, L. tinctum, L. daphnoides,* and *L. cordifolium* was investigated following a 24h pretreatment in 200mgl^{-1} Promalin, GA4+7, or BA, are shown in Table I. Promalin treatment gave a significant increase in germination in all species except *P. magnifica.* Treatment in GA4+7 alone improved germination in *P. compacta, P. magnifica and L. tinctum* but not in *L. daphnoides* and *L. cordifolium.* Benzyl adenine(BA) alone did not improve germination in any of the species and had a significantly detrimental effect on germination in *P. compacta, P. magnifica* and *L. cordifolium.* In an attempt to clarify which component of Promalin is active in promoting germination, a further series of experiments was conducted on *P. compacta* achenes.

Table 1

Germination of achenes of *Protea, Leucadendron and Leucospermum* following pretreatment with Promalin (GA4 + GA7 + BA) and its components, GA4+7 and BA (200 mgl^{-1})

SPECIES	TREATMENTS			
	Control	Promalin	GA4+7	BA
Protea compacta	30+/-6	60+/-6	52+/-4	14+/-8
Protea magnifica	60+/-8	66+/-8	78+/-5	24+/-10
Leucadendron tinctum	4+/-1	62+/-4	76+/-8	4+/-2
Leucadendron daphnoides	25+/-4	34+/-2	26+/-5	26+/-4
Leucospermum cordifolium	16+/-2	34+/-7	22+/-6	8+/-4

P. compacta : control treatment

In the distilled water control, germination commenced 19 days after the start of imbibition and continued until Day 36 (Figure 1). The maximum germination recorded, however, was only 28 %. Indeed, a tetrazolium test (Figure 2) revealed that only 52 % of this seed sample was viable, this figure included the achenes that germinated.

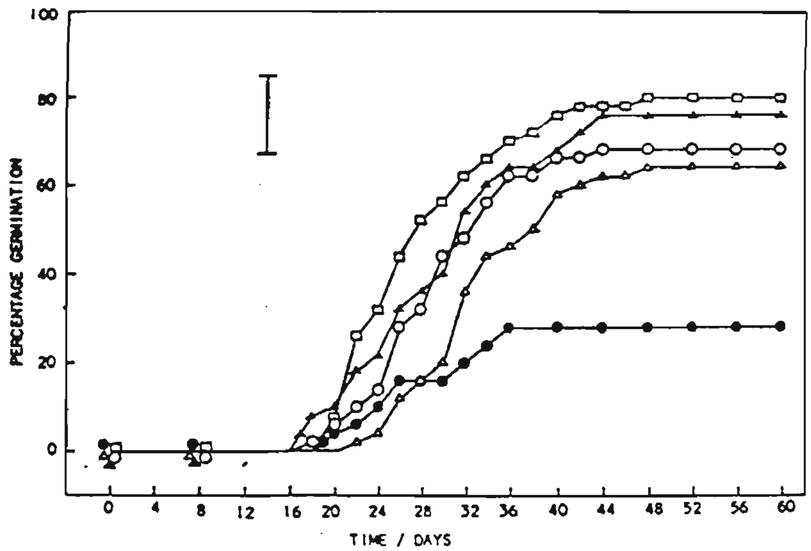


Figure 1. Germination of *Protea compacta* achenes incubated at 10°C following a 24 hour Promalin pretreatment.
(● = control; ○ = 50 mgl^{-1}; □ = 100 mgl^{-1};
△ = 200 mgl^{-1}; ▲ =400 mgl^{-1})
Vertical bar represents the least significant difference ($p < 0.05$)

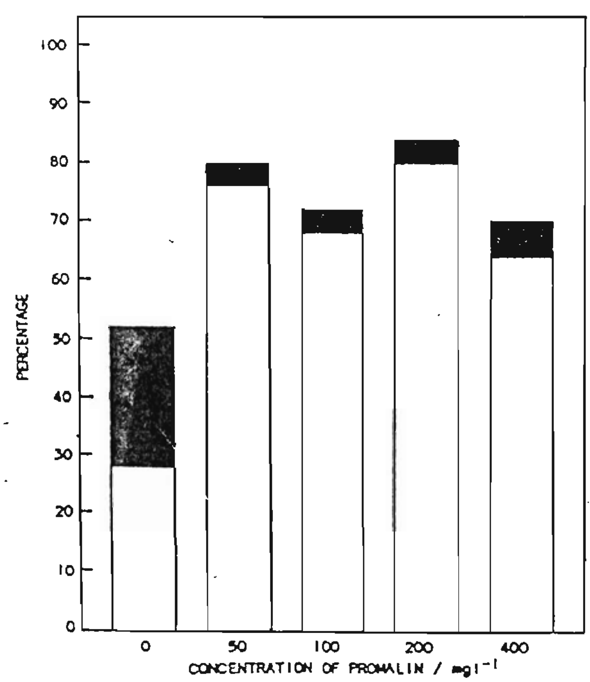


Figure 2. Total percentage viable *Protea compacta* embryos (■), as determined by a tetrazolium test, relative to the percentage of the achenes that germinated (□), following a 24 hour Promalin pretreatment.

P. compacta : promalin treatment

The pattern of germination occurring during the incubation of achenes following treatment with promalin, was very different to that of the control (Figure 1). Although germination commenced at roughly the same time as in the control, it continued until Day 50. The final germination percentages were significantly greater than the control, with all concentrations of promalin. The treatment involving 200 mgl^{-1} gave the highest percentage germination, namely 80 %. A viability test conducted on promalin-treated and untreated achenes (controls) showed that a higher proportion of viable achenes germinated following promalin treatment in comparison with the controls (Figure 2). It appeared that the factor(s) blocking germination in a high proportion of untreated achenes was overcome by promalin treatment.

A viability test conducted on a random sample of unincubated achenes, showed that only 75 % were viable. This indicated that a germination percentage higher than that obtained with the promalin could not be expected with this particular batch of seed. Also, it could be concluded that the factor(s) that blocked germination in a high proportion of the untreated (control) achenes was overcome by the promalin.

P. compacta : GA4+7 treatment

There was again little difference in the time of commencement of germination between the GA4+7 treatments and the control (Figure 3). The final germination level in the treatments involving 200 and 400 mgl^{-1} GA4+7 was significantly greater than the control, being 56 and 66 %, respectively. This is considerably greater than the germination percentage obtained by Mitchell et al (1986) following GA3 treatment. Wareing and Saunders (1971) also reported that GA4+7 is more effective in overcoming seed dormancy than GA3, as have Ikuma and Thimann (1963) and Frankland and Wareing (1966). The results therefore corroborate the suggestion by Mitchell et al (1986) that it is GA4+7 specifically that is involved in the germination-promoting effect of promalin. However, promalin still yielded the highest germination percentage. Therefore, it is not GA4+7 alone that is responsible for this result. Supporting this, a tetrazolium test revealed that more of the viable embryos remained ungerminated following the GA4+7 treatment than previously found with the Promalin (Figure 4).

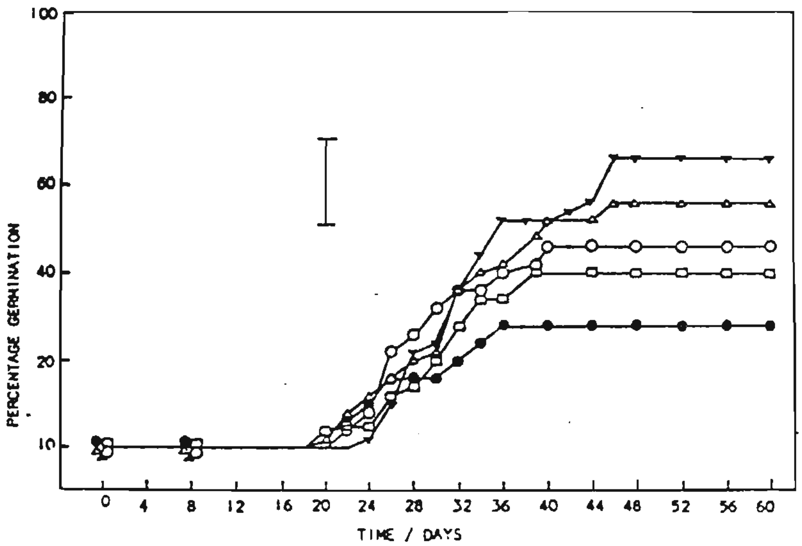


Figure 3. Germination of *Protea compacta* achenes incubated at $10^{o}C$ following a 24 hour GA4+7 pretreatment.
(● = control; ○ = 50 mgl^{-1}; □ = 100 mgl^{-1};
△ = 200 mgl^{-1}; ▲ =400 mgl^{-1})
Vertical bar represents the least significant difference ($p < 0.05$)

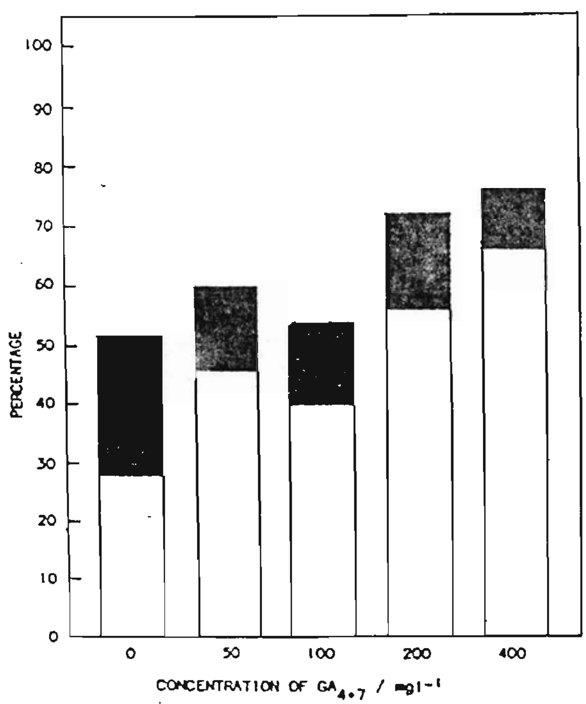


Figure 4. Total percentage viable *Protea compacta* embryos (■), as determined by a tetrazolium test, relative to the percentage of the achenes that germinated (□), following a 24 hour GA4+7 pretreatment.

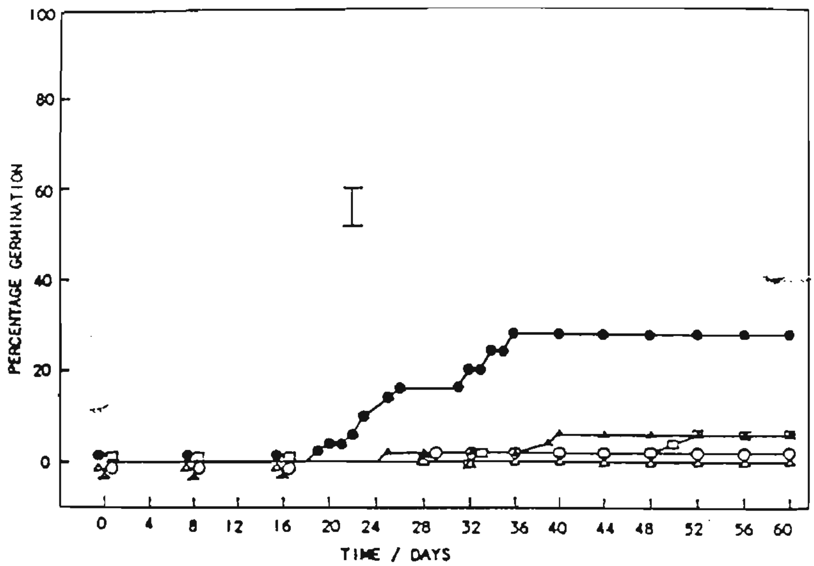


Figure 5. Germination of *Protea compacta* achenes incubated at 10°C following a 24 hour BA pretreatment.
(● = control; ○ = 50 mgl^{-1}; □ = 100 $mgl=^{-1}$;
△ = 200 mgl^{-1}; ▲ =400 mgl^{-1})
Vertical bar represents the least significant difference ($p < 0.05$)

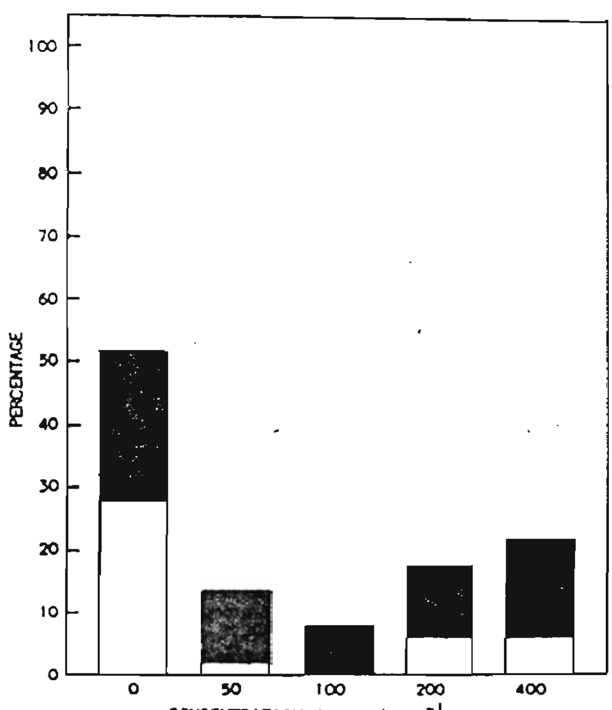
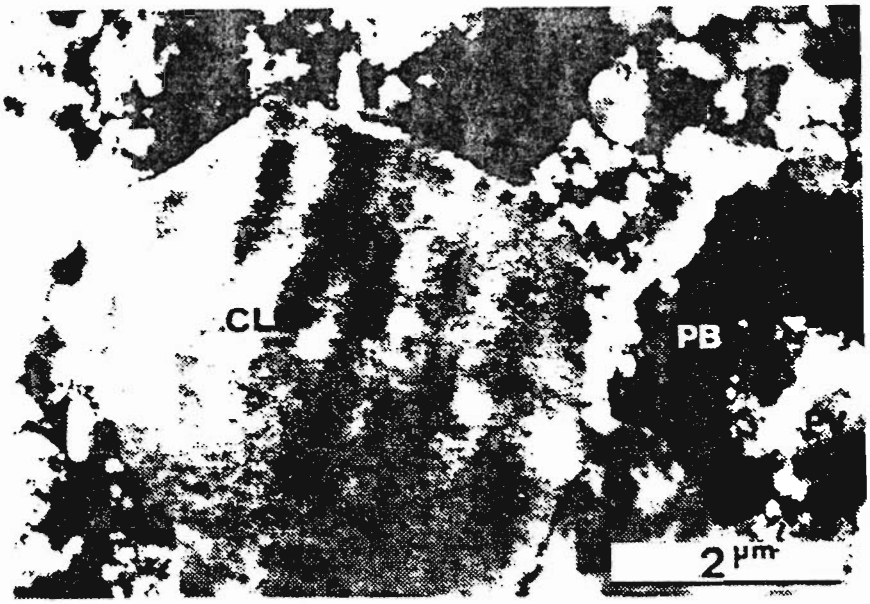
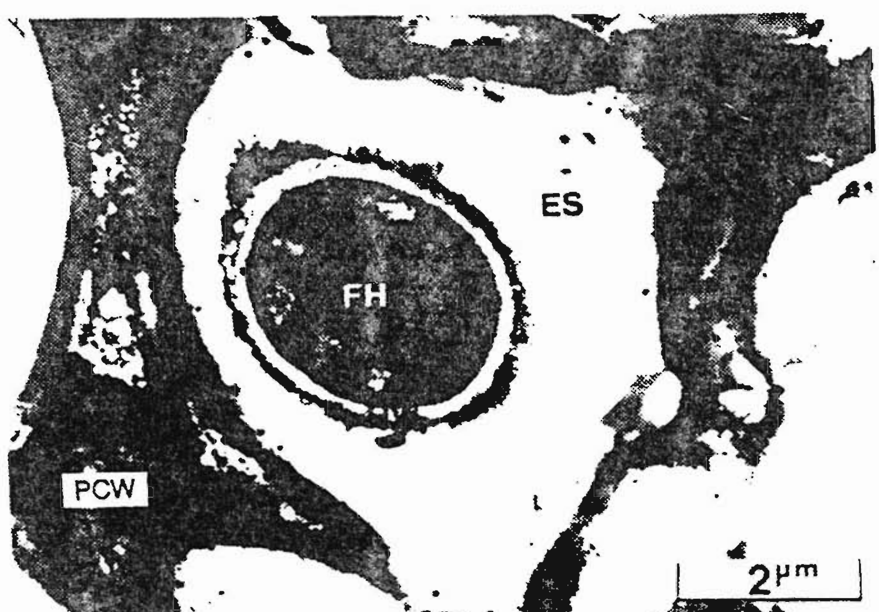


Figure 6. Total percentage viable *Protea compacta* embryos (■), as determined by a tetrazolium test, relative to the percentage of the achenes that germinated (□), following a 24 hour BA pretreatment.



<u>Figure 7.</u> Section through cell in embryo axis of *Protea compacta* achene, incubated for 22 days following BA treatment, showing coalesced lipid bodies (CLB) and protein body (PB) with vacuole (PV).



<u>Figure 8.</u> Section through cell in embryo axis of *Protea compacta* achene, incubated for 30 days following BA treatment, showing infection by fungal hyphae (FH). (ES = empty space) (PCW = plant cell wall)

P. compacta : BA treatment

The germination results obtained following the BA treatment were very different (Figure 5). With all concentrations, the final germination percentage was very low, a maximum of 6 % being reached. In the case of the 100 mgl^{-1} treatment , no germination was recorded throughout the entire 60 day incubation period. The BA therefore appeared to inhibit germination. Mitchell *et al* (1986) also found BA to be inhibitory.

A tetrazolium test revealed that very few of the embryos treated with BA were viable (Figure 6). This implies that during the incubation period, a large proportion of the embryos were rendered non-viable. Therefore, BA, when applied alone, has a definite negative effect and does not simply inhibit germination.

The ultrastructural investigation of the embryonic axis confirmed that the embryos were not viable, an increasing number of cells showing sign thereof with time. Lipid-body coalescence, which is reported to be a sign of non- viability of embryos (Anderson, Baker and Worthington, 1970), was widespread (Figure 7). In addition, necrotic nuclei were visible . The dark patches are considered to be heterochromatin, this arrangement apparently being indicative of a non-functional nucleus (Villiers, 1970). Van Staden *et al* (1975) reported necrotic nuclei and lipid body coalescence in aged *P. compacta* embryos, thus confirming that seed senescence was commencing.

In the present study, evidence of fungal infection was observed (Figure 8). Cells containing hyphae were noted to be depleted of most contents, large empty spaces surrounding the hyphae. The BA may therefore result in low germination by reducing the resistance of the embryo in some way, thus allowing infection by fungi, which results in senescence of the embryo. Why this occurs when BA is applied alone, but not when applied together with GA4+7, remains uncertain.

Overall, the germination results appear anomalous, since the effects of the individual components of promalin can neither be added nor subtracted, to give the resultant effect of Promalin itself. However, it is just this form of contradiction that forms the basis of Khan's (1975) hypothesis. The cytokinin, in this case BA, does indeed appear to have a permissive role in germination, when applied together with GA4+7, while the gibberellins still maintain the primary role. Khan (1975) postulated that the cytokinins modify the effects of other hormones, without inducing any marked effects by themselves. Although in *P. compacta* BA does have a definite effect, namely negative, this hypothesis still provides the best explanation of the situation in this species. The details of how this occurs, however, are unclear. The consistently promotive effect of Promalin on the germination of *P. compacta* achenes nevertheless provides a simple means of obtaining an acceptable level of germination.

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Polymorphism in seeds of Asteraceae: Germination of seeds of *Dimorphotheca* spp.,*Bidens* spp.