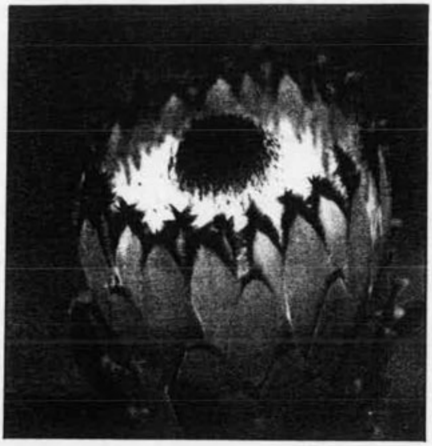
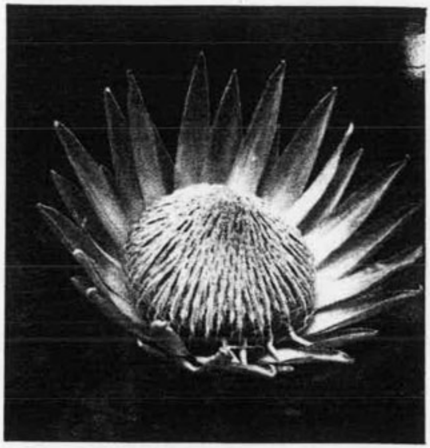
PROTEA GROWERS HANDBOOK

by
JACK HARR

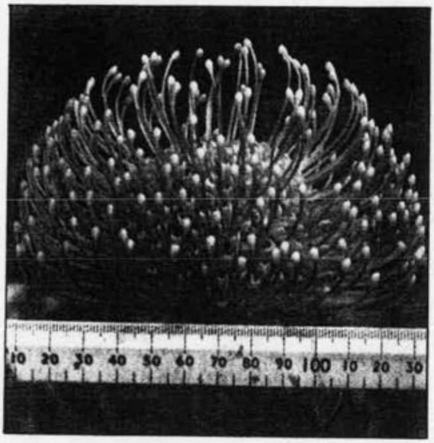
Commercial Cut Flower Version



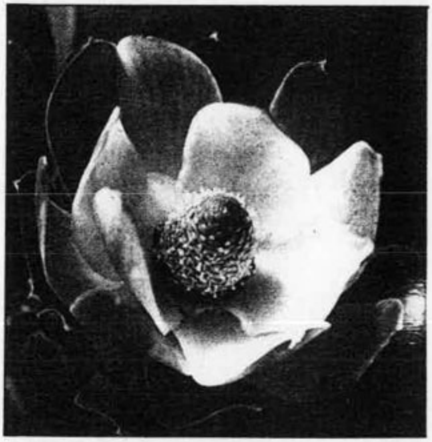
P. Magnifica Hybrid



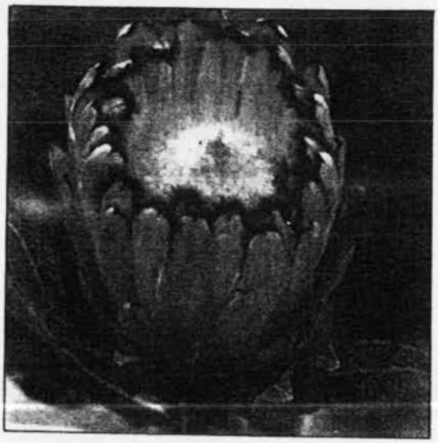
P. Cynaroides



Lsp. "Harry Chittick"



Ld. "Waterlilly"



P. "Double Mink"

Telopea "Starburst"

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Commercial Cut Flower Version

International Edition

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Preface

It is now about fifteen years since the commercial production of proteaceae in plantations began and in that time there have been millions of proteaceae plants planted. In those fifteen years some people have lost money over them, many have lost sleep over them, a few have done quite well out of them and I have written two books about them.

The first of these was "Proteas". It was written because in the mid 1980s there was a great need for information on the skills of the vegetative propagation of proteaceae so that growers could break away from the seedling syndrome that was taking so many of them down the wrong track "Proteas" dealt mainly with that topic.

The second book, "Profit From Proteas" dealt with the importance of clonal selection and the economics of planning production. It was written after my first trip to Zimbabwe where I had seen first hand what happens to a budding floriculture industry when the wrong advice is given and hundreds of acres of the wrong thing is planted in the wrong place.

This third book has been produced to fill a current need. Each year I spend many hours talking to growers who visit me seeking information. I also spend many hours writing replies to the numerous appeals for information from overseas. This book makes available information both old and new on the basic fundamentals of plantation planning and production. It answers most of the questions that new growers must know to make informed decisions about their project. It also contains material which brings established growers up to date with new information about production and plant health which has not previously been published.

Here then is what I call a basic 'nuts and bolts hand book'.

Jack Harré
May 1995.

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SECTION ONE

An Introduction To Proteaceae.

1:1 Where and how do proteaceae grow in nature.

The name Proteaceae often shortened to Protea is derived from the mythical Greek god Proteus who has the power to show himself in many forms. They are a large family of plants that are indigenous to the southern hemisphere. Many of the cut flower varieties such as Protea, Leucospermum, Leucodendron, Serruria, Paranomus, Mimetes are found in South Africa. Australia is host to other cut flower varieties with their principal ones being Banksia, Telopea, Dryandra, Isopogen, Grevillea. New Zealand has Knighta excelsia the Rewarewa tree and a Kunzea and South America has the Chilian Fire Bush and one or two others

To grow these plants successfully a grower really needs to understand them as many varieties are quite complex in their requirements of soil type and climatic conditions. There is no better place than their natural environment to study a plants growing requirements and this section briefly explores how and where the South African species live in nature. Your greatest key to success is to apply their demands to your plantation. The same principals can be applied to the Australian genera.

When we look at South African Proteaceae in their natural surroundings we find that each particular variety of a species and quite often a particular variant of a variety are quite specific of the climatic conditions and the soil type that they will live, survive and reproduce in. This is particularly so in areas where there are extreme variables in climate and soil types and even within quite short distances such as is encountered in some of the Cape province of South Africa you will find a large range of Proteaceae each living in their own little colony which then gives way to another variety.

Time and again you will see a stand of pr. repens and it will suddenly end and there will be pr. nitida or pr laurifolia instead. All varieties are found either growing with old dead grasses or litter protectiong their roots. They are never seen with bare ground around them and this is a point that persons growing them in plantations must take notice of. All Proteaceae hate having theit root zone bare.

Each varieties genetic make up is finely tuned to live, survive and reproduce in that particular climatic location in that particular soil type and if seed is taken from there and planted in another location even quite close by it will probably fail to establish. It is this fact that a particular variant of a variety must have such specific climatic and soil type requirements that makes it difficult to grow some Proteaceae. On the other hand there are those that in nature are widespread such as ld salignum, P. neriifolia and P. repens which have much wider range of acceptance of soil types and climatic conditions.

The one aspect that makes Proteaceae stand alone from all other genera is that they have a very special dual root system. There are the primary roots which like any other plant genera reach deep into the ground to anchor the plant and keep it supplied with moisture from the soil. Some Proteaceae varieties roots can reach as deep as three metres and in doing so they are capable of providing moisture to the plant even under very dry surface conditions. Proteaceae primary roots must never become flooded or they will start to degenerate and for this reason good drainage is essential at all times to the depth that a particular varieties roots reach. This depth varies greatly between different varieties and this is why some varieties get affected and some don't when high watertables occur in plantations.

The other system of roots are called proteoid roots. These are highly specialised and unique to Proteaceae. They form at or just below ground surface level and therefore operate in a relatively dry and well aerated environment. These two factors are paramount to proteoid roots well being. They must never become waterlogged.

These roots resemble hairy sponges and their function is to absorb and store nutrients from the soil and release them into the plant when the plant is making a vegetative growth. . They form during the rainy season (when ever that may be) and in most varieties reach their maximum efficiency towards the end of that period Following the process of releasing the stored nutrients into the plant to promote the next growth cycle of branches, leaves and flowers, these proteoid roots die to be replaced by a new system the following rainy period. Their function is not to supply the plant with moisture. The primary roots alone do that.

As proteoid roots are invariably at or just below the surface of the ground it makes them particularly vulnerable to damage from ground dwelling insects, cultivation, overdosing of fertilizers and weed control chemical misuse. The dangers of these to the plants well being is dealt with in the following sections.

The foliage of different varieties varies greatly. A particular varieties leaf make-up and colour are always in harmony with where they grow in nature with the green leaf varieties being found in the lower light areas and the blue/green, grey or red foliage ones being found in higher light areas. On the whole, other than a few varieties, Proteaceae are seldom found in high sunlight areas and indeed most species and varieties that we use in our gardens and for cut flower production are quite sensitive to high sunlight levels. It is interesting to note that in South Africa almost no Proteaceae are to be found growing on north facing slopes, ie. facing into the afternoon sun. Further to this, most Proteaceae occur naturally in the area along the seaboard and inland to the mountain ranges stretching from the Cape to Port Elizabeth, an area that is greatly influenced by sea haze along the lower ground and mists along the mountain tops.

When Proteaceae are planted in countries outside of their natural environment they often do not take kindly to the high light intensities some of those areas have and in some places such as Maui in Hawaii they can not be grown successfully below the level that is not protected by the daily cloud bank that builds up on the mountain. This is a point that growers should bear in mind when they are planning a plantation. Wherever possible always choose land facing away from the afternoon sun; ie. northern hemisphere facing north or north east, southern hemisphere facing south or south east. This is not quite so important with blue/green, grey and red foliage types. The light factor is dealt with in more detail in 3:8 to 3:10.

The combination of high temperatures and humidity is the biggest threat to Proteaceae in cultivation. In nature they are only to be found growing where there is virtually always some air movement. High humidity does occur where they are growing in the form of fog and sea haze but as it rolls in off the ocean it is accompanied by a drop in temperature. Proteaceae are quite happy with 90% humidity provided the temperatures are below about 10C. This is a point that growers must heed when choosing a plantation location. Constant air movement does compensate to some degree for high humidity but when a location experiences four or five days of 90% humidity and a temperature of +25C like some parts of New Zealand does when there is a large tropical cyclone moving in, fungi can be a big problem. Humidity is dealt with in some detail in 3:4.

It can be seen from the foregoing that growing proteaceae successfully is not a soft touch occupation as some persons would have you believe. It is a full time profession - not a part time week-end hobby.

1:2 Proteaceae flowers and their place in the international floriculture market.

The flowers and bracts of Proteaceae are endlessly variable in their forms and range from p. cynaroides which can be 30cm in dia to the smallest leucodendrons which are but a few mm in diameter Because of this they have greatly varying uses in floral work. All of them can be used in a vase but some of them only last a day or so once picked while others have a vase life of weeks. It is those with the longer vase life that have a value as a cut flower.

It is now about thirty years since South African farmers started harvesting Proteas from natural stands and air freighting them to Europe to be sold in the flower markets or on the streets by flower vendors. In that thirty years Proteaceae have not progressed very far in the percentage of world market sales. There are a number of reasons for this with the primary one being that dealers still lack confidence in them because they are so variable in supply and quality. Whilst it is understandable that wild picked material will always be variable in quality and the supply pattern will be governed by seasonal flowering patterns it is a fact that growers around the world now growing these flowers in plantations have done little to improve quality, presentation and supply patterns.

There are indications that this may now be changing as the many opportunist plantations that were planted with anything that looked like a protea come to the end of their life but a real change won't take place unless present andm new growers make a huge effort to improve their quality and supply pattern. Much of the problem lies with plant producers some of who go on pumping out and selling to unsuspecting growers material that can only be described as junk. There is a great need to rationalize proteaceae clonal selection and production. These subjects are dealt with in some detail in "Profit From Proteas" and how to propagate vegetatively is dealt with in "Proteas". Both are written by the same author and are still available from Riverlea Nurseries, P.O. Box 69, Feilding, New Zealand.

1:3 Commercial proteaceae cut flowers species/varieties.

The three principal species of South African Proteaceae traded as commercial cut flowers and foliage are Protea, Leucospermum, Leucodendron. Others of a more minor nature are Mimeties, Serruria, Paranomus. The three main Australian ones are Banksia, Dryandra, Telopea with Grevillea, Isopogen of lesser importance.

In the Protea group there are three main types. The king (P. cynaroides) stands alone as by far the largest Protea flower. Of the bearded types the principal ones are repens, neriifolia, eximia, magnificia and hybrids of all of these. The remaining group are those that have the tubular type flowers. In general these have a short vase life but they are often used in the advanced bud stage as fillers. These include P. mundii, lacticolour, aurea etc.

Many hybrid Leucospermums have been developed over the past fifteen years and their colours range from reds and pinks through to orange and yellows. Many of these are quite specific in the climatic location that they will grow in successfully. Some of them are not frost tolerant and some give problems from excessive fungi invasion. Leucospermums are not an easy crop in frosty or high humidity.

Although there many new forms of leucospermum, the market still has a strong preference for cordifolium which has a flower that opens to be up to 12cm (5") across and is a strong vibrant orange. Some markets tend to ignore all other leucospermums if cordifolium is available except for Christmas time when reds are popular

Leucadendrons which are not flowers but are bracts, are developing as a high profile international floral material. There is a wide range of varieties now being traded ranging from the laureolum/Safari Sunset types through the many multi-bract forms, (floridum, salicifolium etc) to the large flat forms (oriental) which are more like a flower than a bract. Because Leucodendrons are regarded as greenery it is important that they achieve long stem lengths, if at all possible in excess of 60cm and in some of the larger ones it is only those of 85cm plus that consistantly bring a high returns.

In the Australian Proteaceae there is a huge range of Banksia which are used in the floral trade both as dried flowers and as fresh flowers. Those used are mostly confined to the West Australian cone types, prionites, menzesii, victorii etc rather than the eastern states bottle brush type like B. ericofolia. Telopea the other major Australian proteaceae traded is almost exclusively confined to the NSW form of T.speciossomma although some hybrids are used. Dryandra and Grevilliea are predominantly regarded as foliage.

Examples of some of the flowers and foliage outlined above can be seen on the inside of the front and back cover of this book.

It is most unlikely that a first time grower will be totally successful with their first crop of any variety. Growing any crop involves acquiring certain skills of judgement in cultivation and handling the crop. Every variety and every location has its own specific variables and growers usually find that they can grow four or five varieties really well and a few others to a lesser degree. The information given in the following sections should help you in achieving your goals..

SECTION TWO

Calculating The Standing Costs Of Development And Production

2:1 Overview.

In any project there are development and production costs. Some of these are quite obvious and some are hidden. This section identifies the standing unavoidable costs.

In most instances the costs outlined here may seem quite obvious to growers but some of them like providing an adequate supply of high quality water may run to thousands of dollars. Because there are so many variables this section does not put an actual value on these costs. This you must do by your own investigations and appraisal.

Section Three outlines additional optional costs that may be incurred to grow a particular crop in a particular climate and those costs will have to be added to the standing costs outlined here to give a final pre harvest costing.

2:2 Land value. The ownership or control of land irrespective of whether it is owned freehold, owned with a mortgage or leased does incur standing overhead costs. These include annual rates or local land taxes, insurance, loss of revenue from the equivalent equity if the land was sold and the money was invested.

When a plantation is part of a farm, the items listed above may be minimal and could be ignored. However at the other end of the scale if the land was close to or within a built up area and consequently of high value and incurring high annual taxes the standing costs of occupying the land would be significant.

2:3 Water. Water is an important ingredient of your future success. The cost of an adequate supply of good quality water can be annual cost in water dues to the supply authority or in energy costs to pump your own supply. On the other hand to some growers it is free. If there is not an adequate supply of good quality water available it may involve a significant capital cost to provide it.

2:4 Development costs.

The development costs include the capital cost of irrigation (if required), weed matting (if used), frost control (if required), light control (if required), provision to support crop by either providing mesh or overhead wires and the cost of labour involved in and installing the foregoing. The pros and cons of providing all or any of the above is outlined in Section Three.

2:5 Live Plant costs. This must be calculated on a per plant basis and not on a per acre basis. The cost should be calculated on the initial cost plus a 10% replacement cost on accidental losses in the first two years.

2:6 Labour costs of establishment. This is in two phases, planting and maintenance. Local pay rates will of course influence these costs greatly as will also the contour of the land and whether or not weed matting is used. If weed matting is used at the time of planting it will greatly increase the initial establishment costs but it will decrease the ongoing maintenance costs through years one to four.

Where growers are doing all or most of the work themselves and in doing this work they are prevented from earning other income, the labour costs must be charged against the establishment costs.On the other hand, if the principal worker in the plantation is a farmer or his wife and they live in an isolated area where there is no local employment, then the revenue earned from producing a crop of flowers is all a positive plus in financial revenue. In an industry where there are a high number of items to be handled and each item is handled a number of times between the bush and the carton, the efficient use of labour can and does determine the final profit margin as the inefficient handling and packing of the end product can cost more than the flower will realize at its final destination. It is for this reason that some growers fail

.**2:7 Expendable materials.** These include fuel, electricity and chemicals. Whilst the costs and uses of energy are somewhat standard, the use and cost of chemicals can vary greatly between plantations.There are two principal reasons for this. Firstly, because of their location, some plantations need more frequent applications of chemicals to control fungi and insects. The second reason is that in many plantations the method of application of chemicals is not as effective as it should be or the chemicals being used are not the right ones for that particular problem or time of year. Because of this more frequent applications are needed which can more than double the annual costs for chemical The uses of chemicals and their application is discussed in Section Five.

2:8 Capital cost of equipment and machinery. If the production of proteaceae flowers or foliage is part of a larger business such as a farm, orchard or market garden etc. then the capital and running cost of equipment is a very small component in the overall annual budget provided all the necessary equipment is already owned. The one item that often has to be purchased is a chiller of sufficient dimensions to handle the crop. It is impossible to produce a high quality end product without one.

If the plantation stands alone, then all allowable depreciation and running costs of plant and equipment needs to be considered and calculated. Your accountant can advise you on the implications this.

2:9 Freight costs. This must be calculated from the farm gate to either: the domestic consumer or if being exported to the premises of the freight forwarder. These costs are usually straight forward and easily calculated. However in most instances international rates tend to rise annually and in four years time they can well be 15% greater than when the plantation was planted. This increase almost invariably comes out of the growers prifit margin. In most instances growers will not be involved in this calculation but if the product is being exported your profit margin will be affected by it. Obviously the most distant destinations are the most expensive to supply and this fact often precludes New Zealand from supplying Europe with proteas. However, since air freight is calculated volumetrically as well as by weight, in the orchid season some proteas can be sent, sharing a pallet with orchids, which do not make up the full volumetric weight on their own.

2:10 Summary. It can be seen that when all the factors listed in this section are taken into consideration that there can be sets of circumstances which preclude a certain product being sold within a particular market or market level. For instance you may have a crop of magnificent King Proteas but because it is summer in Europe the cost of getting them there is greater than their value there is in their summer. In another situation you can have a product that has all the right physical qualities right but it has cost so much to produce it in overheads because you had to provide expensive frost protection and your pack house labour was inefficient that there is no margin left when it is sold at current market levels. On the other hand if you have planned your operation well, planted the right clones for your climate and management skills and you have a perfect product in quality, stem length, colour etc., grown efficiently, packed and delivered to the consumer in a professional manner at the right time of year it will sell at a price which is much greater than all the standing and running costs and you will make a profit.

SECTION THREE

Pre Planting - Investigate And Decide.

3:1 Overview

This is the most important section in this book as it investigates most of the aspects you are likely to encounter in plantation planning. Once you have read and absorbed it you should be in a better position to make the right decisions for your own location and management skills. The decisions you do make may incur additional development costs and these will have to be added to those already calculated from Section Two.

The success of your plantation and to some extent what you can grow in it will largely depend on whether or not you make the right decisions prior to planting Some of these, which you have little control over will affect what varieties you can plant as a crop because the plants you plant must be matched to your soil type and climate. Some decisions you make will affect the long term future management of your plantation. For instance; are you going to use weed matting to control the weed growth, are you going to provide irrigation for your plants, are you going to provide frost control for your crop, are you going to provide shade for your crop. Some decisions you can delay and implement action on them later if it is found that they are necessary. Some decisions are necessary before planting because if you are going to implement them it may widen the range of varieties that you will be able to grow successfully.

In a hand book such as this is difficult to recommend production procedures as different locations have different needs. For instance in Hawaii, California, Zimbabwe, West Australia and some parts of South Africa, irrigation is provided as a matter of course because it is impossible to grow a crop through the dry season without it. Likewise in those same countries the use of weed matting would in many instances be an unnecessary expenditure as weed growth there is usually a low key problem. On the other hand in New Zealand, Tasmania and some parts of eastern Australia, weed growth is a problem because of the more regular year round rainfall experienced in those areas. This regular year round rainfall, besides making weeds grow almost all year round also provides a more or less adequate soil moisture level for Proteaceae to survive in and because of this many growers in these areas doubt whether it is necessary to provide irrigation.

3:2 Soil type.

The one factor that you can not change is your soil type. All Proteaceae must have well drained soils. This does not mean dry soils and in fact to produce a flower crop most varieties need quite a high soil moisture level. This is dealt with in some detail in 3:11 to 3:13.

The term well drained soil means that if your land is wet and soggy during your wettest part of the year and your feet sink into the surface when you walk on it immediately after 25mm (1 inch) of rain, then the land is unsuited to proteaceae production unless it can be improved by drainage or ridging. Even with these steps to improve drainage the presence of a high water table (which is sure to occur every few years during an extra wet season) is a very great risk and will usually result in unacceptable plant losses. *If your soil is wet and soggy don't plant Proteaceae.*

3:3 Climatic environment.

The elements that make up your climatic environment are other factors that you can not change but you do have some control over some of these by way of providing irrigation in a dry climate, frost protection in frosty areas and light control in high sunlight areas. However there is one climatic factor that you have no control over and that is humidity and after soil type this is your first consideration.

3:4 Humidity

Fungi invasion in a Proteaceae plantation is always related to the sum of the combined temperature and humidity prevailing in a location at any given time. A simple means of calculating the risk factor in your location is to take the temperature reading in Celsius and add it to the relative humidity in percentage. For instance; a temperature of 20C. and a humidity of 65% gives an aggregate of 85. For reference purposes this has been given the equation of th/c followed by the number, in this example it is th/c85. If it were to be calculated in Fahrenheit it would be th/f133. The higher the combined temperature and humidity aggregate, then the greater is the risk of fungi invasion.

Research on my properties and observations in other areas around the world show that the danger level to varieties of Proteaceae with smooth hairless leaves is around th/c100. There are exceptions to this especially in some variants of p.cynaroides which will take up to th/c110, but above this level even these are at a high risk of invasion by fungi. For varieties with hairy leaves and particularly those of a blue/grey colour the danger level begins around th/c85 and it is even lower than this when there are prolonged periods (more than three consecutive days), when th/c never drops below this especially if there is a total absence of sunlight caused by cloudy conditions. Such conditions can be experienced in tropical monsoon or sub tropical hurricane conditions. The eastern states of Australia and New Zealand quite reguarlarly experience these conditions when there are hurricanes hovering away off shore in the Tasman Sea and Pacific Ocean.

Note; Prolonged low light levels especially if associated with very calm conditions definitely lower the th/c danger point and increase the incidence of many fungi problems. If there is no sunlight for four consecutive days the danger level could drop from th/C90 to around th/C 80 for some varieties.

	140	Suitable for growing bananas and rubber.
	130	Suitable for tropical hibuscus
	120	Uncontrolable fungi problems in all Proteaceae
Th/C value.	110	Fungi all varieties all ages Proteaceae.
	100	Problems with most varieties under 1yr old.
	90 }	Fungi starts especially in grey and hairy leaf varieties.
	}	
	80 }	Fungi starts in ld. discolour - procerum and similar.
	}	
	70 }	Safe level for most commercial varieties
	}	

Humidity/temperature (th/c) tolerance of Proteaceae.

Danger levels will vary plus or minus about 5 points depending on air movement, ie. if there is a constant breeze (another reason to encourage air movement in lay out design, see 4.3) the plant that was safe at th/c100 could be safe at th/c 105 but if it were a dead calm for several days then the safe level of th/c100 could be lowered to th/c 95. In humid conditions with no air movement for several days all varieties are at high risk at th/c85 and above. Growers should be aware of what their th/c levels are and which are the danger times of the year. In variety selection, first time growers should be guided by existing local knowledge. Established growers will already know what varities are not possible in their location. First time growers who want to establish plantations in risk areas should avoid varieties like Lsp. cordifolium and P. magnifica. Some fungi control is possible by regular chemical applications during danger periods but this is time consuming and expensive. Chemical controls of fungi are dealt with in Section Five

3:5 The dangers of frost.

Sub zero temperatures are another climatic factor which controls what crop can be viably produced. If however frosts of no more than -2C. are ever experienced in your location your can discount the remainder of this discussion on frosts as -2C has virtually no affect on any Proteaceae plant of any age unless it is in very active growth.

For those growers who do have frosts greater than -2C. it is important for you to determine what is the maximum frost factor of your plantation is it will greatly influence what varieties are safe for you to plant without protection.

The effect that frost of more than -2C. but less than -5C., has on a plant, is not related solely to the minimum temperature but is the compounded effect of the degree of below zero temperature multiplied by the hours that the frost is lying. This calculation has been given then name of "frost/factor" abbreviated to f/f. If there is a frost of -3C. for six hours the frost factor would be f/f18. On the other hand if you had -4C. for three hours it would be f/f12. In practice it will be found that -4C. with a f/f12 will do less damage than -3C with a f/f18.

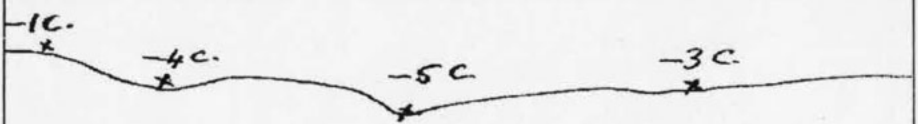
Provided the temperature does not drop below -3.5C. the plants of, and the crops of most mature proteas and leucodendrons will survive f/f22 in one night but the buds of many leucospermums will be damaged. With any frost exceeding -3.5C which records a f/f of 25 or more in one night, severe crop damage can be expected. Frosts of and exceeding -5C. will do considerable damage to many varieties even if they only lie for relatively short periods of an hour or two. The temperature of -6C is the absolute cut off point for most Proteaceae except telopea. Even if the plants do survive the crop will be seriously damaged.

3:6 Measuring frost.

During the winter prior to establishing a Proteaceae plantation growers should put out a grid of maximum - minimum thermometers on the land and read them once a week over the coldest twelve week period and record the highs and lows at each station for each week. Thermometers should be set at 40cm above ground level. Whilst these recordings won't give you the frost factor unless you read them daily and record the hours the frost lies each night, it will record the minimum temperature. If frosts of -5C. regularly occur your location is too frosty for most crops without protection.

The readings from your thermometers will quite probably show that there are big differences between stations - as much as a three degree C. variation is quite normal between the highest point and the lowest point even over a distance of only fifty metres. In most instances this three degrees makes the difference between success or disaster. It may be found that some areas within a plantation site are too frosty and some are OK or that it will be possible to grow frost tolerant varieties in the colder areas of the plantation and the more tender ones where there is less frost. It is much better to find this out prior to planting than have a wipe out after two years. I have visited many plantations that show the sorry story of not carrying out a survey of frost levels prior to planting.

It is a fact of life that as the plants in the plantation grow larger they tend to slow down or prevent night air movement thereby increasing the frost intensity. In practice I have found that a plantation of proteas five years planted and two metres tall increased the frost level at the zero to one point seven metres above ground level by about two degrees. This means that where there was a maximum of -3C before planting was done, after five years -5C can be quite common. Growers sometimes think the climate is changing, it isn't, they have changed the environment by stopping the night air movement with plantation plants or shelter belts. In any location there will always be the chance of the occasional 'rogue frost' which may only happen on an average of once every ten years. This is something that all horticulturists must live with.

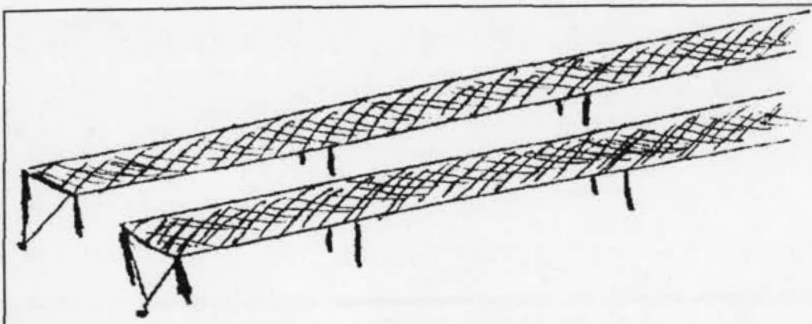


Slight variables in contour can influence ground temperatures. As little as 30cm. can make the difference of two derges C.. Be sure to measure at the lowest point. It is always the coldest spot.

3:7 Frost Protection.

There are several ways of providing frost protection in plantations. These range from installing sprinkler systems that come on automatically at zero C degrees, smoke pots, powered wind machines and stretching cloth fabrics over the crop. All have their advantages and disadvantages, Some of the frost control fabrics are somewhat flimsy and only have a one or two winter life span. Some of them are too thin to give adequate control. All systems incur extra costs and growers must measure these costs against the returns from a crop that otherwise can not be grown without protection.

I have to protect Leucospermum Harry Chittick to be sure of producing a successful crop each year. For this I use wind cloth stretched over an arrangement of wires strung along posts, (see sketch on next page). A complete cover of the area reduces the frost under the cloth by 2.5C to 3C which means that with a -3.5 frost only about -1C reaches the flower buds. However a total cover if left on for several weeks in the winter does cause possible fungi dangers. Because of this I have arranged every second 1.8m strip of cloth so it can be rolled up to let more light in during non frosty periods. In my instance the cost of this frost protection is shared by the fact that in our location this crop also needs shade in the summer and this could well be the case with many growers (see 3:8).



Frost and shade cover arrangement.

Posts are 3m long giving head high clearance and spaced not more than 15m apart. Wires are stretehed over cross arms end to end. Cloth 1.83m. wide is fastened along wires using clothes pegs or hog rings. Gap between rows is also 1.83m wide and is covered during frosty weather with another run of cloth. Rows run north/south. This is important.

3:8 Light and its affects on Proteaceae.

As outlined in Section One many Proteas, Leucospermums and Leucadendrons are sensitive to high light levels especially if a high light regime extends over a period of several months. There are various means of light measurement but the most accessible method to persons without sophisticated equipment is by the use of photographic light meters. Some of these will give read -outs in foot candles (ft/c) of light while others need correlating against one that does.

The amount of light striking the earth's surface varies from area to area. For instance on the island of Maui at 3,500 ft altitude, it can reach up to 17,000 ft/c if there is no cloud sheet. In parts of Eastern Australia where I have had a chance to measure it, the maximum has been around 9,000 to 11,000ft/c but I have no doubt that there are places where it is much more. In West Australia it is around 12,000 ft/c near the coast rising to 15,000 ft/c and more as you get some 30 km. inland. Most of Zimbabwe measured 15,000 f/c in the clear winter skies but less than this in the eastern highlands.

In practice it is not just the intensity of light (ft/c) which affects plants but the sum aggregate of radiation that it is exposed to over a given period. To measure this aggregated radiation a formula was worked out and was used in my other two books.

3:9 Measuring light. This formula was arrived at by multiplying the intensity of light measured in ft/c by the number of hours per day with that intensity of light. This is not a recognised scientific light unit but one which I evolved for the use of pesons without specialized equipment. The unit was originally given the name of Jack's light unit, but was later abbreviated to j/lu. This unit is used throughout this publication when ever reference is made to aggregated radiation. Light does not shine at the same intensity all day but reasonably accurate calculations of the daily aggregate will be obtained for a clear day by assessing that the first and last three hours of sunlight will average approximately half of that recorded at mid-day

As an example, in Zimbabwe:
First three hours @ 50% of 15,000 ft/c = 7,500 X 3 = 22,500 j/lu.Middle six hours @ 100% of 15,000 ft/c = 15000 X 6 = 90,000 j/lu.Last three hours @ 50% of 15,000 ft/c = 7,500 X 3 = 22,500 j/lu.Total aggregated for day = 145,000 j/lu.

As a comparison in New Zealand:
First three hours @ 50% of 9,000 ft/c = 4,500 X 3 = 13,500 j/lu.Middle six hours @ 100% of 9.000 ft/c = 9,000 X 6 = 54,000 j/lu.Last three hours @ 50% of 9.000 ft/c = 4,500 X 3 = 13,500 j/lu.Total aggregate for day = 81,000 j/lu.

The difference between these two levels of daily light has a marked effect on plants and crop. For instance a clone selected in New Zealand because it had all the right characteristics may, when planted in Zimbabwe, suffer severe leaf burn, scorched flower buds, or fail to set buds at all until it is large enough to create its own shade. On the other hand, if a clone selected for Zimbabwe conditions was transposed into New Zealand conditions it may grow vegetatively and not set buds.

Proteas least affected by high radiation are those that have glaucous leaves, green leaves with a red edging or those with downy (hairy) leaves. In addition to these there are those that have their leaves set in the perpendicular or semi-perpendicular such as P.cynaroides from Tsitsikamma. In Leucospermums it is those with the downy leaves that are more resistant and or those with smaller leaves especially the varieties with the bright red tips which are the most tolerant to bright light. In Leucadendrons it is those with red or glaucous leaves and those with downy surfaces that are more light tolerant. This is why Ld Safari Sunset and red salignums grow well in practically any location.

Note; In New Zealand the maximum light recorded in the years 1984 to 1990 was 9,000 ft/c but in the past five years this has risen to 11,000ft/c on a clear day. This means that our daily aggregate on a clear day in summer has risen from 81,000 j/lu to 99,000 j/lu. This is probably the result of the hole in the ozone layer which affects some of the southern hemisphere. The result of this 20% rise is that clones which were tolerant to New Zealand sunlight in 1984 are not tolerant to the levels in 1995. One particular instance is the Leucospermum cultavair Harry Chittick. Up until the late 1980s this did well in my own location in full sunlight. In 1995 we can not grow it without providing 40% shade through our summer months December to April. Other growing areas may be experiencing the same phenomena.

A parallel happening is that the incidence of eye cancer in Hereford cattle in New Zealand has risen dramatically in the past decade which is the direct effect of higher light intensity.

3:10 Protection from high light levels.

Protection from light can be carried out in the same manner as frost protection is with cloth stretched across poles and wires over the plants. A cloth with a 40% shade factor if arranged as a complete cover reduces the daily aggregate by 40%. However if the cloth is running north/south and it is arranged with one run alternating with a space of the same width then the light factor is only reduced by about 15%. In most cases this is an adequate amount of reduced light as too much reduction can cause extended elongation and a weakening of flowering stems and fungi complications. Fungi problems are dealt with in Section Five..

Research still in hand indicates that sensitive plants in our location with a clear day summer aggregate of 99,000 j/lu benefit from a 20% reduction starting from about the longest day and continuing for the next ninety days.

3:11 To irrigate or not to irrigate.

About fifteen years ago, Dr. Phil Parvin, the scientist who was in charge of Proteaceae research in Hawaii for some twenty years, made his first visit to me and one of his first remarks was "What no irrigation?" My reply was, "No we don't need irrigation in New Zealand. We get plenty of rain. Anyway proteas like it dry."

How wrong I was. Sure, most people in New Zealand, some parts of Tasmania and some eastern states of Australia can grow proteas without irrigation but that is all they can do - just grow them. The plants survive (most years) but the commercial grower can not be sure of a good and bountiful crop every year.

Many commercial growers have no option about irrigation - they either irrigate or they don't grow any crop at all, but those in temperate areas that have regular rainfall have the doubtful option of whether they risk some crops without irrigation or they just grow what will survive and produce a reasonable crop (most years) without it These are what I call the **'hit, miss and out,'** growers, ie. with their crops they **hit** it right when it rains at the right time, they **miss** when it doesn't rain at the right time so they then pull them **out** and plant something else to start their hit, miss and out programme all over again. Serious commercial growers can not afford this situation.

3:12 The affects of low soil moisture on proteaceae.

Many of the ailments that Proteaceae experience are the direct or indirect result of the plants being put under stress from a lack of soil moisture. I am now quite sure that the 'mysterious spotting' on Leucodendron Pisa, Rewa Gold and other laureolum, Patea Gold, floridum male, Leucospermum cordifolium, and some P. cynaroides variants, (to name but a few), is the result of stress caused by a shortage of soil moisture. Stress causes galling which affects the leaf surface, firstly on the upper more exposed surfaces but if the stress period is prolonged it will affect a large amount of the leaf surfaces on all the leaves of the most recent growth. It is like sunburn on a fair skinned person. The more dehydrated you get the worse it is. In a Protea stress is more likely to show up as tip burn or a burnt fringe on the leaves or aborted flower buds but a close study of the leaf will often show galling of a minor nature.

Trials (which I carried out by deliberately shutting down some drippers on a range of varieties of plants), have proved that the primary cause of this and many other problems in Proteaceae plants is stress caused by insufficient soil moisture being available for that particular variety/clone at that particular phase of its annual growth and development pattern. I have found that it is possible to turn the problem on and off as simply as turning a tap on and off.

In its initial stage, galling is not perceivable with the naked eye and it is usually not noticed until some weeks later when it shows up as an orange rust-like mess on the leaves. As soon as growers see this they think that their plants have an attack of rust type fungi and in this they are probably correct as by the time they notice it there is a fair chance that the damaged leaves will have become invaded with a rust type pathogen. If it is in the autumn it will quite probably be *septoria* or the beginnings of *drechslera* but these are always secondary and never the primary cause of the condition. All the fungicides in the world, even if applied every few days through the whole growing season will not prevent the rust like appearance of the leaves if the plant is short of moisture, all the chemicals can do is control the secondary problem. There are very strong indications that the regular application of fungicides to proteaceae plants especially those under stress from soil moisture shortage is a contributing factor to galling and the resultant rust. **Only adequate soil moisture at all times will prevent the condition.**

There is the argument that some growers who do irrigate can still have this 'rust' problem. This is quite true but in every instance that I have investigated, the problem has been traced to management in the way of;

* There had been careless application of chemicals made.
* The wrong chemicals had been applied.
* Irrigation was started too late in the dry season.
* The plants were not getting enough water when they were watered. *(See note (a)*
* The periods between watering are too far apart. This is most likely the problem when young plants are affected. *(See note (b)*

Note (a) :- It has been calculated that a four year old Lsp. 'Harry Chittick' can transpire more than 10lt per day (see 3:13). This is far more water than even the most generous grower ever gives their plants.

Note (b) :- During a recent hot dry period we had to apply 5lt. of water per plant every third day to a first year planted crop of Lsp.cordifolium plants. If they were left four days they became stressed. These plants had 40% shade for 50% of the day and had a grass/clover cover on the ground. If the ground had have been bare and if they had have been unshaded they would have needed water at least every second day to survive. The soil is a fine silt 25cm. deep over stone.

In the past I have had growers who do not irrigate say to me that their plants are not short of soil moisture because when they scratch down into the ground by the plants they can see or feel the moisture there so they think there is plenty of moisture. This is what the grower thinks! In practice plants have the final say and they often say there isn't sufficient moisture in the soil and they show it by presenting the grower with a mess of orange/yellow leaves a few weeks later. <u>You can not accuratly assess how much soil moisture there is available to a plant by just poking you finger into the ground,</u> it must be measured with a tensiometer.

Trials with plants growing in containers indicate that they can be irreversibly affected by soil moisture shortage with only two to three hours of stress. In a plantation situation this could happen on one exceptionally hot sunny windy afternoon with low humidity if the soil moisture was at a marginally low level. ie; if the trigger point was 40c/b under normal conditions, on an exceptionally drying day the trigger point may be 35c/b. (See below for definition of c/b).

3:13 Assessing the adequacies of soil moisture.

The soil moisture available to a plant is measured by an instrument called a tensiometer which measures not the amount of water in the ground but the suction in the soil that the plants roots must overcome to extract moisture from the soil. The readings are given in centibars c/b or sometimes in cases of high accuracy millibars m/b. In practice 25c/b is a very wet soil, 80c/b is so dry that you can not detect any moisture if you feel it with your hand. Coarse sandy soils reach high suction danger levels well before fine silts or clays.

It has now been identified that Proteaceae vary greatly in their ability to extract water from the soil. Most of them have a built in survival system that enables them to maintain life at 70c/b or even higher. However, there is a vast difference between survival and producing a bountiful crop of saleable flowers and to do that proteaceae must have adequate soil moisture available to them during critical periods. Research over the past few years show quite clearly that each variety and even different valiants of a variety, as well as having greatly varying abilities to extract moisture from the soil, also have greatly varying total daily uptakes of moisture.

This research has been carried out in the past four years and was done in two trials. In the first trial five named clones were used. They were; Ld 'Safari Sunset', P. hyb. 'Silvan Pink' (also known as 'Pink Ice'), P. cyn. 'Willitt', Lsp. 'Harry Chittick' and Lsp. 'Firefly'. The plants were between one and two years old and were growing in 2lt. containers. They were set up in such a way that it was possible to measure their daily transpiration rate. A plants transpiration is in relation to its total leaf area so their water loss was calculated on the loss in mils. per square centimetre (ml/sq cm.) of leaf area.

The results showed that per week 'Firefly' was the lowest at .54 ml/sq cm. 'Silvan Pink' was the next lowest at .61ml/sq cm. followed by 'Safari Sunset' at .65ml/sq cm.. There was then a big jump of almost 300% to 'Willitt' at 1.88ml/sq cm. and the highest was 'Harry Chittick' at 1.69ml sq cm. It has been calculated from these figures that a four year old plant of' Harry Chittick' with 50 harvestable stems and supporting juvenile foliage developing during the late autumn, would transpire some 85 litres per week at a day shade temperature of 28C. and a relative humidity of 45% (average).

This initial trial showed that there was a big difference between the two Leucospermums in their transpiration rate per sq/cm of leaf area but as 'Firefly' has a denser leaf area than 'Harry Chittick' the difference per plant was not so great for the same size and age of plant. To investigate whether this was consistent in another variety I ran a trial on P. cynaroides as each clone has a similar leaf area for its relative age.

This second trial used the same system only this time I used four selected clones of P. cynaroides. These were; 'Willitt', clone#10,'Woodlands', 'Tsitsikamma'. The results of this trial showed that per week #10 transpired 2.5ml/sq cm. of leaf area. This was 20% more than 'Tsitsikamma' at 200 ml/sq cm., about 90% more than 'Woodlands' and double the 'Willitt' clone. These results show conclusively that not only are there are wide variable in transpiration rates between varieties but also within a single variety and prove that some Proteaceae plants can use 300% more water per day than others can. It is also thought that some can extract their daily needs from soils that are as dry as 50 c/b or even 60c/b while others must never get above 35c/b.

These two trials were fully published in volume 28 (November 1994) issue of the International Protea Association Journal.

The next step (which is still ongoing) is to determine what are the optimum soil moisture levels needed for a particular Proteaceae variety/clone to produce a viable cut flower crop. Whilst it is appreciated that plants have different moisture demands during their different growth stages with higher demands during rapid vegetative growth phases, at this stage it is assumed that in general, those which had the least transpiration rate per sq cm will also have the lesser soil moisture level demands. Preliminary findings indicate that this is so but there are sure to be some exceptions. At present the only clone that has been fully investigated is Lsp. 'Harry Chittick' and in this clone it has been determined that under normal climatic conditions (maximum day shade temp. 27C with 45% humidity), the available moisture must never fall below 37m/b within its total root zone. If it does the plants will go into stress and produce the rust syndrome.

The implication of these findings is that plants without irrigation that are reliant on a combination of soil type and rainfall pattern to keep them adequately supplied with soil moisture are at great risk without irrigation. This puts great limitations on what varieties you can grow without irrigation even in "reliable??" rainfall areas more especially so in coarse sandy soils. It can also greatly influence how much water you will have to provide if you are to irrigate to grow a crop like 'Harry Chittick' as against 'Safari Sunset' or some other lower demand variety.

Many growers particularly in New Zealand have pulled out large numbers of plants of many varieties because of this 'rust' problem. They blame the weather, fungi invasion and unknown causes for their demise. In my opinion the only thing that is rusty is the growers management and attitude to irrigation.

Note; I don't know of any substitute to the use of a tensiometer for measuring the soil moisture availability to plants Unfortunately they are very expensive (in New Zealand a good one with ten probes will cost over $1000) but it should be possible to engage the services of a qualified horticultural consultant who has one to at least get an indication of what your plantation soil moisture does drop to in your driest months. Measurement need to be made at the depths of 15cm., 35cm and 60cm. preferably daily over a period of a week or more. If you don't there is a fair chance you will be a 'hit and miss and out,' grower. If you are an established grower you may be wasting huge quantities of water on some varieties whilst on other varieties that extra water will make the difference between a crop or no crop.

3:14 Irrigation set-up costs.

Besides having to provide a source of water or paying for what you use you must also calculate your instillation costs. This should be done on a per acre rather than a per plant basis, as the cost of irrigation installation is relevant to the amount of piping and controls needed to cover a given area. The cost of irrigating 700 plants at a density of 350 per acre is almost double that of irrigating 700 plants on one acre. The operation of irrigation is dealt with in 6:6.

3:15 Weed control.

Whilst weed control really comes into the physical aspect of plantation management, the question of whether or not to use weed matting is one that has to be answered prior to or at the time of planting because the initial cost factor must be weighed against future ongoing labour costs. The use of weed matting is now widely used by growers in some locations. There have been varying results depending largely on the varieties being grown and the local rainfall. On a cost basis over a four year period it is often more expensive than hand weeding is as hand maintenance for a four year period would amount to approximately three minutes work per plant. The reason for this low time factor is that the between row mowing or maintenance has to be done whether the plants are hand weeded or weed matting is used. The cost of three minutes of labour is much less than the cost of the material and the laying of it. In some instances however an extra growth factor occurs in the plants which can bring the plants into production a year sooner. This will more than make up for the initial cost.

3:16 The benifits and disadvantages of weed matting.

Some disadvantages have been identified in the use of weed matting. Whilst these are significant, good management can counter them to some degree.

The principal problem identified is that in areas that experience much of their rainfall in the form of many small showers rather than big downpours, much of the rain runs off to the sides of the matting and it does not therefore get readily to the immediate root zone of the plant. This can cause soil moisture levels to get to dangerously low levels very rapidly - much sooner than where there is no matting. This is a greater danger especially to young plants that have not yet got their roots out past the edge of the matting. The speed of this drying out is also expatiated by the fact that during sunny weather the temperature at 100mm below soils surface level under the weed mat is about 4C higher than in the soil not covered. This extra temperature greatly speeds up transpiration from the soil. This problem accentuated with young plants as their canopy does not shade the matting like that of older ones. Because of these two conditions created by the use of weed matting it means that in areas where the need for irrigation was marginal it becomes a necessity if you use weed matting.

There are several other problems; the rise in temperature created by the matting also raises the possibility of invasion by the soil borne fungi *Phytophthora cinnamomi* (see 5:6) which thrives in wet soils at and above 15C a condition that could be created by irrigating plants planted in matting. Clean water and the application of some specific chemicals (see 5.6) through the irrigation system during danger periods will minimise the chances of *Phytophthora* occurring.

Because of the extra soil warmth some varieties grow more rapidly and some that are normally very upright in their growth become more pendulous in their habit thus rendering some of the crop unsaleable. This is something that can be minimised by the use of the correct fertalizers applied at the correct time of year (see 6:7 - 6:8) and or the use of netting (see 6:13).

In New Zealand plants grown in matting without irrigation tend to frost more readily than those not planted through matting. This is due to two factors. Firstly, because of a soil moisture shortage during the summer the plants make a late autumn spurt of growth when the autumn rains start. This means that the plants enter the winter with soft growth which frosts at a much lower temperature than adult well hardened wood does. The other reason why they frost more is because the matting prevents any residual warmth that may be in the soil from coming up from the soil on a frosty night and creating a warmer layer around the plant This is only a small amount of heat but it is significant. Plants in weed mating often get damaged in the 70mm to 120mm zone above ground level where as those in grass cover don't.

The final problem is that matting is a wonderful haven for insects such as the rose weevil and other ground dwelling insects. These insects which are nocturnal come out at night and chew great chunks out of your leaves, particularly Leucodendrons. The problem can be minimised by the use of certain prills (see 5:18).

Whether or not weed matting is used in a plantation must be weighed up against all the items above. On the plus side plants growing through weed matting, provided the management is excellent, often come into full production a year before those set out in open land and there is virtually no weeding to be done during the whole development period. An alternative to weed matting is to use some form of mulching. This outlined in 3:22.

3:17 Calculating the cost of weed matting. Like irrigation this is relevant to the area planted rather than the number of plants. In some instances the capital cost of weed matting and its initial installation is greater than the cost of four years of maintenance labour.

3:18 Hand weeding.

Weeding by hand or hand held tools is the safest method especially when the plants are small. The time factor of labour involved is not great when worked out on a per plant basis. Time sheets kept over a two year period on a test plantation containing 350 plants planted on flat ground in three meter rows by one and a half meter spacing revealed that the total time expended per plant for those first two years of the plants life in the field took 3.5 minutes per plant including mowing between the rows.

A further break-down of time showed that of this 3.5 minutes only 1.5 minutes per plant was expended on hand weeding.The use of hand held petrol powered weeders which use a revolving plastic string to cut off weeds, whilst making the control of weeds close to the plants easier and (debatable) quicker, do present a hazard to Proteaceae plants particularly those less than three years old. The revolving plastic string is deadly on the bark of young Proteaceae plants particularly in the spring when the sap is running. One slip in control and it will completly remove the bark off a three year old plant at ground level. The plant will die. This is called 'weed eater blight'.

3:19 Chemical weeding and the dangers associated with it.

Chemical weed control ranges from giving troublesome weeds an occasional burn off with a desiccant to carrying our a scorched earth policy with total kill compounds which are claimed to be selective in what they kill and appear (at least visibly) to affect only specific families of weeds. The fact that they do not visibly affect proteaceae, at least during their first year of use in the plantation does not mean that they have had no effect at all on the Proteaceae population..

The use of any chemical to control weeds within the root zone of any Proteaceae plant puts the plant at some risk. The level of risk varies with the variety of the plant, the chemical used , the time of year it is used, the soil type, rainfall and/or irrigation (if used), and the accuracy of both the rate and placement of the chemical along the rows.

Discounting spray drift onto a plants foliage (which is irreversible damaging), the danger level of a chemical to a specific plant depends on what chemical it is and whether that plant has proteoid roots active or not at the time of the application or during the active period of the chemical. In year round rainfall areas Proteaceae proteoid roots are active for much of the year especially if there is a considerable herbage cover of the ground adjacent to the plants. In such instances, particularly from late winter through to early summer it is possible to find proteoid roots right on the soil surface under matted weed growth. An application of any type of weed control chemical over these roots can be disasterious. If this publication included colour photos I could have published some hair raising pictures of the results of this.

Two chemicals that have been used widely in Proteaceae plantations are Round-up and Simizine and their counterparts. Both of these at full strength are "total kill" to weed growth. When Round-up has been used in plantations where there are weeds with thick fleshy roots, such as kikuya and couch grass, clovers, docks, Californian thistle, yarrow etc., problems have often occurred through the trans-location of the chemical from the weed roots to the plant roots. This will cause ill thrift and sometimes death. It is not uncommon to see Californian thistle dying over two metres away from where the chemical was applied. See 8:9.

This risk of damage from trans-location diminishes if the weeds being controlled are only shallow rooting but if proteoid roots are present and active near the soil surface at the time of application, a high risk factor still exists. If Simazine is used within the root zone of Proteaceae similar results can be expected especially if it is still present in the soil during the period when proteoid roots are present and active. See 8:8

Soil structure greatly influences the penetration of this type of chemical: coarse sandy/porous types are affected to much deeper levels than fine silts and heavy clays. In the latter there appears to be little penetration beyond surface levels unless excessive quantities are applied over a long period or the ground surface is deeply cracked at the time of application.

If chemical weed control is to be carried out, local information should be sought as to "safe"? compounds to use on that particular soil type and the rates it may be used at. Accuracy in application is essential as the difference between weed control and toxicity to plants may be very fine.

I believe that there is no safe weed control chemical that can be used in a Proteaceae plantation.

3:20 Identifying damage from weed control chemicals.

The first indications of chemical damage via the root system is a paling of the leaves, sometimes accompanied by slight variegation particularly on the tips of the leaves and in many varieties an out of character flushing of pink/red on the edges of the leaves particularly on those more exposed to the sun. As it progresses general ill thrift and a stunting of growth develops. Leucadendrons may form bracts earlier than seasonally normal. If you take a stem of an affected plant and cut or break it, it will be found that the wood has a yellow colouring rather than the normal white/green colour. The core (pith) will be dark brown colour instead of greenish and the general texture of the whole stem will be corky and with more advanced poisoning the bark will look and feeling dehydrated. Eventually, (especially in colder climates) in an advanced stage of poisening the plant may take on a silvery appearance. It is a condition I call False Silver Blight. For further information on this syndrome see 5:12..

In warmer climates the plants may not go silvery but they will show considerable ill thrift, a reluctance to make vegetative growth from the terminals and take on a yellow hue. It is like AIDS, there is no cure.

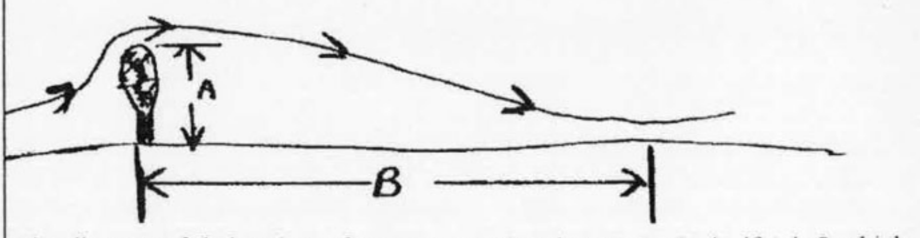
3:21 Provision of wind shelter.

Some areas may have all the aspects of being an ideal site for Proteaceae production but are too windy to grow saleable stems without the provision of wind control. A high wind run over a prolonged period can greatly affect stem length especially if it coincides with the spring growth flush. Strong winds can also be very damaging to plants and shorten their productive life somewhat. No Proteaceae variety is that well blessed with a strong root structure at ground level, infact it is the weakest point of most varieties. Consequently many plants end their productive life prematurely from being blown over if it is very windy and they are not protected in some way

There are two methods of wind control; wind fences made from timber and cloth fabric or trees. Both have advantages and both have problems.

Wind fences made from timber and cloth are expensive to erect but do give immediate protection. Tree hedges grown from such species as poplar, willow (poles) or from young trees of some type (quite often there is a suitable local native species) are cheap to establish but have the disadvantages of robbing the soil of nutrient and moisture. They can also act as host to many insect pests and some fungi. These can be a big problem as it is almost impossible to effectivly spray tall hedge rows to control them. They also have the disadvantage that as they age they may create so much protection that 'frost pockets' form within the plantation, see 5:3 to 5:6.

First time growers should be guided by methods and types of trees that are used locally in providing wind protection. The amount of protection that a fence or hedge line will give is demonstrated below.



The distance of shelter that a fence or trees gives is A X 6 = B. ie. if A is 8m high it will protect B which is 48m wide

3:22 Mulching the root zone.

As stated in Section One, Proteaceae in nature are never found growing in bare ground - their root zone is always protected by old dry grass trash or a litter of their own fallen leaves, twigs etc.

Mulching is growing in favour with many growers. By providing a mulch you create conditions much closer to what Proteaceae have in nature. This litter which is several cm deep protects their delicate proteoid roots from wildly fluctuating temperatures and soil moisture levels and as in nature it also creates an environment where micro organisims thrive. These are an essencial part of any plant life, particularly proteaceae (see 'Proteas' page 185). There are strong indications that Proteaceae being grown in plantations that are rich in micro organisims are much less susceptible to fungal invasion. It is part of their built in immune system.

There are many materials that can be used for mulching and they range from local dried grasses, cereal straw, bark from trees, sawdust, husks from nuts and other vegetative waste. The one thing to ensure about any material that you are going to use is to make sure it does not contain any toxic chemicals (such as some cereal straws can in the form of a residues from the weed control hormones used on the crop) or that the material that you do use does not go through a toxic phase while it is breaking down. This can happen with such materials as pine bark if it is used before it has aged.

Some growers are now using mulching machines to mulch the prunings from within their plantation and using this in their plantation. This practice carries a high risk of recycling diseases present within the plantation and spreading them throughout all the plantings. It may be a contributing factor to the greatly increased fungi problems reported by some growers.

SECTION FOUR.

Plant Variety Selection, Layout, Planting.

4:1 Overview.

Section Three dealt with the various aspects and options available in planning a plantation. This section deals with the selection of plant varieties that will grow and crop within the parameters you have set yourself by deciding whether or not you will provide irrigation, frost protection etc. It also outlines the practical aspects from plantation layout right through to putting the plants in the ground.

4:2 What varieties will you plant?

For a first time grower this is a difficult decision to make and it is even more difficult for someone who has not had experience in cut flower production.

Growers who are in high humidity areas with th/c levels of 100 and more on a regular basis will be governed by this factor as it is a waste of time, energy and money to plant a variety known to be intolerant to such conditions. For this reason growers not experienced in cut flower production should be guided by what is already planted locally. With regard to the varieties that are suited to your location you must also be guided by what the export agent or domestic end user says about supply and demand. Don't plant something just because you happen to like. It may flower at the wrong time of the year to command a good price or the consumer may not show your enthusiasm for the same flower.

If the cut flower project is part of a wider horticulture programme care should be taken that you do not choose varieties whose harvest period clashes with peak work periods of other crops. In some instances your environment will govern what you can grow or not grow. Particular attention should be paid to the items in the previous section dealing with soil type, humidity and frost.

The safest and perhaps in the long term the most profitable for the new grower is to plant the easiest varieties to grow. These will not necessarily be the highest yielding crops but they are relatively safe and suited to do a learning process on while still giving a worthwhile return. In New Zealand by far the safest and easiest crop to grow is leucodendron Safari Sunset. It enjoys steady market demand autumn to early winter and mid to late spring. It grows well in most locations and is quite forgiving even if the beginner does make a few mistakes in culture and management. Returns are worthwhile but it is not in export demand May through to August so it either has to be harvested in the autumn or spring.

Every country and growing area has its own easy crop? Don't just plant something because it happens to be available from a plant producer at a special price, it could be available because nobody else wants it.

In summary:- Don't start with a variety that is known to be a difficult subject such as serruria florida is in most locations. The price being offered for the end product may be very attractive but if it is that good and easy to grow and such a big money maker somebody would already be doing it.

Be wary of varieties if they have been imported and not extensively trailed in your area. Quite often their growth and performance is different to that in their country of origin. This is particularly so with Leucospermums. They may be fine in Africa, West Australia or Hawaii but a disaster in eastern states of Australia and New Zealand because of different humidity, light and temperature factors.

4:3 Plantation layout.

Irrespective of the contour, the design of the plantation should always take into consideration the factors of ease of harvesting and the promotion of good air drainage. On steep land where it is not possible to use a tractor, layout should be arranged wherever possible so that all harvesting is done downhill to collection points. The end product of most Proteaceae is bulky and often quite heavy. A lot of your prospective profit can be used up in labour in harvesting in a poorly designed plantation where a lot of hand carrying is necessary to get the product to the vehicle that is to take it to the pack house. Air movement helps to moderate temperatures on leaf surfaces in summer. It also tends to provide slightly higher temperatures in frosty conditions.

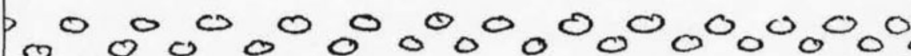
Dense stands of tall proteas or hedge rows running cross wind will reduce air movement particularly in the critical zero to one point seven meters above the ground zone where most of your crop will be harvested from. In some areas the margin between the normal local frost level and one that would cause damage to the flowers or buds, is only one or two degrees Celsius. As this is the difference that night air movement makes when it is encouraged rather than restricted, it is important to arrange the rows to encourage air circulation. Frost control is discussed fully in 3:6 - 3:7.

4:4 Plant spacing.

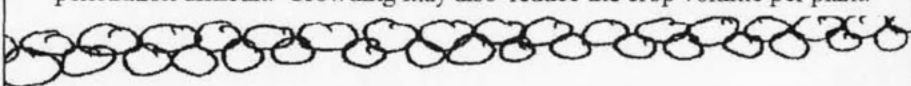
On flat land where it is possible to use machinery the width between rows is controlled by the width of the machine, and is a sum of the ultimate width of the plants plus the width of the machine. Most proteas and the larger types of leucospermums are usually at three metre rows with one and a half metres between plants, (10 feet X 5 feet) and for the smaller Leucadendrons two and a half metre rows and 60cm to one metre between plants. These spacings permit satisfactory access and air movement even when the plants reach maturity On steep hillsides spacings are usually a little closer and often have to be varied to suit the terrain. Being a little closer on a hillside is acceptable as the tiered effect gives more air space to each plant. Where irrigation is being installed on hillsides the rows always run across and follow the contour. This helps to equalise water pressure at the drippers and thereby give even rates of water application.

Another method of plant layout is to plant two rows back to back (see sketch). This method is sometimes used with the taller growing more upright types of Leucodendrons like Pisa and Safari Sunset. It has the advantage of saving space thereby giving a greater plant population in a given area. In the first two years it also lends to the plants protecting each other from wind. At maturity it has the disadvantage of making it difficult to get adequate penetration of sprays and the ultimate size of the plants may eventually result in crowding thereby reducing the crop on three sides of the plant.

Back to back is ok when they are small and not crowded.



It is not so good when they get large and start crowding. It make spray penetration difficult. Crowding may also reduce the crop volume per plant.



4:5 Pre planting preparation of the land.

If chemicals are to be used to clear existing herbage it must be borne in mind that the roots of all Proteaceae plants are highly sensitive to most chemicals particularly those that have any residue or trans location effects. Simizine or Round-up or their counterparts must never be used either before or after planting within the area of the root zone or where the roots will penetrate within two years of planting. The dangers of chemical weeding is discussed fully in 3:19 & 3:20.

Another danger to Proteaceae plants is the decaying roots of woody plants in the ground particularly conifers. It has been observed in many locations that where significant growth of woody plants has had to be removed prior to planting, then poor plant performance or at times significant losses of Proteaceae plants may occur for at least the first two or three years after clearing - longer with some slow decaying types.. The decaying roots of some species of plants in the ground will make it unsafe to plant with Proteaceae for seven years. In West Australia I have seen Proteaceae affected three years after Eucalyptus were removed. In Zimbabwe they can not plant tea for seven years after removing the natural flora. Proteaceae would probably be the same. In El Salvador Proteas were planted where coffee had been removed and deaths occurred for three years and in California Proteas were a dismal failure where scrub oak was rotary hoed into the land prior to planting. If conifers have been in the land prior to planting Proteaceae you are sure to experience this problem and may even have a 100% loss. Where kiwifruit orchards have been cleared and they are being over-planted with Proteaceae, rows should be sited down the middles between the old rows and not along the old kiwifruit rows. Over-planting in kiwifruit orchards also carries the risk of encountering herbicide residues (see 3:19).

4:6 Compatibility of container medium to plantation soil type.

The medium in which the plants are grown in the nursery has a great bearing on how successful plantation establishment is of many varieties of Proteaceae. Whilst plants grow quite satisfactorily in mediums composed of a high content of peat and or pine bark during the nursery production phase, it is when they are planted out in their final site that problems occur. This syndrome is not restricted to the genus proteaceae but is applicable to many plants found in cultivation. Both peat and pine bark as the dominant material in a container medium create a number of problems for Proteaceae plants when they are set out in the plantation. Both materials become air-locked when they become dry and when this happens they will not take in moisture by normal capillary action from the surrounding soil. This means that if the plants are meant to get their moisture from rain the moisture never really gets into the mass properly once it has dried out. This can cause very serious and sometimes permanant damage to the plants (see 3:11 to 3:13).

To be re-wetted they must be flooded to expel the air and this can only be achieved by having the dripper emitting directly into the container mass. This then causes the container mass to act like a sponge and it becomes excessively wet. When this happens and it is associated with soil temperatures of 18C and over it becomes a perfect harbour for the soil-borne fungi *phytophthora c*. The sponge effect also acts as a collection point for damaging water soluble minerals, i.e. nitrate salts, phosphate, lime etc. which can seriously damage the plant especially the delicate proteoid roots.

Plants that have been container grown in these soil-less mediums unless manipulated in some way almost invariably have great difficulty establishing a root system outside of their original container mass. This problem is ongoing and is the reason for many Proteaceae plants to suffer from stress in later life. It is quite common to see plants that have been planted for three years with no significant root activity past the perimeter of the original container. These plants are often starving, short of soil moisture or both and even if they do live they often show constant ill thrift with a resulting loss of production.

Comprehensive trials which tested the effects of various commercial mediums on the development and survival of proteaceae plants were run over a period of three years and were completed in 1986. The findings of those trials which were fully published in 'Proteas' showed quite clearly that the effects that these materials have on root systems development after planting out and can be the cause of losses of up to 70% inside the first two years.

4:7 Combating the peat/pine bark syndrome.

If you have to use plants that have been nursery produced in these mediums you should take action to minimise the risks.

The magnitude of the problem is to some degree related to the container size that the plant was in when it is taken to the field for planting. In practice plants in 5cm (2inch) tubes give less problems than those in 2 lt (1/2 gal.) containers. This is probably because some of the material often falls away from the smaller root mass when it is taken from the container for planting. Larger sizes are usually quite solid and compacted in their root - medium mass and no material falls away when they are removed from the container for planting.

If the plants are in small containers (up to 400cc - 4 inch) and not root bound it may be possible to shake 50% (minimum) of the medium mass from them and then plant them in the field. This is only safe to do if climatic conditions are at low transpiration levels as a small plant will perish in a day with this treatment if it is hot, windy and sunny even if it does have adequate soil moisture. The safer course is to remove the plants from their container, shake 50% of the medium from them and re-pot them into a slightly larger container using a mix of 50/50 of the plantation soil and a coarse sand. Stand the plants in a sheltered position with 40% shade for about a week and keep moist but not wet. Remove the shade after a week and within three weeks they will produce a new set of roots in this medium which will be compatible with your plantation soil. They can then be planted out without any risk of future problems from incompatibility. Do not add fertilizers - you may seriously burn the roots.

Larger plants are a problem as what ever you do they will still have that peat/bark mass at the base of the plant. If transpiration conditions are low they could be partially bare rooted and planted in the field provided adequate soil moisture can be guarantee. Alternatively they can have the same treatment as the smaller ones. If I purchase stock plants that have been produced in these mediums I wash them clean under the tap and then plant them. This is somewhat drastic but it does work - most times.

4:8 What size plant should you plant?

Your overall financial situation may influence your choice of plant size. However it is recommended that plants should be a minimum of nine months old and a maximum of eighteen months old when planted out. Plants younger than nine months are still in their juvenile stage and do not have the resilience to cope with the adverse weather conditions they will encounter following final setting. It can be a tough life for a young plant out in a wind swept wet cold field. At the other end of the scale plants older than eighteen months start to lose vigour in their root systems, unless that vigour has been maintained by moving the plants up successively into larger container sizes during their time in the nursery. Plants older than eighteen months often suffer wind rock and are almost always eventually outstripped by younger plants in their development to production in both time and final volume of crop.

Provided they can be looked after adequately following setting out, and they have been well prepared in the nursery, grown in a medium that is compatible with the soil type of the plantation, 9 - 15 month plants from a 100mm (4") pot, or 18 month plants from a 150mm (6") pot, give excellent results. Plants of this size are at a point of development when a strong primary root system will grow rapidly. This strong root system is the basis of their future production capabilities. Plants should be provided with adequate soil moisture during their development and throughout their productive life. This is discussed in 3:11 to 3:13.

4:9 What is the best season to plant.

Planting time is usually controlled by the climatic conditions that are experienced during the seasons. There are a number of factors to consider. In areas that can expect frosts of more than -2C. there is little point in setting out young plants in the autumn if they are going to be damaged by a -4C. frost during the winter. On the other hand it is debatable whether it is prudent to plant when you are just entering a six month dry period unless you are sure that you have adequate water and labour to apply the water to see the plants through to the next rains.

When planning your planting consideration should also be given to the plants natural rhythm of development as there are periods when Proteaceae make major primary root development and other periods when they make none.

Whether they are in their native habitat or under cultivation, all Proteaceae follow their natural seasonal rhythms of growth and although they don't all do the same thing at the same time, they all have periods when they are growing roots, or growing leaves and branches or resting and growing nothing. It is virtually impossible to break their seasonal rhythmic pattern of growth and rest periods.In all varieties and species primary roots develop sometime from early winter to late winter and then again from mid spring through to about the longest day so if you are to capitalize on these two periods when there is a rapid development of primary roots, the two best times to plant are just entering winter and again around the springe equinox. First time growers should be guided by local trends in planting times. We always plant just after the spring equinox when the chances of frost are past.

4:10 Setting the plants in the ground.

It is imperative that the plants are hardened off prior to planting. This is one of the most important phases of establishing a plantation. Plants straight out of a shade house will almost certainly fail from the effects of sudden exposure to the elements.

For several weeks prior to planting, plants should be given increasing exposure to light and air movement while at the same time gradually reducing their reliance on frequent watering. If you notice the foliage turning pale during the hardening off process this indicates that the process is being done too rapidly. Increase shade and water to rectify then after a few days start the hardening off process again.

Plants should be set in the ground slightly lower than they were in the container, with the soil being back filled and only lightly firmed down. Do not pound down hard! Plants must have air in the soil or the roots won't develop as they should. If you think they are going to rock in the ground stake them immediately. Proteaceae all tend to be a little weak about ground level.

If it is considered that they need immediate watering after planting, this indicates that the soil was too dry before planting was done. It should have been moistened prior to planting. Heavy watering immediately after planting will expel the air from the soil and will have the same affect as pounding the soil down too hard. If at all possible watering should be with held for four or five days as if the plants are made to hunt for moisture they will continue to do so throughout their life. However under no circumstances should freshly planted plants be left under stress for want of soil moisture. It may do lasting damage to the root structure. Ideally the soil where they are being planted should be slightly damper than that of the container mass.

SECTION FIVE

Fungi And Insect Control.

5:1 Overview.

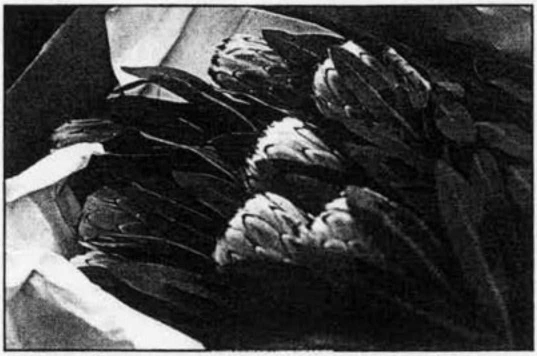
As outlined in 3:4, climatic conditions have a great influence on whether fungi are a problem in a particular location. If you have a high th/c you can expect problems. Once the plants are in the ground you are committed to keeping diseases and pests under control. This section outlines how to combat the most probable problems you will encounter.

In an outline of diseases, pests and other Proteaceae ailments such as this, it is impossible to cover the huge range of fungi which can invade Proteaceae or identify the individual species of insects that will invade plants from time to time as each location or country will have its own local forms of fungi and insect populations. It can however distinguish at least some of the fungi forms that are common to all growing areas and identify the different types of insects that will be encountered. It can also outline how to combat and control the problems caused by fungi and insects and this is what this section does.

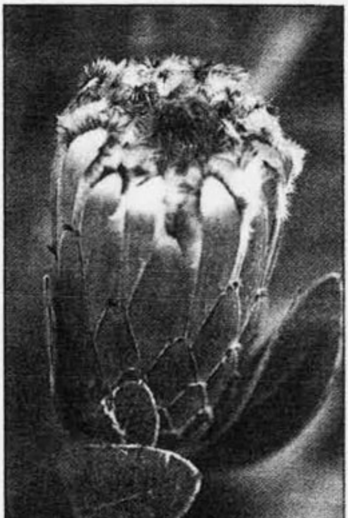
There will be occasions when growers will encounter problems outside of those covered here. In such circumstances it is important that expert local advice is sought for identification and control. As discussed in Section Three the provision of the correct environment by paying attention to the th/c levels, air movement, light levels and selecting the correct variety or variant for a particular location will go a long way in reducing problems. If you haven't done this and you have planted the wrong species/variety/clone for your location, you may encounter uncontrollable problems, in which case you will probably have to start all over again and plant varieties more suited to yoour location.

5:2 Types of chemicals.

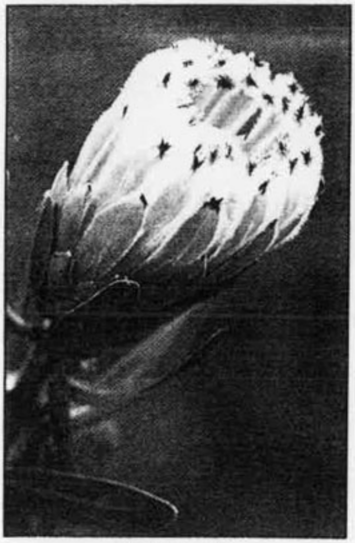
Although there is a growing move towards biological control of fungi and insects in all manner of crops, the most usual way is still with the use of chemicals. There are two basic types of chemicals - contact and systemic. Contact sprays work by enveloping the plant with a chemical that will control or kill the fungi or insect pest and are effective until it becomes oxidized, weathered off to such a level that it is ineffective or the plant has grown new tissue thereby outgrowing the protective layer. When any of these happen a new application of chemical must be applied to retain control. The systemic types work by becoming absorbed into the sap stream and remain efficient as long as they do not become diluted to an ineffective level through an ageing process or when the plant grows more tissue. This happens more frequently when the plant is growing rapidly in the spring/summer than it does in the winter. Systemic chemicals are very effective if they are applied at the recommended



These flowers were poorly handled at harvest.



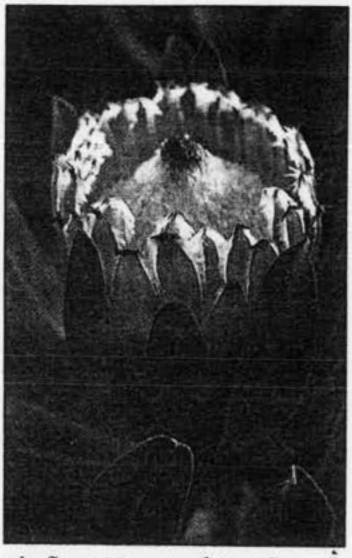
Plants grown from seed almost always produce flowers below expectations like these two. The chances of getting a good flower form from a seedling is less than one in five hundred.



Pink Satin

Silvan Pink

The Proteas on this page are all selected clones.



Candy floss. Near perfect colour, form and texture.

Excellent Magnifica flower.

The lighting where a flower is used is important. This is Ld. Safari Sunset. The photo on the left was taken in fluorescent light. The one on the right are the same flowers photographed in natural light.

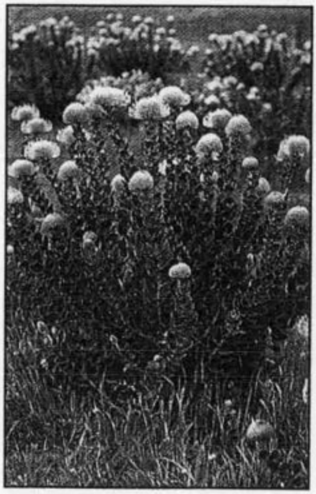
Diseases in Proteaceae must be controlled. The photo on the left shows Botrytis a very common fungi in proteas. The photo on the right shows a plantation in Zimbabwe where Pestalotia was out of control, a case of having planted the wrong variety for that location.

Serious by-pass

No. by-pass

These two photos show what by-passing is.

Highly productive proteas which have been planted twenty six months. The variety is "Lett's White".



Three year old Leucospermum "Harry Chittick" which have been planted for thirty months.

rates. However some varieties of Proteaceae are susceptible to foliage damage from them particularly on plants that are less than two years old and most leucadendrons of the multi head types of any age. This is particularly so when the plants are in very active growth.

Plants should never be sprayed with any chemicals when they are under stress from dehydration from any causes, nor should they have it applied in full sun if the temperature is above 25C. (78F.) Safest and best cover is obtained when sprays are applied in the morning just as the foliage is drying off from overnight dews.

With all chemicals read the label properly and apply at the lowest recommended rate. Quite often Proteaceae won't be listed on the container. If they arn't listed use the minimum recomended rate for ornamentals or avacardo. Do not add an extra dash or cup full of chemical for luck. It may do untold damage to the plants. Also, irrespective of what the labels say about the product being compatible with others, I am a strong advocate of applying all chemicals on their own and not mixed with others. Serious damage can happen to leaves and at times the bark on young branches when the wrong chemical is used, when too much chemical is used and when some combinations of chemicals are mixed and applied together. Plant tissue damage whether it is caused by misuse of chemicals, frost damage or excessive light levels is one of the prime causes of continuing fungi infection in Proteaceae. The fungi enter through or initiate in the damaged area. A healthy undamaged plant is at minimal risk. A sick or damaged plant is at great risk.

A sound investment for any grower is to purchase the current chemicals manual in your country. A good one will help you identify your problem, list all the chemicals available and their counterparts under other trade names and outline their uses and application rates and methods. ***Read it, study it and follow it.***

5:3 A specific chemical for a specific use.

Both contact and systemic formulations come in many forms and each one has usually been developed for, and is efficient in, controlling one or two fungi or insect groups but none will control all forms and types of either. Because of this it is necessary to use or have available at least two different formulations each of fungicide and insecticide which may be of either the contact or systemic types.

It should also be borne in mind that with most fungi and insects there is a percentage in any population that will be immune to a particular chemical. Most of the protege of these immune fungi and insects will also be immune to that same chemical and over a period of time you will have a population explosion of greebies or insects that just laugh at that chemical. For this reason it is necessary to switch formulations every second or third spray to keep them off balance. I know of one grower who has used the same insecticide (because it is cheap) for about eight years and he can not understand why he can't kill his bugs. I'll bet the bugs laugh their heads off every time he sprays.

There are composite formulations available for home garden use which will control a broad spectrum of fungi and insects together and in most instances these are quite suitable for home garden use and in a plantation for general control. However for commercial production it is better to use a specific chemical to control a particular problem and switch chemicals every third or fourth application.

5:4 Methods of application.

The effectiveness of any chemical is to a large degree controlled by the competence with which it is applied. This is particularly so when you are dealing with plants that have a leaf structure that is difficult to wet. Some Proteaceae have such a leaf and when treating these types it is necessary to add or increase a sticking agent.

There are many ways of applying chemical sprays with the principal ones being: high or low pressure which sprays the chemical on and air blast assisted dispersion. High pressure application is much more effective than low pressure but pressures of 500 lb/sq inch can damage foliage and flowers if the nozzle is too close to the plant. Any method of low pressure application has the problem in that it does not have good penetration through dense foliage. Sprays can also be applied at low pressure by knap-sack hand operated sprayers.

The air blast method injects the chemical into a high volume air stream which disperses it throughout the plants in very fine particles. Such a system is effective provided the correct amount of chemical is distributed per area treated. Unless well operated this method can blow the chemicals right through and out the other side of a plant and leave insufficient on the plant to be effective. Remember, what ever method is used it is important that the foliage is properly covered as the control of fungi or insects will only be as good as the completeness of the spray cover.

.5:5 The control of fungi - overview.

In spite of taking every precaution to avoid fungi problems, climatic conditions will prevail from time to time which makes chemical control a necessity. This is proving increasingly frequent in the production of Proteaceae where the practice of monoculture at high densities, sometimes in less than ideal situations, creates conditions that foster fungi. not previously known to invade Proteaceae. Most fungi may be controlled but once it is present it is improbable that it will be eliminated in any crop. Because of this it is necessary to continually monitor the crop and apply chemicals on demand to control fungi invasion and or improve plantation management. It is much better to prempt a problem and prevent it than to have to try to eradicate it once it is out of control

The following information is given as a general guide to the control of fungal diseases. As the problems that will be encountered vary so much from one location to another and all chemicals are not universally available, it will be necessary for operators to implement their own specific treatments for the special problems they will encounter. Expert advice should be sought from the agricultural chemicals division of the parent distributing company for full information of their product's effectiveness in controlling specific fungi and the correct method and rates of application needed to gain that control. Don't rely on what the local plant shop assistant tells you.

5:6 Soil borne fungi.

There are three principal soil borne fungi that affect Proteaceae. They are ***Phytophthora cinnamomi*, *Fusarium*** and ***Rhizoctonia***. They are present in many soils through out the world and affect proteaceae plants wherever they are grown .

If P*hytophthora c*. is a real problem in your plantation it is an indication that the site is unsuited to proteaceae production and that you have made a basic mistake in planting there. It is a water-borne spore which under the right conditions can multiply at something like forty eight times every twenty four hours. To do this it needs temperatures of above 18C. (65F.) and a high water content (25c/b or lower) in the soil. If you have these conditions you may be able to partially control it (at great cost both mentally and physically) but you will never beat it.

Partial short term control can be had by using the chemicals, Terrazole in both wettable powder and emulsion forms, Ridomil and Aliette in Wp form. All of these are useful but not infallible.

Ridomil should be used with restraint especially on smaller plants as proteaceae have shown an intolerance to other than low levels of this material, especially during hot bright weather. When this chemical is used it must be drenched in as it will only travel in an upward direction in the plant and as it is the root area where control is needed it must be flushed down to that level. On the other hand Aliette travels in a downward direction so it should be applied to the leaves. If you are treating varieties that have shiny leaves that spray won't stick to you should use a sticker with this material or you will not get satisfactory control. These three chemicals along with some other products containing phosphorus acid as a control agent have had some success. One of these named Foschek although registered as a liquid nutrient has shown excellent control of *Phytophthora*.

Fusarium and *Rhizoctonia* operate at ground surface level. They are seldom a problem in established plants unless the plants become overgrown with grasses which are a principal host to these two diseases. As *Fusarium* and *Rhizoctonia* are frequent turf disease problems, products registered for their control in turf may be tried for control in Proteaceae.

. 5:7 Fungi above the ground - overview.

It is the control of these fungi that growers will mostly be involved with. If you are having problems which are outside the scope of this book seek local help .Local knowledge of what fungi are likely to be present and their control are a growers best weapon. Also check your chemicals manual.

5:8 Botrytis.

The most common fungi that will have to be dealt with is *Botrytis cinerea*. This fungi is present almost everywhere and will be found on most plant species. In Proteaceae it will affect all varieties to some extent with those with hairy leaves being at the top of the scale and those with smooth leaves being least affected. At and above th/c105 (th/fl60), all varieties may be affected to some degree in the growth tips, immature leaves and flower buds. Commercial varieties that are particularly susceptible to this fungi are pr. magnifica and lsp. cordifolium, but all varieties are at risk. The problem is most likely to develop in the growth tips. It forms a grey powdery mildew which under the right conditions can spread rapidly. It is much better to anticipate the problem and apply chemicals as a preventive measure rather than to have to eliminate it once it is established. Captan, Difolatan, Ronilan and similar chemicals will all control this fungus. The best long term control is to provide good air movement,

Under the same conditions that *Botrytis* is present and active there will also be other fungi active and it is difficult without expert identification to identify which ones they are. Fortunately most of these are controlled by the application of the chemicals listed above.

5:9 Pestalotia.

If fungi problems persist following treatment for *Botrytis* the plants are probably infected with *Pestalotia*. This fungi is more likely to appear in the early autumn than the spring/summer seasons and once established it can persist through the winter. It mostly affects Leucadendrons and Protea and is seldom seen on Leucospermums. It first appears as a brown lesion on the leaf, usually at or towards the tip but it may be on the side about half way along. It almost always starts where there has been tissue damage to the leaf area caused by photo sensitivity to sunlight, chemical burn, or in the winter, frost damage. As it develops, a dark brown to black fringe shows on the side of the infected part of the leaf. This fringe is always on the side which is nearest the stem of the plant. If it is left unchecked it will progress quite rapidly along the leaf and it will enter the plant stem via the leaf petiole. If this happens on young plants it will kill them especially if the invasion is near ground level. On older plants it will cause the branch to die off.

When *Pestalotia* becomes established it is difficult to eradicate. Control is by applying Benlate/Captan or Octave. Check your local chemicals manual for what chemicals are available to you. Treatment should continue until the dark brown/black edge disappears and becomes a grey/brown colour. As long as the black edging is present the fungi is still active. If the infection is not widespread consideration should be given to clipping off all infected leaves and burning them. This is not a substitute for applying chemicals and these should still be applied.

5:10 Drechslera.

This is a serious problem if you have it. In some locations it has made the commercial production of Lsp. cordifolium as a cut flower impossible. This disease is widely distributed in various forms and has infected leucospermums in Africa, Australia and New Zealand with each country having its own particular strain. It is identified initially as a tan coloured spot which develops a purple margin. As it progresses it destroys the leaf and sometimes the stem tissue and in a very advanced stage it may form a canker like appearance on the stems causing die back and sometimes death.

Its natural host is grass and its principal shrub host is Leucospermum. I am now quite sure that one of the reasons it invades plants is because the plant has been stressed or damaged in some way and that its active presence in a plantation is almost always secondary to this stress or damage. If you can eliminate the stress or the physical damage you will have gone a long way to eliminating the disease from your plantation. Once it is established, control is difficult and not very cost effective. Check your chemicals manual and take a long holiday.

5:10a Elsinoe disease.

This like *Drechslera* is also a very serious disease and is brought on by similar weather conditions and also probably following physical damage. It starts with red scab lesions on the new seasons stems and as it progresses it may cause stems to twist and become distorted. In an advanced stage it may cause cork like scabs on stems. It is very damaging to Leucospermum and to a lesser degre on Leucodendron, Mimetes and Serruria. Once established it is very difficult to control and virtually impossible to eliminate as it can remain dormant for a considerable time and re-emerge the next time weather conditions favour its development. Sanitation pruning and chemicals may give some control. A long fishing trip or skiing holiday is recomended.

5:11 Silver Blight. (Common name). *True form.*

This fungi *(Chondrostereum purpureum)*which is commonly called silver blight or sometimes silver leaf is commonly found in stone fruit crops and has now become established in leucadendron plantations in New Zealand. The incidence of this fungi in Proteaceae crops in New Zealand is almost certainly primarily due to cross infection from willow shelter belts - a known principal host of silver blight. A classic example of this is recorded on page 29 fig .4.4 in' Protea Diseases' by Sharon Von Broembsen which shows a very sick plantation of L Safari Sunset planted adjacent to a willow hedge and bare ground around them from the use of Round-up. Both willow trees and the use of this type of chemical close to Proteaceae plants are short-cuts to disaster.

Some control may be achieved by good hygiene at all times and the spraying of all cuts following harvesting or pruning with Difolatan/Captan + Benlate. There has been a paste developed for use on cuts. Once established silver blight is impossible to eradicate and it is best to remove infected plants from a plantation as they are a constant source of cross infection to others. There are many instances when growers think they have silver blight and they don't. What they do have is a physical disorder which I call 'false silver blight'.

.5:12 False Silver Blight.

Whilst it is true that silver blight has been identified in Proteaceae plantations in New Zealand, there is a phenomena which occurs that has a very similar appearance. There are some years when this condition is widespread and reports indicate that it has been seen in most plantations at some stage. It is a serious condition as it renders the crop unsaleable

I first noticed it in Proteaceae about 1980 on some Protea nerrifoila and I have perceived it itermitantely since then on various varieties. On at least four occasions in the intervening years (1980 - 93) I have had pathology reports done on samples and on every occasion the report has read that it is a physical condition with no pathegons present.

Observations have now identified that there are three major causes of this condition - severe frost damage (see 3:5 to 3:7), severe late spring pruning (see 6:1) and root damage from weed control chemicals (see 3:19 - 3:20).

In 1993 our Protea plantation was struck by a -8.5C frost which lasted for fourteen hours. The damage was great on all varieties with branches up to 1cm in diameter being stripped of bark. Many of the plants looked as if they would die but most of them did live. A high percentage of them developed the false silver blight syndrome by late spring eighteen months later almost all of them have now grown out of it.

In the winter of 1994 much of the northern and north eastern part of the north island of New Zealand was struck by a very severe frost and areas that had had little or no frost prior to this experienced severe damage to all manner of horticultural crops. In some instances three metre high Avocado trees were killed. Proteaceae crops six years old and two metres high were severely damaged. In the summer of 1995 reports of what people think is silver blight (which isn't) are widespread.

There is no doubt that severe frost damage and almost certainly severe structural pruning in the late spring (which can cause branches to die-back) cause the false silver blight syndrome. It is also thought that constant ongoing foliage damage from the use of the wrong fungi and insect control chemicals or the overdosing of plants with them may also be a contributing factor to false silver blight. The first signs of damage from these two causes often shows as a distorted flower bud or bract bud in the form as if it is trying to open prematurely. This is usually accompanied by disfigured leaves immediately below the bud. It is often seen in P. cynaroides heads in the year following frost. If you take the stem and split it length ways back into the third to last growth section you will see that the pith is a dark brown instead of green. Miss-use of weed control chemicals also cause the same symptoms in p. cynaroides and Ld laureolum. See 3:19 - 3:20.

When this condition is caused by severe frost damage or severe spring pruning, providing the damage has not affected the main trunk and stems, the plant will often grow out of it. This is not the case however with root damage from weed control chemicals. Once this has happened the plant is almost certain to develop false silver blight and there is no hope of the plant fully recovering. Plants affected in this way are sure to fall victim to all manner of fungi invasion and it is quite possible that it will latter become infected by true silver blight. The only control for false silver blight is to avoid the factors that cause it.

5:13 Septoria.

The disease shows as an orange spot with a dark edge and infection can reach a level that the leaf area of a plant is virtually completely covered by these spots. At this level it is very disfiguring and renders the crop unsaleable. It has been noted that the greatest incidence of this fungi has been where plants have been in close proximity to poplar and willow shelter belts indicating that these may be a host or that they are creating a humidity trap that triggers the problem.

Whilst high humidity seems to be the triggering factor for this disease it has been noted that it does at least sometimes occur as a secondary infection, following plants having being under stress from a lack of soil moisture in which case it enters the plant through the damaged leaf tissue (see 3:12 - 3:13). Once infected there is no way that the disfigurement of the leaves can be repaired. For a commercial crop it is therefore necessary to monitor soil moisture closely and carry out preventative spraying with

Benlate or Mancozeb, and if the host source can be identified remove it. I have never seen a properly irrigated crop with this problem.

5:14 Tip Die-back.

This is quite common in a number of varieties and it is difficult to define whether it is a physical disorder that is peculiar to particular clone, whether it is the result of photo-sensitivity to bright sunlight, reaction to chemicals, fungi invasion of a minor nature or unusual "one-off" weather conditions such as salt burn, wind damage etc. An analysis will usually show that "there are pathogens present of a secondary nature", or in other words it is an indefinable problem. It is often confined to one or two particular clones in any specific climate, eg. Clarks Red, (Jack Clark in California). Best control is to discard the clones that are prone to these disorders in your particular climate and grow only those that do not have them.

5:15 Water soaked leaf spot.

It is not clear whether this is a physical disorder which is then invaded by fungi or whether it is short term low level unidentified fungi invasion which causes the condition. The problem shows as a dark water soaked patch on the leaves and is most prevalent in leucadendrons but occasionally shows in protea and leucospermums. Hybrid leucadendrons that are related to Ld. strobilinum seem to be most prone to it. It has been referred to as Wiri Wire wilt in New Zealand.

Research shows that the disorder can be induced in almost any variety of Proteaceae by keeping them under very low light conditions for several consecutive days. In a plantation the problem can occur at any time of the year when there is a period of several consecutive days when there are very low light levels because of heavy cloud cover accompanied with high th/c levels.

Treatment with the fungicides Octave, Captan/Ronilan plus Benlate at three day intervals appears to restrict its progress but it is not very cost effective. If you are plagued with the problem discontinue growing that variety/clone.

5:16 The control of insect pests - overview.

The efficiency of insect control is dependent on the competence with which the insecticides are applied, not only to the crop but also to any host plants within or surrounding the plantation. Host plants can be anything from weed growth, grasses, shelter belts or ornamental plants within the plantation. If these are not treated at the same time as the crop, or removed from the cropping area, they are a constant source of re-infestation. If they cannot be treated or removed maintenance spraying will have to be carried out much more frequently.It is not possible or desirable to kill everything in an area but it is necessary to control insect populations to acceptable levels to enable a profitable crop to be harvested. The following is a brief outline of how to achieve an acceptable level of control.

5:17 Nematodes.

By far the most serious soil-borne pest problem in Proteaceae is nematodes. These are found in most places where these plants are grown being more prevalent in warmer climates. In more temperate climates such as New Zealand they are not a problem. Nematodes are somewhat of a local problem and expert local advice should be sought where they are serious.There are soil treatments that can be carried out to control their presence but once they are established in adult plants there is little that can be done to eradicate it. At high levels of infestation it causes general ill thrift in plants which in an advanced stage become unproductive. The best coarse to take is to seek out nematode resistant clones and plant only those.

5:18 Other ground borne insects and animals.

There are many ground-based pests which will affect Proteaceae to some degree. These vary greatly from one location to another and range from gophers in California, termites in Africa to grass grubs in New Zealand. For sub-soil surface control there are chemicals available which are usually in a prills form which can be used. These are mostly slow acting and to be fully effective should be applied about twelve weeks before the insects are expected to reach their maximum active period. Check your chemicals manual for what is available and permissible to use. The uses of some of these chemicals are forbidden in some countries especially if they may come in contact with food or be washed into water ways.

Another method of control is to run bantams (hens and roosters) in the plantation at the rate of seven per hectare (three per acre). These will control virtually all soil-borne insects, slugs, snails, weevils etc. and will also keep the populations of many of the above the ground pests to low levels

.5: 19 Daily and short term visitors above the ground.

These are those that visit on a daily basis, bees, wasps, butterflies etc., and those that are mostly found only in the flower heads on a seasonal basis such as earwigs, wood lice, spiders etc. All of these do little damage to the plants but can be destructive to the flowers and are a real problem when flowers are being exported especially when they lay their eggs in the flower heads. Those that are seasonally resident in the flower heads such as spiders are controlled to some degree by insecticides that are applied to control the permanent resident forms (see below). There is little that can be done to control those that are highly mobile.

5:20 The more permanent residents.

There are two basic types; the chewing and sucking ones (leaf rollers, loop caterpillars, weevils, aphids etc.) and the mites, thrips and red spider. All of these are serious in a plantation and to be able to sell the crop successfully they must be controlled. Control is by the application of insecticides, usually systemic, such as Lorsban, Lannate, Orthene etc. Check your local chemical manual for identification, control recommendations and safety precautions. Most really effective chemicals are quite toxic to humans and care is necessary when handling them.

.5:21 Scales.

This group which has little power of locomotion. In Proteaceae they can be on almost any variety particularly P grandiceps, magnifica, repens, neriifolia (some variants only) and cynaroides (some variants only). They also infest Telopea and populations on these can reach immense numbers.There are many types of scale all of which live on the underside of the leaves or occasionally on the stems but always out of direct sunlight. Because of this they are often not detected until flowers are being harvested.

Control is difficult as scale are to some degree resistant to insecticides. Check your chemicals manual for identification of the scale type and use the correct chemical for your scale type. It is usually necessary to use the available chemicals at the maximum recommended rates with wetting agents added. This may cause foliage burn on some varieties, it will certainly cause post harvest problems (see 7:4) with the flowers and for this reason such high rate chemical applications should be finished three weeks before harvest starts. It usually takes three applications of chemicals at nine to twelve day intervals to get control.

5:22 Biological controls.

Whilst it may not be possible to grow a crop of Proteaceae flowers that can be traded internationally by pure biological control of fungi and insects there is certainly the possibility of producing crops for domestic use by these methods. It is not a subject that I have investigated to any degree but in our own instance we have found that with the provision of the correct amount of soil moisture, the right balance of soil nutrients, light protection, frost protection and paying attention of ensuring an adequate air flow through the plantation, that it is possible to grow a crop of Leucospermum cordifolium and export it to Japan with only one spray per year each of a fungicide to control *Botrytis* and one to control seasonal insects. There is also strong evidence to show that if Proteaceae have access to the right balance of trace elements (see 6:9) many of their ills disappear or are minimised. The plants are much healthier and much more productive without the constant drenching of chemicals. It is a case of the health and resistance to diseases coming from within the plant. A healthy body is a happy body!

SECTION SIX

Plantation Maintenance And Operation During The Development Years.

6:1 Overview.

Having made the pre planting decisions on what you will provide for your plants, chosen the varieties and planted them, most crops will then take from two to five years to come into production. The care of the plantation during this period is just as important as the actual production years as many of the things you do will affect the plant for it whole productive life. The thing to remember is to be flexible in your approach. Don't set your ideas in concrete as some of your earlier decisions may have been in error. If you have obviously made a mistake you will have to change your management or provide facilities to grow a viable crop from the varieties you have chosen.

6:2 The first hundred days after planting.

If the plants were container grown in a medium that was compatible with the soil of the plantation site (see 4:6 to 4:7), and they were well conditioned before planting, they should need little attention for the first three months other than keeping sufficient soil moisture available, possibly restraining from wind-rock, protected from pests (including rabbits they love Proteas), diseases, weed growth and some initial training of future shape. A sharp watch should be kept to guard against the invasion of diseases and pests but unless pests (both insect and animal) were present at the time of planting there should be few problems except from those that are highly mobile, ie. rabbits, hares, gophers, birds, flying insects and those insects that develop rapidly on a seasonal basis.

The same does not apply to fungi invasion as this can occur at any time when conditions favour its development or if the plants become stressed. For this reason an inspection should be made at least every week and prompt action taken if any problems from fungi.

6:3 Initial shaping.

The initial shaping of plants should have been carried out during the nursery production stage. Basically a plant should be encouraged to form the shape it will eventually achieve as a producing plant. If it is a Protea neriifolia and meant to be on a trunk it should have one; if it is meant to proliferate from a central root mass such as Protea cynaroides it should be allowed to do so; if it is meant to grow from a central trunk and "rest on its elbows" like Peucospermum cordifolium it should do so, provided it does not induce fungi invasion from the ground or herbage. Double stems from near ground level on varieties that normally grow on trunks must be avoided at all costs as almost invariably the plant will split in half right down to ground level by year four.

Keeping this in mind, plants should be encouraged to develop their shapes by removing unwanted branches and where necessary pinching out the tips to promote good strong lateral branching. This is the basis of the plants future cropping wood. When pruning plants of this age it is important that the amount of foliage removed at any one time is never more than 25% of the total leaf mass and that branches the thickness of a pencil are not cut off when the plants are in very active spring growth. The removal of branches during very active growth periods will cause a high sap loss through the cuts. This will almost always result in die-back on that portion of the plant. Never prune late into the autumn if there is the slightest possibility of a frost of -3C or more. Cuts made near winter are at risk of causing severe plant damage from frost. This damage can run down into the main structure of the plant and it may later cause false silver blight (see 5:12).

6:4 Control of fungi.

General inspections should be made at least on a weekly basis and daily in high danger periods (see 3:4) to observe if there is any fungi development and prompt action must be taken to identify and treat whatever ones are present. General notes on this can be found in 5:1 to 5:15. It is much better to pre-empt a serious problem rather than have to cure it after it is heavily established. If you do find a problem your motto should always be:-

Act now, not tomorrow or the next day but NOW.

Plants of less than one year old can be wiped out in days with some diseases if they are not treated.

6:5 Control of Insects (development period).

Unless the insect invasion is one that will permanently affect the plant such as scale, thrips mites etc,. control in the developing years is not too important unless the population reaches a level where it affects the health of the plant. If for instance in the first year there is a low level population of leaf roller in Leucodendrons which are only going to cause a few holes in the upper leaves which are not going to be harvested and sold anyway, you may do more damage to the young plants by spraying their juvenile growth with powerful chemicals than a few caterpillars will do chewing a few leaves. Damage from insecticides is often where fungi enter the plant.

.6:6 Irrigation.

Readers should study 3:11 to 3:13 and pay particular attention to 3:13 because if you do not have adequate soil moisture available to your plants at all times you are exposing them to the probability of long term and sometimes permanent damage.

It is absolutely impossible to make a firm recommendation as to the amount of water to apply and how frequently it should be applied but observations in many places indicate that most growers leave it too far between applications and when they do apply water they quite often apply too much at once for the plant to make use of. This observation is particularly valid where plants are less than three years planted.

If your aim is to grow a succesful crop every year irrespective of the rainfall, it is absolutely essential that you know what the soil suction level is in the plantation is at any time. This is particularly so during periods when high transpiration is likely to take place.

First visible indications of a shortage of soil moisture is when the leaves start to go pale and take on a lack-lustre appearance. However by the time you notice this it is almost certainly too late to prevent such crops as Lsp. cordifolium and many yellow Leucodendrons being affected by galling (see 3:12).

If the land is suited to Proteaceae production and is free draining you won't hurt any plant by applying water frequently to it provided it is <u>done through drippers</u> **(not ever overhead)** and the <u>water is of good quality</u>. It is not water that is a danger to proteaceae but what is in it. I have grown a number of varieties in hydroponics for several months and have never lost one by doing so.

Growers, both established and new should at least do a series of readings with a tensiometer to ascertain what c/b levels their soils get to after ten days without rain, how much water does it take to dampen the soil sufficiently when it reaches danger level and how many days does the properly wetted soil take to reach danger levels again under specific transpiration conditions of temperature and relative humidity.

<u>Soil moisture can not be ascertained with any accuracy by poking your finger in the ground!</u>

In the absence of any firm findings the following is my <u>guess</u> of the minimum levels some of the more common cut flower varieties should be subjected to if they are to produce a viable crop each year. Further work is being carried out on this subject.

<u>Min c/b's at shade temp. 28C& 45% day relative humidity</u>

P. compacta	45	Ld Safari Sunset	60
P. cynaroides	45	P coronata	40
P. eximia	60	P mundii	50
P. neriifolia	50	P Silvan Pink	55
Ls cordifolium	35	Ld glabrum	60
Ls pattersonii	45	Ld discolour	70
Ld floridum Pisa	45	Ld laureolum	40
Ld salignum	60		

Lsp cordifolium and Ld. laureolum should have an upper limit of around 40c/b and the rest of them at no higher than 45 - 50c/b except Ld.discolour which may give problems if the level is wetter than 55c/b especially in hot weather.

There are reports that excessive soil moisture especially when associated with regular applications of nitrogen may inhibit bud set in some varieties especially Proteas. Because of this growers should watch the performance of their plants in relation to water and nitrogen applications. Bud set on most genera of plants is usually associated with the amount of potash and boron available to the plant. For instance with orchids you must feed potash from the longest day onwards to make them set flowering stems. If Proteaceae are the same, balanced fertilizer and trace element applications in relation to the plants annual growth cycle may be the key to higher bud set.

6:7 Fertilizers and trace elements.

Many years ago I read in a SAPPEX newsletter what a scientist had calculated (I think hypothetically) that Proteas needed annually per acre to maintain the crop that could be taken from them in a plantation. I can not find the article but I remember that the amount of N.P.K was quite mind boggling and I thought at that time almost sure to blow the plants brains out. I think that calculation was made on the principal that the removal of a certain weight of dry matter of Protea stems and flowers would remove that much N.P.K. from the soil and in that I am sure it was correct.

There has been much said and written about this subject and there are those growers who believe it is necessary to apply an annual dose of something (they often don't know what) while others believe that Proteaceae plants don't need anything. Probably both schools of thought are right to some degree and wrong to some degree.

The danger with the annual dressing is that there is no known adequate but safe level of N.P.K. for Proteaceae. This is not supprising as it was established in Section One that Proteaceae are highly variable in their requirements and probably no more so than in their fertility and trace element demands. For instance (also hypothetically) an annual application of 10gm per plant per years planted of formula A to P. cynaroides may be ideal but if the same is applied to P. exemia it may blow its brains out while on the other hand the same dose of compound Z may be ok for it. *Note: Formulas A and Z are hypothetical fertilizer mixes.*

It is a fact that where new land is used for establishing a Proteaceae plantation that almost invariably the plants start to run out of steam by the third year if no fertilizer has been applied. The problem is to know what to apply and how much. The only thing that I know for sure is that fast release compounds must be avoided as no proteaceae will stand a sudden shot in the roots of any element.

For most varieties field nutrient levels of NPK should be: Nitrogen 40ppm of which the nitrate level should never exceed 30ppm Phosphate 25-30ppm. Potash (K) 300ppm. In accepting these levels it should be borne in mind that they are the levels that most proteaceae will survive in without any untoward demise. However there is no surety that these N.P.K. levels are the best levels for any particular variety to produce its optimum crop. In depth research would show that there would be large variables between various varieties in their optimum N.P.K values.

A 25% differential either side of the above quoted levels is unlikely to cause any problems provided there is always sufficient soil moisture present (50centibars minimum) and the pH is around 5.5. An analytical services laboratory will be able to test your soils and make recommendations to bring your land into line with these values.

6:8 Liquid feeding.

Because of the uncertainty of knowing exactly what, when and how much solid fertilizer to give Proteaceae, I started work in 1992 on supplying Proteaceae plants with their fertilizer requirements by using only water soluble materials applied in the form of liquid feeding. Several proprietary liquid fertilizers were used which ranged from one that was made from fish (very smelly), one that was made from blood and bone (very messy), one that was a "complete plant food"? made from unknown chemicals (very expensive) and one that we were using to grow lettuces and tomatoes in a hydroponics system. All but the hydroponics one caused damage to the plants by the third application (monthly intervals) no matter what strength it was applied at. The damage ranged from minor leaf burn to severe nitrate and phosphate poisoning. As the hydroponics mix created no visible signs of damage I decided that I would pursue that one but to ascertain what levels of fertility were safe to apply it was necessary to conduct tests. .

A bench was set up and plants of a number of varieties of Proteaceae plants which were all between six and twelve months old were washed clean of all medium and placed in a hydroponics trough which for the first week had only water running through it. Throughout the whole trial the liquid was run at the rate of 1.5lt per minute. After one week sufficient fertilizer was added to bring the CF level up to 8 and then every week after that the CF level was raised by 2 points.

One week after the CF level was brought up to 20, which was seven weeks after the start of the programme, the first signs of toxity were noticed. The level was dropped to CF18 for two weeks and the toxity symptoms disappeared.

Following that, the rate was again increased by 2 points each week. At CF22 quite a few varieties showed signs of toxity, at CF26 only L Safari Sunset and P Silvan Pink could handle it and at CF30 (tomato strength) those two also failed.

On these results it was considered that overhead applications at CF20 would be quite safe for young plants provided they were properly moistened twenty four hours beforehand and the fertilizer was washed in after it was applied. Having used it at this rate and under these conditions it has now been found safe to apply it at CF26 overhead if washed in. The same rate has been used for a full summer at two monthly intervals through trickle irrigation in a plantation of Leucospermums at .5lt per plant per application. It has also been used on P cynaroides at 2lt per plant alongside the "complete fertalizer" compound for almost a full year with some on a monthly basis and some on a two monthly basis.

These plants are two and a half years old and are planted indoors in the soil. The results to date support the use of the hydroponics compound on a monthly basis as being the one that produces the longest straightest stems. The "complete fertilizer" at monthly intervals virtually destroyed all the plants by the fourth month but at two monthly intervals it is showing great promise on P cynaroides with significantly more but shorter stems than the hydroponics. On the other hand a few Lsp cordifolium also treated with this compound were destroyed by even the two monthly treatment. There is obviously a lot of scope in this field to find the right rate of the right compound for each crop

Observations on these two plantings as well as a wide range of container grown plants show quite conclusively that the use of the hydroponics compound promotes healthy upright growths that do not have the weakness and bending in the stems that is associated with nitrogen feeding. It has also proven that provided applications are ceased 60 days before the first frosts are due that these growths are much more resistant to frost damage. Plants fed in this manner are also much more resistant to fungi invasion than untreated plants. It is thought that it is a combination of a balanced fertilizer plus the trace elements that are so beneficial. Further research is now being started by feeding some plants with the full hydroponics compound and some with the trace elements removed.

Note. CF is conductivity factor of a solution; ie. the higher the number the greater the amount of solids the solution holds in suspension. CF is measured by an electronic probe.

The formulation of the hydroponics fertalizer used is:
At CF24 — the value of each component in ppm = Calcium 182; Nitrogen 252; Potassium 316; Magnesium 57; Sulphate 229; Sulphur 76; Phosphate 11; Iron 4.46; Manganese 1.62; Boron 0.35; Copper 0.18; Zinc 0.16; Molybdenum 0.06.

This formula would be a good basis to start from for growers or researchers wishing to carry out their own experiments to find the perfect mix for a particular crop.

6:9 Trace Elements.

In 1984 I published a home gardeners Protea hand book (the litle red book) and in it I advised growers that if they had a problem with Proteaceae plant health to use a 'cocktail' on them. This cocktail was applied as a liquid and contained 2000 ppm sulphate of ammonia, 1000 ppm epsom salts, 500 ppm sulphate of iron and 500 ppm sulphate of zinc. Admitidly this was somewhat of a powerful shotgun approach but it does work and many commercial growers in Zimbabwe adopted it as their 'fix-it' mixture. Ten years later there is growing evidence that the health and well being of Proteaceae is closely linked with the availability of certain trace elements and there is little doubt that it is the inclusion of these in the hydroponics compound described above that is one of the major factors in making the plants treated with it so healthy.

Research is now being started in this field but it will be a long time before any concrete findings are available. In the meantime I suggest that if growers suspect that they are short of trace elements in their land that you take the shotgun approach and apply one of the trace element mixes that is available. **Follow the instructions on the pack fully. Remember they are TRACE ELEMENTS and a little goes a long way. Don't go putting great dressings around your plants. You could do great damage**

Note:- Many trace element deficiencies can be read from the leaves of plants. Some of these are described in Section Eight.

6: 10 Lead time to first harvest.

If one to two year old plants have been used to establish the plantation most Proteas and Leucospermums will take two years to develop to a point of a possible small first harvest and a further two years to reach full productive maturity. With some varieties it is best not to harvest at all until the third year as if more than 25% of the foliage is removed at any one time it often slows down their structural development which may affect their cropping ability in later years. Telopea and Proteas grandiceps and magnifica will take at least three years following planting to reach a stage of maturity that will enable a first harvest to be made without adversely affecting their further development. They often take five years or more years to reach full production. With leucadendrons a first harvest is usually possible at the end of the second year. Full or near full production can be expected by the third year. Leucadendrons should not have more than 40% of the foliage removed at any one season until they reach maturity which in most varieties is at three years after planting. From then on higher rates of foliage can be harvested quite safely.

6:11 The year before the first harvest.

During the year leading up to their first harvest it is imperative that fungi and insect damage is kept to an absolute minimum. Section Five outlines control procedures of most problems that may occur.

To ensure that a high percentage of flowering stems grow to be a marketable product it takes control, good management and some extra work. It is important to note that as the plants get older and change from a juvenile type of growth to a mature type that will produce flowering stems it will also put greater demands on fertility and soil moisture. Files 6:7 & 6:8 deal with fertility and 3:13 with adequate soil moisture and the following files 6:12 to 6:14 should be followed

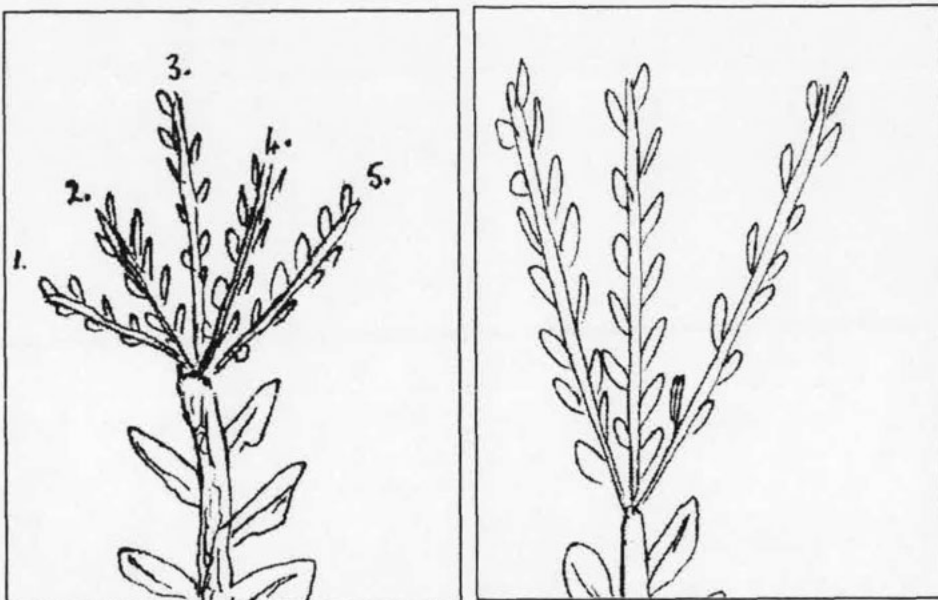
6:12 Thinning the crop.

With all varieties it is necessary to carry out a certain amount of training. Some may need the crop thinned out to encourage a better type of final product while others may need their flower heads either training through netting or tying up.

With regard to thinning, it is a fact that with all Proteaceae varieties, the length of the stem that develops from a growth point is more or less in proportion to the number of stems that are allowed to develop from that growth point. In practice each growth point is capable of supporting X cm. of growths in a given location.

If for instance a Leucospermum cordifolium is capable of producing a total of 1.8metres of stem length from a given point and you allow six stems to develop from that growth point then you will end up with six stems each about 30cm. long. If however you were to thin those six stems back to the three most dominant ones you will get three stems each around 65cm long. The same principal works on Proteas. On the other hand almost all Leucodendrons produce their longest and best flowering stems from the juvenile growths from the previous year that are to be found within the canopy of the bush in the spring time. If these are removed then you remove that portion of the following years crop. All Proteaceae are partially bi-annual croppers and the removal of these juvenile growths makes many of them almost totally bi-annual. The cropping of P cynaroides and all salignum type Leucodendrons including Safari Sunset are seriously affected by the short back and side method of pruning. These principals are illustrated in the sketches on page 53, 54 and 55.

To decide whether you want a high number of short stems or a smaller number of longer stems is a matter that you should discuss with your buyers a year ahead. In most instances longer stems are easier to sell and bring a better price than shorter ones do. However with some crops the difference isn't that great and occasionally you may find that with some varieties it is better to have six stems at 90 cents than three at $1.25. This is more likely to be the case with Leucospermum and Protea flowers rather than Leucodendrons.



By removing growths 1 & 5, this Leucospermum growth point will grow three stems each about 65cm long instead of five that are only 30cm long. It must be done just as spring growth starts in earnest.

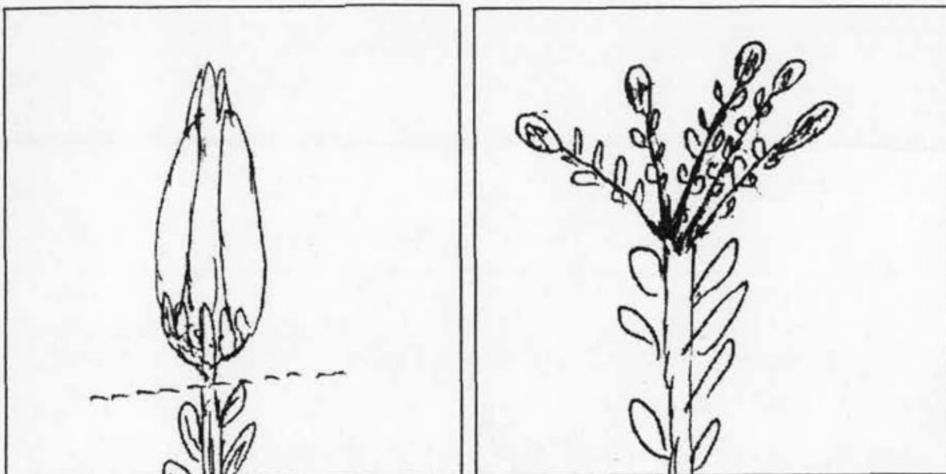
6:13 Tying up or supporting your crop.

With heavy flowers such as P cynaroides it will be found that the saleable crop can be greatly increased by tying the flowers up to overhead wires thus reducing the number of bent and useless stems. If the crop is being shaded or protected from frosts the same supporting wires can be used for tying up to.

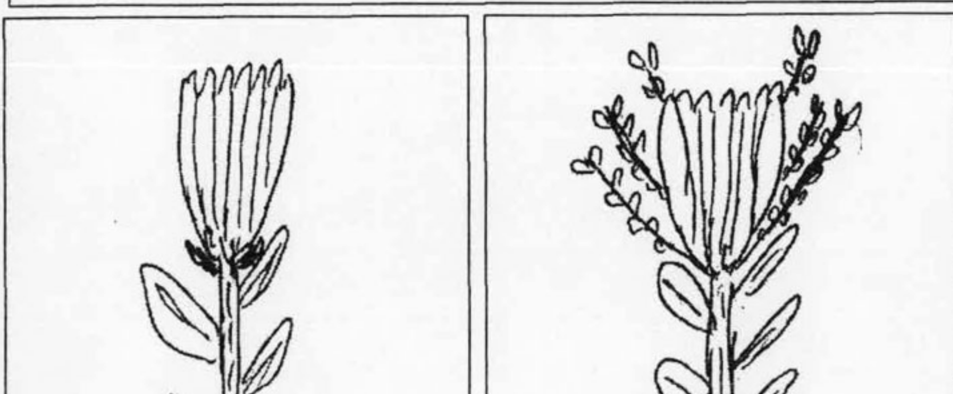
The saleable percentage of Leucodendron crops can also often be greatly increased by some means of support by using either flower netting along the sides of the rows or stretched over the top of the rows so that the stems can grow through them and be supported. Many other crops are supported in this way so why not Leucodendrons.

6:14 Manipulating your crop.

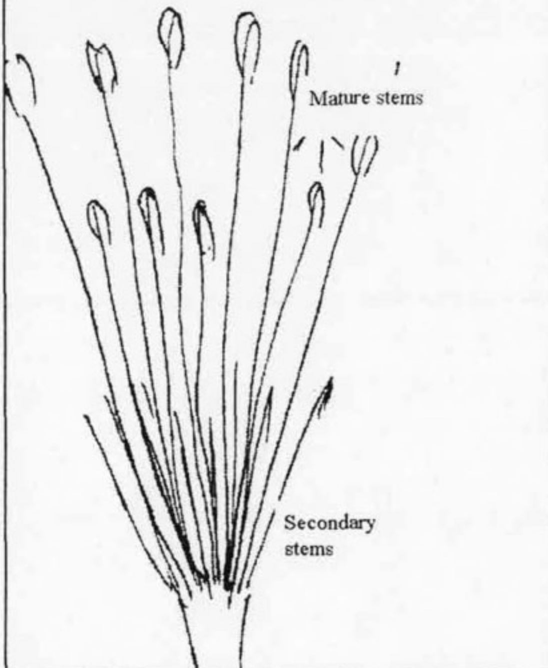
Many crops, if left to their own devices, do not produce their maximum potential. With some it is necessary to do some manipulation to get the most from them such as removing by-pass growths from around Protea flowers, thinning Leucospermum flowers to one head per stem or converting a Leucodendron stem from a single bract stem to a multi-head stem. These operations are all pretty straight forward but like tying up if they are not done at the right time then quite often only a portion of the potential crop will be realised. Inexperienced growers should be guided by what their exporter/wholesaler want. If they want multi-head Leucodendrons in the spring time then they should be produced. This means that you will have to manipulate your plants in the previous mid-summer. If they want single flowers on each stem of Leucosperm then they should be thinned to singles at least six weeks before harvest. It is sometimes possible to double the returns from a crop by putting in a few hours work at the right time.



With Leucodendrons like Safari Sunset, multi heads are sometimes worth up to three times as much as a single head. Timing is important in removing the single head to promote the multi head. It is usually about a month after the longest day.



Some Proteas have by-pass growths. These must be removed before they develop to any extent as in the left sketch. If they are not removed you will end up with a flower as shown on the right. It is unsaleable.



Many Leucodendrons carry the basis of their next years crop within the canopy of the base of the plant. These are secondary stems which if left untrimmed will elongate to form the longest saleable stems the following year. If they are cut away you destroy much of next years crop. This is why some growers have poor stem lengths and crop numbers.

The 'short back and sides' annual trim up should be avoided

6:15 Annual pruning.

Annual pruning is a part of ongoing management and is usually done after the removal of the crop and before any new seasons growth starts. However as growers gain experience in production techniques of specific varieties to specific market demands, many of them have found it necessary to modify some of their earlier practices particularly the 'short back and sides' execution that many of them used to carry out on the late spring.

A certain amount of annual tidy up after the crop has been removed and sold is necessary to keep the bushes in order but the annual hacking away of everything that has not flowered should be avoided at all costs. Such a practice is in truth removing a fair percentage of the following years crop. I have seen one Leucodendron plantation pruned with a chainsaw right across the top and along each side. It is a great way of producing cutting material but a write off for producing long flowering wood. Almost every plant in that plantation developed false silver blight within three years.

ECTION SEVEN

ʼre Harvest, Harvest And Post Harvest ʼrocedures.

:1 Overview.

:aving selected the right varieties for your environment, planted them and cared for iem for several years and grown the flowers to perfection, **all** of these efforts can e nullified by poor handling between the bush and the carton. This section outlines rocedures that need to be followed to ensure that the crop is not damaged during iis phase of production.

:2 Pre-harvest - conditioning the plant before harvest.

:very effort must be made to minimise those things that cause leaf blackening of 'roteas and or the rapid degeneration of all flowers following harvest. Although nany growers fail to realise it, these problems are quite often caused by the physical ondition of the plant at the time of harvesting the flowers and when they are the ause, no amount of good post-harvest procedures will change it. The flowers and 'oliage will still degenerate more rapidly than they should.

'here are three principal pre harvest causes of leaf blackening and rapid flower legeneration and they are: -

i. dehydration (quite often undetected) within the plant at the time of iarvest, caused by a shortage of soil moisture (see 3:12 - 3:13). Observations on a iumber of selected clones indicate that there is only a fine line between a deficiency n soil moisture level that would cause the problem and that which would not.

ii. the plant experiencing a sudden surge of sap run, (caused by the plant iaving been unduly short of soil moisture and then suddenly receiving water .

Note:- a sudden rise of temperature in the very early spring will have a similar effect.

iii.. the affects of chemical reaction from the application of insecticides. This is particularly so with the liquid formulations of insecticides. To minimise the isk applications of chemicals should be made at least a week before harvest commences.

Therefore, plants that are bearing flowers that are within two weeks of harvest should have their soil moisture levels checked and if they are found to be too dry the moisture level should be brought up to optimum at least ten days before harvest starts. At the same time a check should be made for fungi and insect invasion and if present treated accordingly at least a week before harvest starts.

7:3 Harvesting - from the bush to the pack house.

Flowers are best if harvested in the mornings when it is cooler as research shows that material degenerates at a greatly accelerated rate at temperatures above 20C and even more so above 25C.. The acceptable time lag from the moment of harvest to being placed in water is on a graduated scale in accord with the temperature at the time of harvest. Below 12C there will be very few problems but cut material should still be placed in water as soon as practical. From 12C. to 20C. the maximum time should not exceed 45 minutes, from 20C. to 25C. 30 minutes and for 25C. to 30C. an absolute maximum of 15 minutes. All these values are based on a relative humidity of 40% to 50%. If the air is dryer than this the time lag from bush to water should be reduced.

When temperatures are 30C. and over, especially if coupled with humidity of less than 30%, the vase life of flowers will be inconsistent,even if the material does appear to be in good condition at the time of harvest, and it is placed in water within minutes of harvest. It is under such conditions that clones that have been selected as having superior vaselife will show their ability to perform.When harvesting it is usual practice to cut to give the longest possible stem length without causing structural damage to the plant. It is important to cause the minimum of tissue damage when handling cut material as broken and bruised foliage will give off ethylene gas which is very detrimental to flowers. On no account should cut material ever be left lying in the sun even for a few minutes as many varieties can not tolerate the suns rays on the back of their leaves. A few minutes can cause some varieties to dehydrate and go black sometimes within half an hour.

Cut material should not be heaped up and left lying on benches. When it is placed in buckets of water it should not be jammed in tight. All flowers and foliage that have been harvested go through a period when its temperature will rise after picking, (usually about 2C.within two to three hours of harvest). It is their natural reaction to being cut. If material is left tight even if it is in buckets of water and not controlled by refrigeration it will continue to heat up which causes it to degenerate more rapidly. Always remember - the flower is at it most perfect state at the moment of harvest. At that point, the plant has done its part; the rest is in the hands of the grower.

7:4 Post-harvest - in the pack house and into the carton.

This is the final phase in the chain and it is where quite often the efficiency of handling and processing the crop means the difference between profit and loss. This is for two reasons. If post harvest is done poorly you will have a poor product to sell and the buyer will only pay a poor price for it. The other reason is that it is in this phase where almost all of the labour content is. Labour whether it is your own or somebody else's costs money and poor co-ordination and handling procedures that are time consuming or non productive will rapidly eat away any profit margin. It is cult to actually put a time frame on processing a crop as some are much quicker ı others to strip the leaves from, grade and eventually pack into cartons. However ır instance you are paying $10 per hour and it takes an average of three minutes Protea flower to strip the leaves, grade and pack in cartons, including closing the on and labelling and addressing it ready to dispatch, then it has cost 18 cents per n in labour to do it. Always remember that it is very repetitive work and a study :ach facet of handling should be scrutinised for efficiency in time and motion for ı facet of the operation.

w the material is handled once it arrives in the pack-house varies between pack ıses.. Some growers stand their flowers in buckets of water then immediately ce them in the chiller, while others may strip the leaves before standing in water 1 placing them in the chiller. Some will use other variables. A system is usually ɪrked out so that the minimum time expires from harvest to bringing the nperature down to around 4C. Once it has reached this temperature dehydration 1 degeneration slow down to near zero and the aging process is almost halted. -cutting of the stems just prior to standing them in water ensures that they have a :sh start. The capillaries on some varieties seal off very quickly in the air, :ectively stopping the stem from drawing up water as it should. A re-cut will nimise this problem.

ɔod post-harvest handling will go a long way to making sure the flower gives its :st possible value to the end consumer. Poor post-harvest handling can destroy the ɔwer well before its due time. Dehydration is the greatest factor influencing the :generation of flowers and the principal cause of this is high temperatures and/or :ry dry air which is not necessarily hot. Cold air can be very dry and can cause :vere dehydration in flowers. This is why flowers often give poor performance after ɔst - they are dehydrated. A chiller is a necessity if you are going to do the post-ırvest job properly. Standing flowers in water without refrigeration is not sufficient ɪ ensure that flowers will give the best possible results. Admittedly it is possible to rocess many varieties of leucadendrons (which are foliage and not flowers) through ıe winter months without refrigeration in some locations with acceptable results, but ɪith proteas, leucospermums and telopea it is virtually impossible to do full justice ɔ them without refrigeration of some kind. Chillers are usually set to run at around C to 6C except for Banksia which seem to degenerate rapidly at anything below C.and should be large enough to handle the crop easily. An overloaded chiller is ɪorse than none as it can reach very high humidity levels. A refrigeration engineer an advise you on capacities.

he quality of water is important as poor water with a high pH. or water carrying ıngi (as out of a small dam) can cause rapid break down of plant tissue resulting in ɔlackening of the leaves and flowers. Water with a high pH. from a mains supply which has been chlorinated can be disastrous to Protea flowers and is probably the reason why occasionally a shipment goes wrong as some mains supplies can vary somewhat day by day in pH. and chlorine content. As water is the common denominator in post-harvest procedures it is also the vehicle by which contamination can be passed from one batch to another and for this reason it is important that fresh water is always used for each batch that comes into the pack-house and that the containers are cleaned frequently. Exposure to ethylene gas especially in high concentrations will do great damage to flowers of any kind. Common sources of ethylene are from cut and bruised foliage and torn stems caused during the stripping of leaves or the removal of by-passes, petrol and diesel exhaust fumes, smoke from tobacco and ripening fruit. Precautions to avoid the exposure of flowers to these sources should be taken at all times.Good post-harvest procedures are really just good common sense.

ECTION EIGHT

Problems - Reasons - Remedies

his section is designed as a quick reference check list to help you to determine what re the reasons for problems which you will encounter from time to time. It is not esigned as a cure all fix it remedy for everything.

Much can be read about your plants health from its leaves and the probable cause of problem can often be identified this way. The listing of symptoms and problems re divided into sections and are filed under the heading where they are most likely o occur. However there are occasions where several things could be the cause of the ymptoms so sometimes you may find it in more than one place.

The system of referrals used in this section is the same as that used throughout the book and it directs the reader to the file containing the information on the subject under review. It is not designed as a cure-all fix-it help-line but rather where to go to for more information.

In each file the problem is printed in normal text. The possible causes are in *italics* and the posible remedy(s) are in **bold print.**

Sub Section (A) - Plant Health

A8.1 Leaves have a horny texture, usually crinkled with high colour on edges and pale on the upper surfaces exposed to the sunlight. Advanced symptoms are dead tissue around the edges of the leaves and general dehydration of foliage and flowers.

i. Too much sunlight for the variety planted.

ii. Probably aggravated by high pH. and phosphate levels

.Remedy. Avoid planting varieties that are sensitive to high light levels where they will face the sun all day. These varieties should always be planted on slopes facing away from the sun or be shaded.

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A8.2 Leaves pale between leaf ribs with ribs highlighted green. Leaf shows chlorosis towards the tip and in some cases tip burn.

i. *Lack of magnesium*

ii If there is tip burn there is also a deficiency of iron.

Remedy.Apply magnesium (Epsom salts), 1000 ppm. and iron (iron chelate), 500 ppm. as a drench spray. Repeat as necessary.Note:- This problem is usually of a seasonal nature linked to the spring growth period.

****

A8.3 Leaves pale between ribs with burning at the tips progressing to severe tip burn and a mottling effect of the foliage.
i.High phosphate levels present probably aggravated by
,ii High pH. and or dry soil conditions
Remedy.It is difficult to bring the phosphate level down. Apply sulphate of ammonia as a drench at 2000 ppm and also as a ground dressing. Keeping the soil moisture up during dry conditions will often help.

****

A8.4 Leaves begin a pale blotching as light and temperatures rise during progress into summer. Leaves eventually go almost white and roll back at the edges and show burn along the edges. There may be a slight pinkish appearance on some varieties.
i. Very high nitrate nitrogen levels. Proteas in particular will be affected. It can be caused by the breaking down of humus at high temperatures such as under weed matting.
ii.Can also be caused by excessive use of applied nitrogen especially those of a nitrate form.
Remedy. Heavy flushing with irrigation does help to reduce it but will not help the plants much that are affected. A delay of six months from the laying of matting or the rotary hoeing of herbage into the ground to planting will reduce the risk of this problem. If you must apply nitrogen do so in small doses

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A8.5 Leaves are small and show tip burn during hot weather otherwise O.K.
i.Shortage of potash
Remedy. Usually a short duration problem. Keep moisture levels up for the remainder of the summer. Apply potash prudently (see 6.7) in the following early spring to avoid a recurrence the following year. Very high levels of potash will cause chlorosis in some varieties. Be careful.

****

A8.6 Plant has rosette leaves with growth tips sometimes arranged in a whorl. Leaves may have a "bird beak" (twisted) tip.
i.Principal cause is zinc deficiency, often associated with iron and magnesium shortages.
Remedy. Apply sulphate of zinc at 500 ppm. as a drench several times. Pay attention to iron and magnesium, see 6:9.

****

A8.7 Foliage of plant is paler than it should be but leaves do not show veining as for magnesium deficiency. Growths are shorter than expected.
i. Shortage of nitrogen, usually shows following spring growth after about the third or fourth year from planting if no supplementary supplies have been applied
Remedy. Apply sulphate of ammonia as a side dressing. Remember - small doses only (see 8.4) or use a liquid fertalizer through irrigation. Refer to 6.8 for information on liquid fertilizers.

A8.8 A cream coloured variegation shows on lower leaves and progresses up the plant intensifying as it progresses. For a start it may only affect one side of the plant or in low doses it may only show as a faint margined yellowing of leaves that were developing at the time of being affected or the leaves may be slightly stunted and margined

i. Almost certainly the result of a herbicide containing Symizine or similar compound being used within the root zone of the plant.

Remedy. Refrain from using this type of chemical within the root zone of plants. Plants will usually survive one or two small accidents but no more. See 3.19 & 3.20 for more information on the dangers of weed control chemicals.

****

A8.9 Plants take on a slightly stunted and lack-lustre appearance. The margins of leaves will often take on a dark appearance and leucadendrons will set bracts earlier than usual. Foliage may later take on a slightly pink hue especially at tips which may then show a photo sensitivity burn appearance. Stems become slightly dehydrated and brittle. In some instances especially in colder climates plants will develop a silvery appearance (about six months later) which is often mistaken for silver blight.

i. Plants are affected by Round Up or similar compound by direct contact (if the symptoms develop rapidly,

or

ii. If the progress of symptoms of poisoning are slow to develop it is more probable that it is caused either by by translocation through the roots from the fleshy roots of sprayed weeds or it has been absorbed by the proteoid roots.

Remedy There is nothing that can be done to improve the plant. Once affected the plant will either eventually die but may malinger on as an unproductive plant for several years. Avoid using this or any other chemical that translocates in the root zone of plants especially if there are any weeds with fleshy roots present. Refer to 3.19 - 3.20 and 5.12.

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A8.10 New growths all over the plant go slightly pink edged silver and foliage is small and slightly twisted. Last few cm.of terminals may be twisted.

i. Plant has been affected by hormone drift, possibly from a great distance away. Proteaceae are very sensitive when making their spring growths

.**Remedy Check your chemical store for leaking containers as some of these chemicals are highly volatile and the vapour can drift to affect plants several hundred metres away. If symptoms are only on the lower foliage of large plants or all over only small plants, the problem may have originated from the use of weed control prills/granules. Some of these give off gas for a few hours when first applied.**

****

A8.11 Foliage of new growths show burning then go grey after a few days and is confined to one side of the plant.

i. Almost certain to be salt burn from dry winds. May occur up to 40km (25 miles) inland. Damage usually shows up after a strong wind which is not followed by rain.

Remedy.Move further inland! Trim off foliage that is showing severe burn as it may later be host to fungi.

****

A8.12 Sudden appearance of random black patches on the younger leaves and temporary tip wilt during the heat of the day.

i. Plant has been temporally short of soil moisture and/or over heated through the lack of air movement.

Remedy. Increase soil moisture, (see 3.11 - 3.13) and air movement.

****

A8.13 Plants fail to establish well and show stress from dehydration. Light even at low levels of exposure cause photo sensitivity. Plants often fail during the second summer.

i. Plant has poor primary root development almost certainly caused by the container medium being incompatible with the plantation soil type (see 4.6 - 4.7) .ii. Plant root system is affected by nematodes (see 5.17).iii. Plant has suffered some physical root damage from ground insect populations (se 5.18).

Remedy. Refer to files listed above.

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A8.14 The flower heads of p cynaroides take on a gnarled and silvery appearance - some leucodendrons particularly the laureolum type also show symptons. The problem is initially confined to the tips but may progress down the stem later.

i. The plant has been seriously affected by frost at some time. If you take the stem and split it through the middle you will find that somewhere between the tip and the base of the plant the pith has turned dark brown or blackish. A close inspection will often show healed over lesions from previous frost damage. This may have occurred two winters before (see 3.7).

ii. The plant has been affected by the careless use of weed control chemical within its root zone (see 3.19 - 3.20) and A8:13 above.

Remedy. Prevention is the only remedy. Refer to files listed above.

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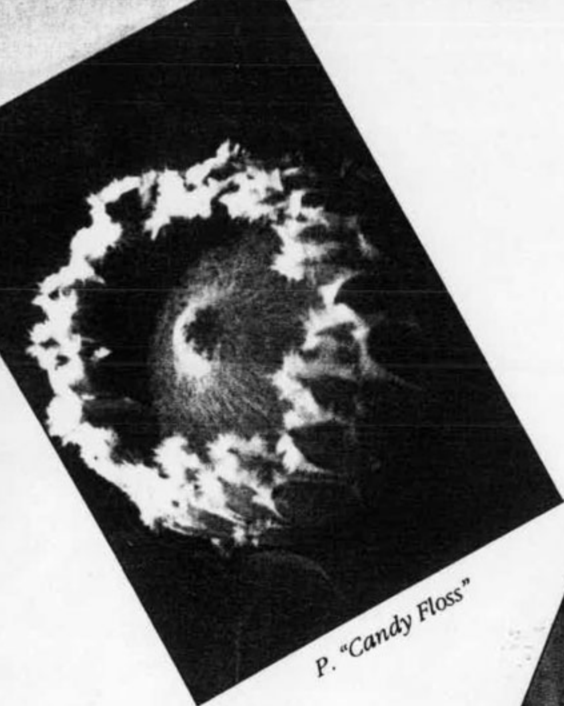
A8.15 A plant that has been very healthy suddenly dies and dead branches goe black within days.

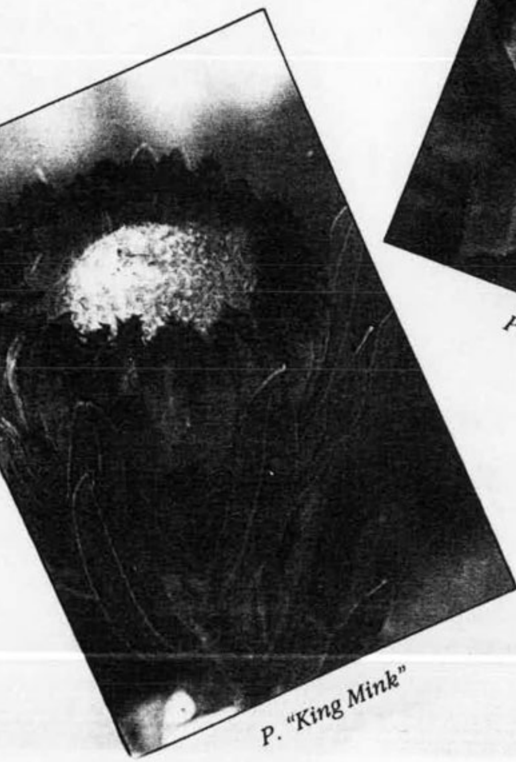
i. The plant has been visited by a dog. They are deadly on all Proteaceae.

Remedy. It is quite obvious!!



P. "Candy Floss"

P. Magnifica



P. "King Mink"