GROWTH CONTROL OF AUSTRALIAN ACACIAS

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Frontispiece. *A. glaucoptera* developed for the flowering pot plant market

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Abstract

The Australian genus *Acacia* includes species with attractively shaped and coloured phyllodes or bipinnate leaves, producing many bright yellow flowers in spherical or cylindrical inflorescences. Some species naturally attain a mature height of less than one metre. This research aimed to produce a small flowering pot plant of *Acacia* less than 35 cm high with more than 50 inflorescences within twenty four months, a potted foliage plant less than 35 cm high within twelve months, or a flowering tub plant less than 1 m high with more than 50 inflorescences within thirty six months.

The species tested were *A. acinacea*, *A. baileyana*, *A. baileyana purpurea*, *A. buxifolia*, *A. cometes*, *A. crassuloides*, *A. craspedocarpa*, *A. decora*, *A. drummondii elegans*, *A. glaucoptera*, *A. imbricata*, *A. meisneri*, *A. myrtifolia*, *A. notabilis*, *A. podalyrifolia*, *A. polybotrya*, *A. pycnantha*, *A. retinodes*, *A. semilunata*, *A. vestita*, and *A. verniciflua*. All experimental plants were grown from seed.

Reduction of plant height has been achieved in other genera using techniques such as high night temperature and chemical application of growth retardants. Flower development in *A. pycnantha* is known to be responsive to low temperature. Thus experimentation included both controlled environment and chemical treatments.

Low temperature (15°C day/10°C night) reduced shoot length and node number in mature plants of *A. notabilis*. Paclobutrazol (2 mgai) reduced vegetative growth at both 15/10 and 20/8.

High night temperature (20/25) had no effect on height or flowering of *A. glaucoptera* or *A. imbricata*, or on height of *A. craspedocarpa*.

After several weeks at low temperature (15/10), strong flowering occurred in plants of *A. acinacea*, *A. buxifolia*, *A. drummondii elegans*, *A. glaucoptera*, and *A. myrtifolia*, but at high temperature (25/20) weak flowering occurred after a

few days and was not sustained. Examination by environmental scanning electron microscopy of *A. drummondii elegans* inflorescences showed inhibition of stamen development and anthesis at high temperature.

Seedlings of *A. acinacea* and *A. imbricata* treated with paclobutrazol (2 mgai) or *A. glaucoptera* treated with 4 mgai, either alone or in combination with pruning or 6, benzyl-amino purine, produced flowering plants of less than 35 cm height within twenty four months. However paclobutrazol reduced the number of inflorescences in *A. acinacea*. Pruning did not control plant height. The cytokinin 6, benzyl-amino purine did not increase branching and flowering at the rates tested.

A. vestita treated with 2 mgai paclobutrazol, and *A. baileyana* and *A. podalyrifolia* treated with 4 mgai paclobutrazol produced foliage pot plants less than 35 cm high either alone
(*A. podalyrifolia*, *A. vestita*), or in combination with pruning, within twelve months. *A. cometes* and *A. crassuloides* produced small sized foliage plants without treatment within twelve months.

A. buxifolia, *A. decora* and *A. drummondii elegans* produced tub plants less than one metre tall with more than 50 inflorescences within twenty eight months with no chemical treatment.

The period of juvenility before flowering for *A. drummondii elegans* was nine months, *A. glaucoptera* sixteen months, *A. meisneri* seventeen months and *A. cometes* twenty three months. The holding period to flowering could be minimised for *A. drummondii elegans* and *A. glaucoptera* by selection of sowing time.

This study has produced a protocol for production of flowering pot plants of *A. acinacea* using a combination of pruning and paclobutrazol. A protocol for tub plants of *A. buxifolia*, *A. drummondii elegans* and *A. myrtifolia* produced satisfactory results for a flowering tub plant with pruning only, thus avoiding the need for chemical treatment.

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Variability in plant size and maturity presented problems in the research. This should be addressed by investigation of clonal propagation of early flowering selections. Future work is required to finalise a protocol which combines low temperature flowering control with time of sowing and chemical size control to produce a potted flowering *Acacia* plant in the minimum time possible.

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Chapter 1 Literature Review

1.1 Introduction

1.1.1 Ornamental horticulture

The development of plants and flowers for ornamental horticulture has resulted from demand for an ever increasing range of lines, especially new and unusual flowering plants and products. Uses include decoration of homes, gardens, courtyards, window boxes, businesses, and for special occasions, as potted plants, hanging baskets, tube stock or as cut flowers. Selection of ornamentals has been underway in Asia and Europe for much longer than in the younger nations of Africa, the Americas and Australia (Beardsell, 1985). However as soon as Europeans reached Australia, samples of the unusual native plants were returned to Europe, and botanical examination commenced (Carr and Carr, 1981). Apart from this initial enthusiasm, Australian plants have largely been ignored in Australia until the last 30 years, and even so are mainly grown as garden ornamentals. Improvement of species for pot plants or cut flowers has commenced only recently (Sedgley *et al*, 1989), and the cut flower trade has depended on naturally occurring stands, such as the everlasting hills daisy (*Ixodia*) (Bennell *et al*, 1991) and *Banksia* (Witkowski *et al*, 1991). Development of Australian plants has also commenced overseas with commercialisation in Germany (von Hentig and Hass-Tschirschke, 1989), Israel (Ben-Jaacov and Ackerman, 1989a), and Italy (Sharman, 1991).

1.1.2 Value to Australia of native flowers

The world export market is estimated to be $5.38 billion p.a. of which the Australian share is 0.05% (James, 1991). Tables 1.1 to 1.5 show details of Australia's exports.

Table 1.1 Export value to Australia of cut flowers and foliage 1990-1991

Product	Value (million $ Aust)
Native cut flowers and foliage	18
Exotics	2.5
Dried flowers	5
Total	25.5

The value of *Acacia* as foliage is estimated as $140,000 p.a. The export value of dried flowers is shown in Table 1.2, and that of cut flowers and foliage to Western Australia and South Australia respectively in Tables 1.3 and 1.4. Table 1.5 ranks the states according to value of exports.

Table 1.2 Purchaser and value of exported Australian dried flowers for 1990-1991

Purchasing country	Value ($ Aust)
Europe	$1,880,000
(1)Germany	$620,000
(2)Netherlands	$650,000
(3)Others	$610,000
Asia	$1,680,000
(1)Japan	$1,520,000
(2)Others	$160,000
North America	$890,000
(1)USA	$720,000
(2)Canada	$170,000

Table 1.3 Purchaser and value of cut flowers and foliage from Western Australia from July 1990 to March 1991

Purchasing country	Value ($ Aust)
Europe	
(1)Germany	$650,000
(2)Netherlands	$900,000
Asia	
(1)Japan	$4,100,000
(2)Hong Kong	$430,000
North America	
(1)USA	$1,700,000

Table 1.4 Purchaser and value of fresh cut flowers from South Australia from July 1989 to December 1990

Purchasing country	Value ($ Aust)
Europe	
(1)UK	$7,000
(2)Germany	$40,000
Asia	
(1)Japan	$500,000
USA	$130,000

In addition small amounts are sent to Canada and the Netherlands.

Table 1.5 Australian states in order of value of flower exports for 1990-1991

State	Value ($ Aust)
Western Australia	$16,500,000
New South Wales	$3,250,000
Victoria	$2,300,000
Queensland	$1,400,000
South Australia	$700,000
Tasmania	$150,000

The National Resource Centre of Floricultural Marketing considers that there is "limitless" potential for export expansion if the industry regulates the quality and volume of product and takes note of the availability of exotic flowers and their price. As the potential domestic market is so small, export must be the aim of flower producers in Australia in the future.

The domestic cut flower market was estimated to be $270 million p.a. at the Australian National Flower Show in Melbourne in 1991, but figures for florist and nursery sales reflect the economic recession and show only $55.25 million. This figure does not include other outlets for cut flowers such as supermarkets. It is estimated that $2,500,000 of proteas were marketed in New South Wales with wild picked banksias being inferior to cultivated blooms (Forsyth, 1991).

In Australia, seven hundred thousand hectares were under cultivation to Geraldton wax, three hundred thousand hectares to proteas, and one hundred and forty thousand hectares to kangaroo paw, and eight hundred thousand hectares to other natives in 1989-1990 (Carroll, 1991), with almost thirty six million dollars produced through native plant sales.

1.1.3 Native Cut flower trade

Native cut flower and foliage plants include banksias, native daisies, eucalypts, acacias (Sedgley *et al*, 1989), *Anigozanthus*

or kangaroo paw (Koster and van Raamsdonk, 1989; Turner, 1987a; b; James, 1990), *Verticordia*, wax flower (Webb and Reid, 1991) and waratahs from Tasmania and Victoria (Alexander, 1991). The procedures for presenting top export quality cut flowers and plant material involve pre picking treatment for insects and disease, the timing of picking, post picking treatment and preservation, and preparation for cartage (Lamont, 1987; James, 1990; Seaton *et al*, 1991). Kangaroo paws should have stems longer than 100 cm when used for cut flowers (Stewart, 1987). Avoidance of water stress, and cooling to increase flower life, must be used to produce a quality product. These aspects need to be investigated for native plants so that suitable cultural methods and treatments can be defined.

In Europe *Acacia dealbata*, *A. retinodes* and *A. podalyrifolia* are cultivated as grafted cultivars for cut flower production, with winter flowering following heavy pruning for the Christmas market (De Ravel d' Ésclapon, 1962). At 25°C, 70 to 90 percent humidity, and with sucrose, silver nitrate, aluminium sulphate and 8-hydroxyquinoline citrate pulsing, *A. dealbata* cv "Goulois" and "Rustica" flowers, picked at the yellow bud stage, are forced to open uniformly within 24 hours (Accati and Sulis, 1980).

Selection and breeding of superior plants, which will produce top quality flowers, are a necessary part of the domestication of wildflowers. This allows savings in production costs, as inferior flowers are avoided rather than being handled as seconds or contributing to the downgrading of the shipment. *Banksia, Verticordia* and wax flower breeding and selection programs are now underway. For example, the high yielding *Banksia* cultivar, "Waite orange" has been developed with high quality blooms on long straight stems (Sedgley *et al*, 1991b; Trease, 1991). In the case of waratahs, vegetative shoots may grow through the inflorescence, detracting from the quality of the bloom (Alexander, 1991). The native daisies *Helichrysum* and *Helipterum* have been investigated and recommendations made for bloom production, stem length and flower diameter (Sharman *et al*, 1989). Frith

(1990) discusses domestication problems such as lack of information on petal drop, and cultivation difficulties.
The currently accepted methyl bromide post harvest treatments for disinfestation of flowers for export can cause problems with natives (Webb and Reid, 1991) and gamma irradiation is under investigation (Richardson, 1984).

1.1.4 Attributes of flowering pot plants

Pot plants are currently a minor component of Australian exports, although there is a large domestic market for flowering exotics. Cyclamen, chrysanthemum and poinsettia are all popular for specialised sales such as Mother's day and their production is well understood and professionally carried out by growers. Australian species have potential for both domestic and export markets, and we need to understand how to produce pot plants efficiently and as quickly as chrysanthemums, for example.

The major requirements of a successful flowering pot plant are that the plant is compact, the flowering life or vase life is more than 14 days under home conditions (Lamont, 1987) and efficient propagation procedures are available. In addition the plant should have good transport life and the ability to be shipped, possibly barerooted under low light intensities (Brown, 1986; Frith, 1990) and under temperatures which may be variable during trucking in Australia (Jacobi and Wong, 1991).

In economic terms Ben-Jaacov *et al* (1989b) summarises that flowering pot plants should be produced for a reasonable price, as well as be attractive, unique, with a long shelf life and not shed flowers. In addition, Davis and Anderson (1989) recommended that many floricultural crops which are too large for pot plants may be manipulated to pot plant size by the use of growth retardants. This avoids the time lag for costly plant breeding development and allows gauging of customer demand. Nevertheless there is a need for continued study in the fields of plant breeding, cultivar selection and physiology of species with potential as flowering pot plants. Nell and Barrett (1989) suggested that a set of references for flower

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life should be developed to allow standardisation of results of flowering experiments. von Hentig and Hass-Tschirschke (1989) discuss physiological limits on Australian plants taken to Germany for development as ornamental pot plants, including effects of latitude and light intensity. Israel sells inexpensive flowering pot plants to Europe, having raised them quickly under outdoor conditions. Unheated structures with the high naturally occurring light can produce winter flowering plants of woody species (Ben-Jaacov and Ackerman, 1989a).

1.1.5 Australian native species

In Australia, study of native species has enabled development of ornamentals, as with species of *Acacia, Banksia,* native daisies, and eucalypts (Sedgley and Aspinall, 1991a), production of four metre tall *Kentia* palms (Brown, 1986), and germination of *Thryptomene* seed (Beardsell, 1989)

A wide range of Australian plant genera have been developed overseas. In Italy Australian cycads and palms have been developed as large container plants (Sharman, 1991). In addition, *Brachychiton, Callistemnon, Cassia, Casuarina, Erica, Eucalyptus, Helichrysum, Leptospermum, Melaleuca,* and *Pittosporum* have been cultivated following the development of successful multiplication techniques. La Malfa (1989) discusses *Kentia* palm production as pot plants in 18 cm pots, and Frith (1990) points out that Israeli and German horticulturists have for 10 years been working at converting Australian natives to commercial scale products for indoor use. In Germany, von Hentig and Hass-Tschirschke (1989) detail procedures for pot plant production of commercial quality from *Brachyscome multifida,* a blue daisy, and *Helichrysum bracteatum,* cultivar "diamond head", and *Pimelea ferruginea,* the rice flower, using growth retardants. In 1985 between 3 and 5 million plants of *Brachyscome* were sold. Lamont (1987) discusses production of *Chamelaucium uncinatum,* Geraldton wax, as a compact pot plant as well as *Cissus antarctica , Crowea bindalong, Ficus benjamina, Pimelea linifolia* and *Shefflera actinophylla* are also grown for an indoor environment. In Israel Ben-Jaacov and Ackerman (1989a) developed *Grevillea* using growth regulators and tissue culture.

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1.2 Biology of Acacias

1.2.1 Introduction

The genus *Acacia* belongs to the family *Leguminosae*, subfamily *Mimosoideae.* Acacias have been studied mostly in their native habitats, Africa and Australia. Australian acacias are characterised by the production of phyllodes rather than bipinnate leaves as an adaptation to the dry climate. Botanical examination of plants is important, with taxonomic division into groups according to floral, leaf (phyllode), seed pod structure, pollen type and overall plant habit (Pedley, 1981; Turnbull, 1986). The enormous size of the genus (over 1200 species) lead to subdivision into 3 subgenera, and the taxonomy of the genus is still under review (Pedley, 1986). As the importance of uses such as perfumery and wood production, dye or tannin production increased, and problems such as cyanogenic chemicals in fodder plants arose, the growth, chemical composition, and reproduction of acacias became of interest (Cannon, 1921; Carr and Carr, 1981; Harborne *et al*, 1971; Shaw, 1959).

In ecological studies of areas of desert denuded by agricultural misuse, acacias showed promise as plants to commence re vegetation, with value to indigenous people in provision of wood and fodder, (Fox, 1986; Doran *et al*, 1983). Australian acacias have shown environmental impact in South Africa as weeds (Milton and Moll, 1982). With the increasing importance of the floral and ornamental aspects of the plants, as shown by their home garden use in Australia (McCarthy, 1979), the control of flowering and vegetative growth of acacias showing potential for ornamental purposes is increasingly important.

1.2.2 Vegetative growth

1.2.2.1 Seed sources

As acacias may form hybrids under domestic conditions (Boden, 1969), seed for propagation is best collected from

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the wild (Simmons, 1988). Plants which produce hybrids may produce seed which is of less value horticulturally, as it does not produce progeny true to type, for that particular species. If possible seed should be collected from well-watered plants which have been verified taxonomically (Fox, 1986). Members of plant societies with permits to collect seed are often good sources of unusual species (Frith, 1990). It is important to select seed from all parts of the plant and to sample different plants, as the breeding system of acacias results in closely related siblings in one seed pod (Doran *et al*, 1983). Beardsell (1985) states that a seed propagated crop must have a high heritability of desired characteristics which in domestic plants has resulted from long periods of artificial breeding. Any superior hybrid individuals must be propagated vegetatively.

Cavanagh (1980) conducted an extensive review on *Acacia* seed germination. Hard seededness is found in the *Mimosoideae* and may be overcome in acacias by scarification of the seed coat (Doran *et al*, 1983). Soaking in hot water (60°-90°C) is a commonly used method which has little cost and is safe, with no chemicals involved. Concentrated sulphuric acid pits the seed coat and is especially useful with African acacias. Burrows (1991) investigated the best way to pretreat *A. saligna* seeds and concluded that mechanical treatment was the most effective, followed by acid, then boiling treatments, but that the most convenient treatment was brief exposure to boiling water. In *Duboisia leichardtii*, which is related to acacias and shows hard seededness, gibberellic acid can break the dormancy and it is suggested that it may act through the secretion of an enzyme to weaken the tensile strength of the seed coat (Martin, 1968). Seeds which would be affected by heat may require mechanical scarification with abrasives. This is more expensive, but the seeds remain dry, even though their storage life may be reduced. Wet-dry treatment was implicated in germination of naturally occurring hard seed and may be an influence in breaking the dormancy mechanism (Doran *et al*, 1983). Some fresh seed will germinate without the need for scarification, as with mulga (*A. aneura*) (Winkworth, 1973). *Acacia auriculiformis* seeds

at two months after collection germinated in 4-6 days, but after longer than 2 months, germination slowed (Pukittayacamee and Hellum, 1988).

1.2.2.2 Seedlings

Acacia seeds produce dicotyledonous seedlings with bipinnate juvenile leaves. There is variation within a species for many seedling characteristics - cotyledon length, time to bipinnate leaf emergence, number of bipinnate leaves, number of roots, and angle and length of phyllodes (Coaldrake, 1971). The suggestion is that both genetic and environmental factors control seedling development. For example, the physiological tolerance of brigalow seedlings (*A. harpophylla*) is very wide, including high water stress tolerance (Coaldrake, 1971). *A. aneura* (mulga) seedlings can also survive prolonged periods of drought (Burrows, 1973). In Queensland, after two periods of summer rain, seedlings of the same age emerged near parent material, both in burnt and lightly grazed ground (Everist, 1949). Plants of this species grew in communities of certain age groups, not with a continuous range of plant ages. Thus stands of mulga tend to be uniform due to the pattern of seedling emergence following rain.

Frost tolerance exhibited by *Acacia* seedlings is related to the site of collection of seed, as seedlings from seed from higher latitudes or altitudes displayed greater frost tolerance (Pollock *et al*, 1986).

Philp and Sherry (1946) found that seedling germination trials produced no multiembryonic seedlings. Abnormal seedlings such as a light blue and a bright green seedling, later found to result from self pollination, always died, indicating the presence of lethal recessive genes.

1.2.2.3 Roots

Root elongation is rapid, with a group of roots formed near the soil surface, and a tap root penetrating the soil which

branches to form fine roots and root hairs (Everist, 1949; Cannon, 1921). All species observed in detail form root nodules in association with *Rhizobium* bacteria (Allen and Allen, 1981; Pedley, 1981).

1.2.2.4 Phyllodes/leaves

Australian species in the main develop phyllodinous leaves, although some have bipinnate leaves, especially alpine, forest, tropical and saline tolerant species such as *A. baileyana*, *A. elata*, *A. drummondii*, *A. decurrens* and *A. terminalis* (Boughton, 1986; Costermans, 1973). The development of phyllodes rather than bipinnate leaves is considered to be a xeromorphic feature. Leaf development in *Acacia aneura* depends on temperature, with the production of bipinnates rather than phyllodes being favoured by high temperature (Carr and Burdon, 1975). Some species, such as *A. melanoxylon* and *A. rubida* have persistent transition leaves with a vertically flattened axis and some pinnae. In xerophytic acacias phyllodes have reduced surface area and are often held in a vertical position (Cannon, 1921). Coaldrake (1971) found a variable degree of angle of *A. pycnantha* phyllodes, which were held wider under moist conditions (Cannon, 1921). In the phyllode structure, the outer mesophyll contains sclerenchyma in varying amounts and there is a difference in the thickness of the outer mesophyll compared to inner layers between arid and humid zone acacias (Boughton, 1986). Apart from this there is little diversity in phyllode anatomy despite wide diversity in morphology, which appears to be related to habitat. Plants originating from humid environments are able to spread into more arid habitats, but the reverse is less frequently the case (Boughton, 1986). Khan (1970) has found that rainfall, temperature, and evaporation effect phenological behaviour of leaf loss and gain, and *A. baileyana* has been noted to put on a burst of vegetative growth following flowering (Boden, 1969).

1.2.2.5 Extrafloral nectaries

Acacias have one or more extrafloral nectaries, or glands, on the petiole of the bipinnate leaf, or along the blade of the phyllode (Boughton, 1986). The extrafloral nectary in *A. terminalis* was found to be boat-shaped to hold quantities of secretion. It was highly pigmented around the margins, with diurnal secretion of sugars with some phenolics, proteins, and lipids. Secretion occurred without the rupture of cells or cuticle of the nectary (Marginson *et al*, 1985). The secretion contained sixteen percent sugar as sucrose, fructose and glucose, and eighteen amino acids, especially phenylalanine and glutamine (Marginson *et al*, 1985; Knox *et al*, 1985). Each petiole of the bipinnate leaf had one extrafloral nectary from which pollinating birds and insects appeared to remove the whole nectar drop. The nectary appears to function as an attractant to pollinators of the species (Thorp and Sugden, 1990).

1.2.2.6 Trichomes

Trichomes or hairs are found on the foliage of acacias and have taxonomic significance (Boughton, 1989). Five non glandular and six glandular forms have been defined of which only one or two types are found per species. Unicellular non glandular straight hairs and club-shaped glandular hairs are the most common types, and form the most frequent combination (Boughton, 1989). Vegetative descriptions of acacias include hair characteristics which contribute to species identification (Costermans, 1973; Simmons, 1987, 1988; Whibley, 1980) .

1.2.2.7 Chemicals.

Australian acacias contain a range of cyanogenic glycosides, which affect their use as fodder crops. About sixty species are cyanogenic due to the synthesis of cyanogenic glycosides from amino acids. Of the sixty species, forty five are Australian acacias (Maslin *et al*, 1988; 1990). When the leaves are crushed as in eating, the glycosides, and

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occasionally lipids, come into contact with endogenous enzymes, such as beta glucosidase, which hydrolyse the glycosides to produce hydrogen cyanide. African species *A. caffra* and *A. hereroensis*, closely related to the Australian subgenus *Phyllodineae*, contain the glycosides, prunasin and sambugrin (Conn *et al*, 1989).

Shaw (1959) listed tannins and other important chemicals detected in acacias such as bark alkaloids in *A. tenerrima*. Harborne (1971) mentions the distribution of chemicals in relation to *Acacia* taxonomy, and to the occurrence of important chemicals in the bark, sap and other tissues. Use has been made of the alkaloids and antiseptic tannins by Aboriginal people (Aboriginal Communities of the Northern Territory of Australia, 1988) with some recent scientific evaluation of species.

1.2.3 Reproductive growth

1.2.3.1 Flowering

Early studies of acacias involved detailed floral and vegetative descriptions, such as the evaluation by Shina (1971) of four acacias, including one Australian species naturalised in the Caribbean Islands. Within an *Acacia* species, early and late flowering trees are found (Boden, 1969), and clones of an early plant, although planted at different altitudes and found to have different flowering times, are still early flowering relative to other plants. *A. pycnantha* produces inflorescence buds all year, but buds produced from November to May flower, with buds produced from June to October aborting (Buttrose *et al*, 1981). This is considered to be a mechanism which produces a plant ready to flower in conducive environmental conditions. Changes in temperature can cause abortion of these developing buds in *A. pycnantha*, with the stage of meiosis being particularly susceptible (Sedgley, 1985). Low light intensity may also block anthesis and prevent floral development despite healthy vegetative growth (Preece, 1971). *A. aneura* produces buds all year (Everist, 1949; Preece, 1971) and has

been shown to flower in relation to water availability, so that out of season rainfall will produce flowering. Late flowering, with reduced inflorescences and no seed set, is the result of water stress and insufficient water at the expected time of flowering. Arid zone acacias frequently show out of season flowering, which is not followed by seed set. The presence of water may promote anthesis but not development of bisexual flowers, thus causing lack of seed set. Megasporogenesis may not take place due to temperature restrictions, or the absence of pollinators may be a problem. *A. deaneii* and *A. oshanesii* have been found to flower continuously under cultivation (Pedley, 1981). However some northern acacias flower during June to September, regardless of the availability of water.

Many southern acacias flower in winter-spring. The pistil and ovary develop within the unopened flower, and within one month of flowering, the petals grow and push between the developing sepals (Knox *et al*, 1989). The structure of the stigma and style of six acacia species has been examined microscopically and histochemically, and the morphology of various species determined to be similar (Kenrick and Knox, 1981a). The sequence of floral development in acacias has been arbitrarily divided into eight stages; (1) meristematic flower bud covered by bracts, (2) meristematic flower bud with primordia visible, (3) style protuberance visible, (4) flower bud green, style has a single fold, (5) flower bud yellow, style has multiple folds, (6) petals open, stigma and tip of style exposed as early female phase, (7) mature flowers with style extended, filaments extending but anthers non dehiscent as female phase, (8) stamens obscure style, fully dehiscent as male phase (Knox *et al*, 1989). Pollen development precedes ovule development, although the female receptive phase of the flower precedes the male phase of pollen dehiscence. Stamen development produces two anther lobes and four locules, in each of which, after mitosis and meiosis, sixteen fused pollen grains are formed in a polyad. Polyads of sixteen pollen grains are the most common in Australian species (Knox and Kenrick, 1983). Flower development within

the inflorescence bud may commence in different months, although the tree generally flowers only once a year (Buttrose *et al*, 1981).

1.2.3.2 Pollination

Stigma receptivity is greatest in the female stage when the flower first opens, and least on the following day when the male phase occurs. The *Acacia* stigma is of the wet type (Heslop-Harrison and Shivanna, 1977), consisting of a shallow cup of sixty to eighty μm diameter. This is slightly larger than the polyad diameter, and following pollination a droplet of exudate forms within thirty minutes which may allow germination of the pollen grains (Kenrick and Knox, 1981b; Knox *et al*, 1989). One polyad on each stigma leads to a full pod of seeds (Knox and Kenrick, 1983) and although two thirds of stigmas do not receive a polyad, there is a high level of outcrossing, so that the allocation of reproductive resources is considered to be efficient. This method of pollination means, however, that all seeds in a pod are generally siblings.

Pollen transfer in acacias has been noted to involve extrafloral nectaries found at the base of the phyllode or bipinnate leaf. In the morning during flowering the extrafloral nectaries secrete a hexose rich liquid (Knox *et al*, 1985; Marginson *et al*, 1985). The flowers of acacias are strongly scented although the flowers themselves have no nectar, and the odour is suggested to be attractive to pollinators. Birds, especially passerines such as 'silvereyes' and 'honeyeaters', visit *A. pycnantha* and *A. terminalis*, and polyads are found in their head feathers (Ford and Forde, 1976; Knox *et al*, 1985). In winter flowering plants, birds are implicated more than insects in pollination, as insects tend to be inactive at low temperatures. The red colour of the nectaries of some species may attract birds which fly from plant to plant to collect the nectar.

In *A. mitchelli*, *A. myrtifolia* and *A. pycnantha*, the activity of bees as collectors of pollen was established (Bernhardt

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and Walker, 1984). Bees and wasps visited nectarless *Acacia* flowers, although wasps foraged extrafloral nectaries in preference to collecting pollen from *A. terminalis* (Bernhardt and Walker, 1984; Bernhardt, 1987) and *A. longifolia* (Thorp and Sugden, 1990). Introduced honeybees (*Apis mellifera*) were dominant on *A longifolia*, but of another seven species studied, *A. mearnsii, A. mitchelii, A. myrtifolia, A. paradoxa, A. pycnantha, A. retinodes* var. *retinodes, A. retinodes* var. *uncifolia* and *A. terminalis*, most visitors were short-tongued native bees belonging to the *Halicitidae*. The greatest number of bee taxa was observed during summer flowering, and bees visited a wide variety of plants for pollen or nectar. Female native bees may collect *Acacia* polyads to feed their larvae after being attracted by the floral colour and scent (Bernhardt and Walker, 1984). Wasps, although fewer in number than bees, were considered important on acacias with functional extrafloral nectaries. They carry fewer polyads than bees (Bernhardt, 1987). The lack of nectar in the flowers of *Acacia* may result in bees moving to another flowering plant genus for nectar and going to acacias for pollen as a source of protein for their young.

Ants are also common visitors to acacias, but their metathoracic gland produces toxins which inhibit pollen germination. They are not observed on all acacias, and do not occur, for example on *A. longifolia* (Thorp and Sugden, 1990). They are not considered important to pollination.

1.2.3.3 Outcrossing

Several *Acacia* species have been found to exhibit self-incompatibility (Kenrick and Knox, 1989). Self-pollination of *Acacia* flowers results in reduced seed set in the case of *A. decurrens A. mearnsii* and *A. retinodes* (Knox and Kenrick, 1983). Plants existing in very close proximity, which are likely to be derived from one parent by root suckering, also show self incompatibility (Kenrick *et al*, 1986). Self-incompatibility is an effective outcrossing mechanism which acts in *A. retinodes* through pollen tube

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arrest in the nucellus (Kenrick *et al*, 1985; 1986). The separation of the female and male phase (dichogamy) also avoids selfing. In studies of hybrids between *A. decurrens* and *A. mollissima* the death of self pollinated seedlings with leaf colour abnormalities and lack of vigour was observed (Philp and Sherry, 1946). Naturally occurring hybrids of *A. brachybotrya* and *A. calamifolia* (Leach and Whiffin, 1978) and other hybrids have been investigated, some with a genetic approach towards the occurrence of abnormalities.

1.3 Current status of Australian acacias

1.3.1 Acacias as ornamentals

Considerable study has been undertaken on acacias, and species identified according to plant habit and inflorescence form which are considered suitable for garden use, or for use as pot plants. Acacias as a group vary from low shrubs, such as *A. imbricata* from Eyre Peninsula, at one to two metres high, through open shrubs such as *A. amblygona*, at one to two metres high by one to two metres wide, to large trees such as *A. baileyana*, a popular street tree (Costermans, 1973; Simmons, 1988). Within species there is much variability in size, although features of flower, phyllode shape, seed number and shape and seed pod shape are more predictable for a species. Costermans (1973) has described some ornamental species such as *A. terminalis* (sunshine wattle) with its features of bipinnate leaves and red tinged pods, and *A. spectabilis* (Mudgee wattle) with its fine bipinnate foliage and slender racemes of globular inflorescences. Whibley (1980) describes acacias for rockeries such as *A. strongylophylla*, or trees with weeping foliage for standards such as *A. salicina* and *A. coriacea*. Simmons (1987; 1988) provides detailed descriptions of many Australian acacias in their natural environment. She selects species according to habit and specific features such as salt and lime tolerance, making recommendations for garden use. Many plants can survive on sparse soil or limestone base rock, and Brownlie and Forrester

(1987) and Whibley (1980) describe some such acacias of particular interest.

Payne (1979) describes acacias selected for desirable horticultural features such as inflorescences, phyllodes or plant habit. The cultivars *A. amblygona* "Austraflora Winter Gold" (height 30 cm), *A. cultriformis* "Austraflora Cascade" (height 10 cm) and *A. dealbata* "Kambah Karpet" are dense prostrate spreading forms. These plants require vegetative reproduction to retain their selected features as ground cover plants. *A. iteaphylla* "Parsons Cascade" is a low arching pendulous type, and *A. pravissima* "Golden Carpet" flowers profusely in its carpet form. These are all variants of the normal plant habit of their species. Through selection of botanical features such as habit, foliage, and time of flowering, garden ornamentals have been developed. Frith (1990) points out that only a small percentage of native species have been used, even as outdoor garden plants.

1.3.2 Acacias as potential pot plants

Simmons (1987; 1988) makes special reference to the suitability of acacias for pot plant or garden use based on the habit of the plants as observed in their natural environment. Small species are most suitable as potential pot plants, such as *A. drummondii* with cylindrical inflorescences, and *A. longifolia* var. *sophorae*, known as coast wattle, Sydney golden wattle and sallow wattle, which is adapted to a wide range of environments. Two species in South Australia of great note, are *A. acinacea*, the gold dust wattle, and *A. rotundifolia*, roundleaf wattle, which are small shrubs with slender branches and cascades of bright inflorescences produced in winter-early spring. Fox (1986) selects and recommends species of short or prostrate habit such as *A. adora* and *A. hillana* for potted ornamental use on the basis of overall species habit.

1.3.3 Australian acacias overseas

Australian acacias have become important overseas for timber, plant extracts such as tannins, gum arabic and perfumes, and

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for floriculture, as well as for ornamental use. They have become weeds in some countries after being introduced for commercial purposes. In South Africa, *A. cyclops*, *A. longifolia*, *A. melanoxylon*, and *A. saligna* replace indigenous plants by more rapid regeneration and earlier growth in the season (Milton and Moll, 1982). *A. melanoxylon*, Australian blackwood (Harborne *et al*, 1971), and *A. dealbata* (Pollock *et al*, 1986) are timber plants. *Acacia* wood is coarse grained, durable, of 640-800 kg/m^3 strength and has been used since biblical times (Allen and Allen, 1981). Dyes and tannins are produced from *A. catechu* (khaki-dye), *A. dealbata* (silver wattle), *A. mearnsii* (black wattle) and *A. pycnantha* (golden wattle) (Harborne *et al*, 1971), with *A. mearnsii* grown under cultivation in other countries (Boland, 1986). *A. senegal*, with a 25-30 year life-span, is used to produce gum arabic, a transparent amorphous powder, non toxic and soluble in water, used as an emulsifier, stabiliser and adhesive (Allen and Allen, 1981; Harborne *et al*, 1971). *A. farnesiana* is used to produce popinac, an oil and flavouring agent. *A. caveriia*, *A. dealbata* and *A. farnesiana* are used for perfume production (Allen and Allen, 1981; Boland, 1986). In France, selections of several naturally occurring hybrids, for example, "Virginia" with its unusual orange flower colour, and "Cap d' Antibes", with pendulous foliage, have been developed for commercial production (de Ravel d' Ésclapon, 1962a,b). Flower production in southern France on calcareous soils is made possible by grafting the hybrid of *A. baileyana* and *A. podalyrifolia* onto *A. retinodes* rootstock (Pryor, 1984). Flower production in Italy also relies on the use of *A. retinodes*, a rootstock suitable for calcareous soils (Ruffoni *et al*, 1990). *A. dealbata*, or Florist's Mimosa, is especially attractive with feathery foliage and fluffy, fragrant balls of flowers (Allen and Allen, 1981; Harborne *et al*, 1971).

1.4 Ornamental pot plants (including species of other genera)

1.4.1 Environmental control

1.4.1.1 Temperature

Sensitivity to temperature is found in many Australian genera, including *Acacia*, and may present problems when they are removed from their natural habitat, and placed in a house. Many Australian acacias flower in winter or early spring (Simmons, 1988) A mean maximum temperature of 19°C and minimum of 8°C is required for meiosis to occur in *A. pycnantha* (Sedgley, 1985) despite floral initiation all year. High temperature results in normal floral development until early anther development, after which buds are shed. A temperature in excess of 25°C inhibits floral initiation in *Helipterum roseum* (Sharman *et al*, 1989a) and 15°C gives greatest inflorescence diameter. Geraldton wax under a combination of short days and 24/16 day/night for three to four weeks will initiate flowers (Lamont, 1987), and *Pimelea linifolia* can be induced to flower all year round at 18-29°C. The number of flowering stems and stem length are important in ornamentals, and *Heliconia psittacorum* "Tay" more than doubled the number of flowering shoots after a 6°C increase in temperature from 15°C, with 90 percent first grade stems at 15°C (Geertsen, 1989). In some other ornamentals of the same genus, photoperiod has been implicated. Ornamental lilies treated with specific temperatures show a low temperature requirement in root development, inflorescence length and number of bulblets. A temperature pretreatment of dry bulbs affects both leaf growth and bulb development. With *Allium aflatunense* this is variable but in *Allium christophii* 17°C is required, and other species require lower temperatures (Zimer and Weckerk, 1989). A temperature difference affects plant morphogenisis, with a drop of 6°C for two hours in the morning being found to reduce stem elongation resulting in compact pot plants at flowering (Moe *et al*, 1991a; b). A temperature increase resulted in height increase and internode elongation, and some plants, such as *Euphorbia pulcherrima* (poinsettia), were more sensitive

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than others, such as *Begonia*. Flower number may be influenced by the temperature difference between day and night, while floral development is controlled by average daily temperature within a certain range.

1.4.1.2 Day length

Photoperiodicity has been widely investigated with exotic ornamentals. Some Australian natives display photoperiodicity, such as *Helipterum roseum* and *Helichrysum bracteatum*, which are quantitative long day plants. However if the time to floral initiation is delayed, with a consequent increase in vegetative development, then more inflorescences result (Sharman *et al*, 1989 a; b). A sixteen hour photoperiod gave most and largest inflorescences in *H. roseum*, and a night break of low intensity incandescent light reduced the time to flower in both species. *Chamelaucium*, Geraldton wax or wax flower, will initiate flowers after three to four weeks in short days of eight hours. Flowering in *Lechenaultia biloba* plants is favoured by short days and low temperatures. Six weeks at 15°C under the short days of autumn produces five to seven flowers on each branch, each flower lasting at least three weeks (von Hentig and Hass-Tschirschke, 1989). Culture in a greenhouse can be undertaken if there is a day length, light or temperature requirement.

1.4.1.3 Light

The amount of light received by plants has been implicated in flowering responses by Israeli and Australian studies of native plants. A seventy percent reduction in sunlight inhibits early floral development in *A. pycnantha* and anthesis is prevented (Sedgley, 1985). Low light intensity (150w/m^2) under shade cloth resulted in poor flowering in the long day daisies *Helipterum* and *Helichrysum* (Sharman et al, 1989 a). *Crowea exalta* "Bindalong compact", flowered in late summer and autumn for twenty two days, with flowering delayed by three weeks after placement under shade house conditions of 50% shade (120w/m^2) (Lamont, 1987).

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Correa requires a minimum quantity of light for flower bud formation, which is not a photoperiodic response, and increasing quantities of light lead to flowering in *Pimelea* (von Hentig and Hass-Tschirschke, 1989). Light extension, of red or far red, has been found to interact with temperature. Increase in stem length in *Campanula isophylla* and *Nephrolepsis exaltata* follows far red light treatment and a positive temperature differential (Moe *et al*, 1991a).

1.4.1.4 Potting mix

Potting medium can have an effect on the number of successfully propagated plants (Handreck and Black, 1984). A perlite and volcanic sand mixture was found to increase the rate of plant development of *Howea forsterana*, a desired result in these very slow growing palms (La Malfa, 1989). With other Australian ornamentals, use of potting mix formulated for more traditional plants requiring high levels of nutrition, especially nitrogen, can lead to bigger plants than desired (von Hentig and Hass-Tschirschke, 1989). Death of *Verticordia* plants has resulted from use of commercial grade potting mix because of added nutrients (Webb and Reid, 1991). Excess phosphorus uptake from enriched potting mix by plants adapted to phosphorus deficient soil, such as acacias and members of the *Proteaceae,* results in toxicity (Beardsell, 1985).

1.4.2 Chemical control

Growth control agents (retardants) can act as a stopgap measure pending the development of dwarf cultivars or environmental cultural techniques. Chemical control of plants normally too large for pot plants, but with attractive qualities, can be achieved through foliar sprays, dips or drenches. The timing for flowering plants to produce consistent results needs investigation for each species. Plants for treatment should be small, and between twenty to twenty-five centimetres in height. A further advantage of a plant treated with chemical retardant may be greener leaves and drought tolerance.

Triazole chemicals, originally developed as fungicides, such as

paclobutrazol (Bonzi, PP333) and uniconazol (Sumagic) are the most widely used growth retardants. They are permitted for growth regulation of floricultural crops, and act by inhibiting gibberellin synthesis. They retard shoot growth in small doses, with persistent effect, and do not cause phytotoxicity. They may also induce early flowering (Davis and Andersen, 1989). Guidelines have been developed for the use of paclobutrazol on ornamentals, of about fifty parts per million active ingredient per treatment, according to dilution tables prepared by Wilkinson and Padgham (1987).

Within the cell paclobutrazol inhibits sterol biosynthesis, preventing catalysis of gibberellin synthesis, so that cell division ceases (Goad *et al*, 1988). Paclobutrazol has two enantiomers, and is a xylem mobile growth regulator which interferes with the kaurene to kaurenol pathway, in the synthesis of gibberellins (Sugavanam, 1984). Gibberellic acid is known to regulate stem elongation (Steane *et al*, 1989), and the paclobutrazol and gibberellin interaction in ornamental production is of particular interest.

1.4.2.1 Vegetative growth

Various growth retardants have been tried on ornamentals, and plant shape can be further improved by pruning prior to chemical treatment. Alar treatment of cuttings gave good results with *Lechenaultia biloba* if treated during root formation, forming compact young plants (von Hentig and Hass-Tschirschke, 1989). CCC (Cycocel 10) used on native hibiscus plants four to eight weeks after striking cuttings, resulted in compact small plants with persistent effects over three years, by reduction of internode length (Sedgley *et al*, 1981). Ancymidol applied with light stimulation activated the kaurene to kaurenol pathway in lettuce (Hazebroek and Coolbaugh, 1990) and retarded etiolation in foliage plants under low light (Davis and Andersen, 1989). 6, benzylamino purine (BAP) increased shoot development in *Boronia heterophylla* and *Rosa* cuttings, but did not increase root development, and nutrient deficiency may occur. Potting on following BAP treatment overcame this and led to increased flowering (Richardson, 1984). *Lillium*

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"Sans souci" treated with ancymidol and growth retardant XE1019 as a soil drench, spray or bulb dip showed reduced plant size but no difference in bud number or days to flowering, although plants suffered lower leaf loss (Holcomb *et al*, 1989). Atrinal produced growth reduction in *Boronia*, *Chamelaucium* and *Eriostomen*, but with no increase in branching, whereas *Correa*, hand pinched, then treated with Atrinal and several Bonzi (Pac) treatments, produced attractive pot plants (von Hentig and Hass-Tschirschke, 1989).

Paclobutrazol (Pac) at one quarter the dose of Alar produced *Chrysanthemum* plants two thirds the size of untreated plants, without affecting the flowering (Richardson, 1984). *Chamelaucium uncinatum*, *Eucalyptus*, *Pelargonium*, *Photinia* and *Rhododendron* treated with PP333 (Pac) were inhibited in growth (Richardson, 1984; Wilkinson and Padgham, 1987), and *Brachyscome multifida*, a herbaceous daisy, formed a pot plant (von Hentig and Hass-Tschirschke, 1989). *Eucalyptus globulus* seedlings had height and internode growth reduced by five repeated treatments with Pac, and smaller leaves with darker colour were produced (Hetherington and Jones, 1990). *Grevillea* "Robyn Gordon", *Grevillea* "Roundo", *Leucadendron discolor* and *Leucadendron* "Safari Sunset" showed good growth control with flower initiated cuttings, but *Leucadendron* showed no flowering within one year (Ben-Jaacov *et al*, 1989b). Roadside regulation of tree size using Pac injected into the xylem results in reduced branch length and increased flowering and seeding in eucalypts (Dean, 1991). Pac does not effect all plants. For example, *Chelone* "Summer Snow" does not respond to treatment with Pac (Beattie *et al*, 1990).

1.4.2.2 Flowering

Hibiscus plants treated with cycocel formed more flowers than controls (Sedgley *et al*, 1981). *Rhododendron* "Sir Robert Peel" which normally flowers on third or fourth year wood, flowered on second year wood after treatment with PP333, (Richardson, 1984). *Boronia* plants treated with BAP formed fewer flowers than controls and Grevillea "Roundo" displayed three times as many flowers on treated as on untreated plants (Ben-Jaacov *et*

al, 1989b). However flowering was delayed but not reduced in *Chamelaucium uncinatum* treated with PP333, (von Hentig and Hass-Tschirschke, 1989). Results lack consistency from species to species, and from cultivar to cultivar with regard to flowering, although growth control is more consistent. The process of floral development in relation to chemical application must be further analysed to find why these differences occur.

1.4.3 Plant breeding

1.4.3.1 Cultivars

The Australian Cultivar Registration Authority was set up in 1963, and is recognised by the International Code for Nomenclature of Cultivated Plants. This organisation is responsible for formal registration of cultivated plants, so that plants selected for flowering, flower colour, leaf and other characteristics can be registered with a name (Butler, 1986; Payne, 1979). Formal rules must be followed so that every cultivar named can be distinguished by distinctive characteristics and, when reproduced, retain these characteristics. Payne (1979) points out that problems occur when cultivars are not selected and tested carefully before marketing. Plant Variety Rights Act Legislation was introduced in Australia in 1987 to protect plants produced by selective breeding. This is expensive, and the legislation allows the charging of royalties and contracts between parties producing products. Plants protected by plant rights may not be reproduced except under licence from the breeder. A *Verticordia* breeding program has recently been set up in Western Australia (Seaton *et al*, 1991) and *Anigozanthus* cultivars have been developed (Koster and van Raamsdonk, 1989). Ink disease resistant kangaroo paw plants are being used for interspecific and intraspecific hybridisation, and also production of tetraploid plants with bigger flowers. Polyploidy is induced in hybrids from infertile plants, following breeding under controlled pollination regimes (Turner, 1987b). Various cultivars of *Hakea*, *Eriostemon* and

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Tetratheca, for example, have been developed as compact flowering plants for the Australian market (Brown, 1987).

1.4.3.2 Vegetative propagation

Potassium salts of auxin hormones are recommended in the use of rooting chemicals, as they are soluble and uptake is very quick. A one second dip has been found sufficient to avoid uptake of toxic amounts (Reid, 1991). Root formation in *Pimelea ferruginea* or rice flower on seven centimetre long cuttings with the lower leaves removed was improved with indolebutyric acid powder (IBA) and temperatures less than 20°C under mist (von Hentig and Hass-Tschirschke, 1989). They also found that growth of cuttings of *Lechenaultia biloba* up to fifteen centimetres long, dipped in IBA, gave plants likely to flower. Some plants cannot form roots as cuttings, and endogenous inhibitors prevent rooting in *Eucalyptus* and *Lophostemon confertus* after the juvenile phase (Beardsell, 1985).

Eucalypts are also very hard to propagate by grafting, but *Lophostemon confertus* "Variegatus", also known as *Tristania conferta* "Variegata" is propagated frequently this way (Beardsell, 1985; Butler, 1986). A technique for grafting *Grevillea* species onto Silky oak rootstock, *Grevillea robusta*, which is adapted to a wide range of soil and climate conditions, has been developed by Boorman (1991). This includes a mild chlorine rinse for fungal control. Not all species are compatible, however. *Banksia* and *Protea* are difficult to propagate, and grafting has been tried using selected rootstocks which are *Phytophthora* tolerant (Ben-Jaacov *et al*, 1989b). *Protea, Serruria, Leucospermum* and *Leucadendron* can be grafted, and pH sensitive proteas are grafted onto proteas tolerant of high pH. Interspecific and intergeneric grafting has been tried with proteas, grevilleas, and banksias along with budding at different times of the year. The macadamia is important commercially, and is regularly grafted (Beardsell, 1985). In Italy commercial production of Australian plants has resulted in *Swainsona formosa*, Sturt desert pea, grafted on

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robust stocks as standards, or in hanging baskets (Sharman, 1991) as a result of vegetative propagation techniques developed by McKenzie (1981).

Micropropagation of *Grevillea* "Roundo" and *Grevillea* "Robyn Gordon" in Israel using agar and sucrose and a rooting medium has given good results, especially as *Grevillea* "Robyn Gordon" was difficult to produce from cuttings (Ben-Jaacov *et al*, 1989b). Tissue culture or micropropagation of *Anigozanthos* for multiplication of selected clones to increase quantity and preserve valuable germplasm has been important in the development of the "Bush Gem" kangaroo paws. There is the added advantage that micropropagated tissue is in sterile culture and suitable for export through quarantine (Stewart, 1987). Propagation for preservation of rare and unusual plants by tissue culture, has shown that auxins and the cytokinin, benzylamino purine, effectively stimulate root initiation. The type of root produced depends on the type of auxin, giving different survival rates. Gelling agent aided root production, possibly through hormone uptake, or more rapid cuticle development. *Cheiranthera volubilis*, an attractive climber, flowered within six months after potting on, while *Olearia microdisca* formed a compact shrub. (Taji and Williams, 1991).

The time of selection of cuttings, the position of the cuttings on the plant and the concentration of IBA all affect the percentage of cuttings which form roots (Thompson, 1986). A range of auxins, including IBA, were tested on native plants including those regarded as difficult to root, and IBA was found to be the most effective. Dissection of ovules of *Chamelaucium* allows controlled pollination and overcomes dormancy problems, speeding up germination and facilitating interspecific and intraspecific hybridisation. Although cuttings will take for waxflower, if large numbers were required, as for new cultivars, then micropropagation would facilitate this rapidly (Stewart, 1987). Frith (1990) suggests that DNA technology and genetic engineering will accelerate the development of Australian plants. Plant Rights will protect promising selections to give incentive to innovation with unique and desirable Australian plants.

1.4.4 Acclimatisation in the northern hemisphere

von Hentig and Hass-Tschirschke (1989) have concentrated on the production of promising Australian pot plants, using mother plants which have become acclimatised to central German conditions, and from which vegetative plant stock is taken. Acclimatisation generally takes one year, but may take up to five. Transfer of Australian plants to Europe is difficult as latitude is higher and seasons more extreme, especially with respect to the shorter day lengths and lower light intensity. Also winter temperatures can reach -20°C so that Australian plants, which have low frost resistance, must be protected. Plants leaving Australia in spring, the growing season, arrive in Germany in winter. Therefore it is best to take Australian plants at the end of their growth cycle, in March, to the German spring (von Hentig and Hass-Tschirschke, 1989).

1.4.5 Vase or plant Life

Production techniques, shipping temperatures and ethylene sensitivity affect the quality of potted plants (Nell and Barrett, 1989). Transport of potted flowering and foliage plants, with temperature variation above 20°C inside containers, caused foliage and flower abscission, loss of colour and tissue damage (Jacobi and Wong, 1991). Plant shelf life can be increased with the use of growth retardants, to over six weeks in *Chamelaucium* (Lamont, 1987), and to three weeks in *Lechenaultia*. *Crowea* "Bindalong Compact" flowers indoors for three to four weeks, and *Pimelia linifolia* flowers all year under controlled temperatures of 18°C to 25°C with a flower life of two weeks (von Hentig and Hass-Tschirschke, 1989).

Kangaroo paws as cut flowers have a vase life in excess of two weeks, with attractive felting, colour and shape (Stewart, 1987). Darkening, fading, wilting and shrivelling of florets, and blackening of bracts, stems and leaves, are cited as end of vase life symptoms. "Gold Fever" kangaroo paw was found to have a vase life of four to five weeks when kept in water, for cut flowers for the local market. The use of 20 percent sucrose on cut flowers prior to long distance transport reduced

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the effect of cool dry storage, which reduced the vase life. Silver salts, (sodium thiosulphate), which help to prevent wilting and flower abscission in ethylene sensitive flowers, do not increase the vase life of kangaroo paws (Sedgley *et al*, 1991c). Pretreatment of fresh flowers with materials such as the product ChrysalOVB® and sugar, directly after picking, extends the vase life and allows completion of opening of flowers picked in the bud stage, of *Gypsophila* and *Limonium* (Jones, 1991). *Chamelaucium* is affected by water stress if out of water for more than one hour after picking and the use of silver thiosulphate at 20°C to 25°C stops flower drop (Seaton, 1991).

1.5 Acacias as pot plants

1.5.1 Selection of cultivars

The basic restriction of pot plant culture is plant size, although floral display and phyllode habit are also important. Prostrate acacias include the cultivar "Austraflora Winter Gold" of *A. amblygona* propagated from cuttings as a ground cover. *A. rotundifolia*, from the Wimmera and Mallee, has an attractive low and arching habit at half a metre to two metres, and *A. semilunata*, is a small tree two to five metres high and grown as an ornamental as far south as northern Tasmania, although originating in the Darling Downs.

Recommendations for ornamental use, including pruning and seed or cutting reproduction have been developed for many species (Brownlie and Forrester, 1987; Costermans, 1973; Whibley, 1980). Manipulation of plant habit to produce suitable sized and interesting plants during pot plant trials includes pruning to shape (Everist, 1949). Several species have shown improvement with pruning. *A. chinchillensis*, originating from Queensland, is grown as a small ornamental shrub and pruned after flowering, while *A. plicata* from Western Australia is suitable as a rockery shrub or container plant, and pruned after flowering.

Selection of some other *Acacia* cultivars has involved specific plants selected from seedlings for prostrate or spreading form and multiplied by vegetative propagation to retain the desired features. Floral display in acacias can be spectacular, with panicles of flowers or spikes in bright to pale yellow, rarely white or mauve, and the number of inflorescences in combination with unusual phyllode shapes, as with *A. glaucoptera*, can make an attractive pot plant. Phyllodes often have unusual colours, for example *A. glaucoptera* and *A. notabilis* have red tips, while an attractive grey-coloured plant is *A. craspedocarpa* with round, curved and hairy phyllodes. Some acacias have bright green or grey bipinnate leaves, giving a soft and feathery effect, as with *A. baileyana* and *A. polybotrya*, the western silver wattle, which also shows some drought and frost tolerance (Simmons, 1988).

1.5.2 Plant Manipulation

1.5.2.1 Environmental control

1.5.2.1.1 Temperature

In view of the effect of temperature on flowering of *A. pycnantha*, with inhibition if temperatures are in excess of 19°C (Sedgley, 1985), the possibility that temperature is a controlling influence on flowering of acacias needs to be examined more closely. Other factors such as water availability, as in *A. aneura* may also be important (Everist, 1949; Winkworth, 1973).

1.5.2.1.2 Light

Light has been found to influence *Acacia* floral development and insufficient light will prevent flowering (Sedgley, 1985). This is an important aspect of pot plant life, so plants selected need to be tested in home light conditions to observe if flowering is prevented.

1.5.2.1.3 Pruning

Pruning young plants and pruning prior to flowering for plant shape should be investigated.

1.5.2.2 Chemicals

Plant manipulation using the chemical growth retardant, paclobutrazol, should be investigated in combination with temperature. The strength of chemical is derived from the guide for other ornamentals (Wilkinson and Padgham, 1987).

1.5.3 Vegetative propagation of acacias

The need for vegetative reproduction of desirable hybrids was ascertained early in the forestry use of *Acacia* (Ledeboer, 1944). Vegetative propagation is necessary to retain cultivar features (Payne, 1979). *A. dealbata* is produced from semi-hardened material in autumn, as propagation is not possible in other seasons. Tip material 75-100 mm long, with another cutting taken further down the stem were successfully rooted using IBA at 2000 ppm in 50% alcohol as a dip for 5 seconds. Root suckers from a desired plant also retain parent form. *A. baileyana* is reproduced rapidly in the form of large plants which have some flowering in the first season and are fully flowering within three years by air layering parent plants in an orchard (Boden, 1969). Flowering clones did not flower at exactly the same time as the parent or as clones at other sites, but the general habit of early or late flowering carried over to the clones.

Micropropagation has been examined for *A. melanoxylon* (Abou Dahab *et al*, 1990a,b). Rooting is affected by the age of the mother plants with younger plants producing a higher number of roots. Also, taking buds from further up the plant reduced rooting. Meyer and van Staden (1987) used more mature plants of *A. melanoxylon* and treated buds in vitro with hormones, finding that Indole-3-butyric acid was successful in producing primary and secondary roots.

As discussed, grafting is an accepted method of reproducing selected acacias on rootstocks which can withstand specific soils, such as the calcareous soils in the Riviera and southern France (Pryor, 1984; Ruffoni *et al*, 1990).

1.5.4 Future Work

Temperature differences investigated by Moe *et al* (1991b) provide a promising method of keeping plants compact and branched, while being environmentally sound by avoiding chemical build-up in the soil. Work with acacias with similar methods may show plant size control.

High light intensity has been implicated in the flowering of acacias, and this needs to be investigated further to see if a period of high light intensity will stimulate flowering. Again this is an environmentally sound method, with no potential adverse effects to the consumer.

Selection of flowering acacias must involve particularly attractive types, so that breeding programmes may be commenced. Selection of acacias which are known to respond to water availability by flowering at any time of the year, or which commence flowering following a period of water stress would increase the predictability of producing a flowering pot plant. The use of genetic manipulation and tissue culture to produce plants with desirable features must be kept in mind for future investigation, as this may avoid delays in breeding programs and produce miniaturised plants with regular sized flowers.

The unusual and very variable acacias show great promise as pot plants, when production schedules can be determined.

1.6 Summary

Acacias are a large and variable group of plants, which are notable for their floral display. Subdivision into groups is on floral, phyllode, seed and seed-pod attributes. Environmental problems, such as reproductive rate when considered as a weed, or as stock feed, have been examined. Overseas there

has been limited use of acacias for their plant products. Only recently have acacias been studied for plant control with the aim to promote the genus as ornamental flowering plants, or pot plants. Now the study of physiology, and the control of plant growth and floral development should determine methods of plant and flower production.

Completed January 1992.

Chapter 2 Project aims and description

2.1 Aim

The overall aim was to develop production methods for flowering pot plants of Australian acacias.

2.1.1 Species selection

An important first step was to select *Acacia* species for experimentation, based on foliage and inflorescence appearance. Criteria included foliage and inflorescence colour and shape, with the absence of thorns. The nursery industry had suggested that fine, dense foliage with bright green or blue colour tones and gold inflorescences were desired in pot plants (Sedgley and Parletta, 1993). Selection of species which were naturally small in size was also a criterion as these were more likely to provide plants of a size suitable for a potted plant, although some attractive larger species were also considered. In addition, seed of some less common small *Acacia* species were obtained and plants established in the Waite Arboretum for future work.

2.1.2 Control of size and appearance

Control of size is essential for a successful pot plant (Lamont 1987). The aim was to develop effective methods for retarding the growth of *Acacia* species which were too large, but otherwise suitable for a potted plant. For a bushier appearance, plants were treated with physical and chemical means to stimulate lateral bud growth.

2.1.3 Control of flowering

The aim was to understand the factors controlling floral behaviour of suitable *Acacia* species, so that treatment methods to control the time of flowering could be applied to plants. Flowering of the species *A. pycnantha* had been determined to be responsive to low temperature (Sedgley, 1985)

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and the aim was to investigate if similar flowering controls might exist in other species. Minimum time to flowering from seed was also investigated.

2.1.4 Development of a pot plant protocol

The nursery industry needs to understand how to produce pot plants efficiently and as quickly as possible. von Hentig and Hass-Tschirschke (1989) discuss physiological limits, including the effects of latitude and light intensity, on Australian plants taken to Germany for development as ornamental pot plants. Israel produces inexpensive flowering pot plants for the European market from winter flowering woody species, having raised them quickly under outdoor conditions of high light intensity in unheated structures (Ben-Jaacov and Ackerman, 1989a). The treatment methods should also meet the import standards of potential overseas purchasers of the plants. Development of a protocol for the production of a flowering potted *Acacia* ornamental would benefit the nursery industry.

2.2 Project description

2.2.1 Species selection

The species selected for this research, using criteria described in 2.1.1, were *A. acinacea, A. baileyana, A. baileyana purpurea, A. buxifolia, A. cometes, A. craspedocarpa, A. crassuloides, A. decora, A. drummondii* ssp *elegans, A. glaucoptera, A. imbricata, A. meisneri, A. myrtifolia, A. notabilis, A. podalyrifolia, A. polybotrya, A. pycnantha, A. retinodes, A. semilunata, A. vestita,* and *A. verniciflua.* They are described in Chapter 3.

2.2.2 Control of size and appearance

Mature plants in the glasshouse were pruned and/or exposed to a range of paclobutrazol treatments to determine the best rate of treatment and to expose phytotoxic effects (Chapter 5).

Seedlings were treated with high night temperature in an attempt to reduce plant size (Chapter 6).

Seedlings were pruned to increase branch number and reduce size, treated with paclobutrazol to reduce size, and a cytokinin to promote branching. Treatments were applied singly, in combination or were repeated, to determine if interaction or increased treatment rates improved results. (Chapter 7).

2.2.3 Control of flowering

Seedlings were treated with low temperature to investigate the control of flowering (Chapter 6). In addition, seed was sown consecutively throughout spring to autumn to determine the response in time of flowering and the most appropriate season for sowing (Chapter 8).

2.2.4 Development of a pot plant protocol

Protocols were developed, based on the results of previous chapters, for rapid production of seedling *Acacia* pot plants of appropriate size, using exposure to ambient winter conditions to produce flowering (Chapter 9).

Chapter 3 Selection criteria and selected species

3.1 Introduction

The genus *Acacia* mainly comprises medium to small shrubs, with some large trees. There is a range of plant habit within a species, which may be due to genetic variability. Investigation of species *A. myrtifolia* and *A suaveolens* revealed that they contained genetically induced tall and short forms adapted to specific environments (Auld and Morrison, 1992).

Inflorescences are either spherical or cylindrical, solitary or in racemes or branched panicles, ranging from bright yellow to pale yellow or cream, although a minority of species has mauve or purple inflorescences. They present a massed display with sweet perfume. Nectar may be present in the subgenus *Aculeiferum*, which includes some African species, but no nectar is produced in the flowers of the Australian subgenera *Acacia* and *Phyllodineae* (Pedley, 1986).

Most Australian acacias are phyllodinous, and this is considered to be an adaptation to xeromorphic conditions. They have flattened leaf stalks, and the anatomy is closely related to the taxonomy (Boughton, 1986). Some species have true bipinnate leaves made up of many small pinnules or leaflets along a branched central stalk. This condition may be evolutionarily primitive, or an adaptation to recent humid conditions (Pedley, 1986). At the base of the phyllodes, or stalk of bipinnate leaves, is a gland or extra-floral nectary which may secrete sugary fluid during flowering.

3.2 Selection criteria

For an ornamental pot plant, species were selected for:
1. small size, of less than 5 m height, preferably less than 1 m;
2. attractive or unusual phyllode or leaf appearance, of blue, grey or bright green colour, but not with spines or sharp points at the end of phyllodes;

3. floral characteristics of inflorescence abundance and bright yellow, gold or lemon colour (Sedgley and Parletta, 1993).

3.3 Phyllodinous species

The following phyllodinous species were included in the experiments.

A. acinacea (Fig 7.3) occurs in South Australia (SA), New South Wales (NSW) and Victoria to a height of 0.5-2.5 m and width of 2-4 m (Elliot and Jones, 1982). It has small obovate or orbicular phyllodes and produces profuse small axillary, globular, bright yellow inflorescences between May and September (Whibley and Symon, 1992). This species now includes *A. rotundifolia*, and is closely allied to *A. imbricata* (Maslin, 1987).

A. buxifolia (Fig 6.4), from Queensland, NSW and Victoria, grows 2-4 m tall and 2-3 m wide with grey-green small ovate phyllodes with soft points. It produces profuse golden yellow globular inflorescences in axillary racemes from July to December (Elliot and Jones, 1982).

A. cometes (Fig 7.5), from Western Australia (WA), is 0.2-0.3 m in height and 0.5-0.8 m in width, with short narrow crowded phyllodes. It produces spikes of globular inflorescences from October to November (Elliot and Jones, 1982).

A. craspedocarpa grows in WA and is 2-2.5 m tall and 1.5-4 m wide (Simmons, 1988) with grey ovate leathery phyllodes. The axillary bright yellow spikes of inflorescences occur between August and October (Elliot and Jones, 1982).

A. crassuloides (Fig 7.4) is 0.3-0.6 m tall and 1-1.5 m wide, and occurs in WA. It produces crowded greyish green, horizontally flattened phyllodes. The golden yellow globular inflorescences appear two per axil from September to October (Elliot and Jones, 1982).

A. decora occurs in Queensland, NSW and Victoria to a height of 2-5 m and width of 3-5 m, with smooth, leathery, bluish

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grey-green phyllodes. The golden yellow, globular inflorescences are produced in long terminal racemes from August to October (Elliot and Jones, 1982).

A. glaucoptera (Frontispiece) from Western Australia, grows 0.5-1.5 m tall and 2-3 m wide, and forms flat continuous triangular blue-green phyllodes in a zig-zag pattern, with red vegetative flush growth. The deep yellow, globular inflorescences occur one per axil between August and November (Elliot and Jones, 1982).

A. imbricata (Fig 7.1), allied to *A. acinacea*, grows in SA to a height of 1-2 m (Simmons, 1988) and width of 2-6 m, with densely crowded, dark green, small phyllodes. The bright yellow, globular inflorescences appear one to two per axil from July to September (Elliot and Jones, 1982).

A. meisneri occurs in WA to a height of 3-4 m and width of 4-6 m with small, light blue-green, leathery phyllodes. The profuse yellow globular flower-heads occur one per axil, or as a short raceme, flowering from May to January (Elliot and Jones, 1982).

A. myrtifolia (Fig 6.5) occurs in all states and is now described as the *A. myrtifolia* group (Maslin, 1995). It grows to a height of 1-3 m and width of 2-3 m, with narrow bright green phyllodes. The globular pale yellow to yellow, relatively large flower heads, in racemes 2-10 cm long, flower from July to October (Elliot and Jones, 1982).

A. notabilis (Fig 5.10, 5.14-5.15)grows in SA, NSW and WA to a height of 3-6 m and width of 3-7 m, with long blunt, leathery, grey-green phyllodes. The golden yellow, globular inflorescences are produced in racemes, shorter than the phyllodes, and flower from July to November (Elliot and Jones, 1982).

A. podalyrifolia grows through Queensland and NSW to a height of 3-5 m and width of 3-4 m, with ovate, silver grey phyllodes. The bright yellow, globular flower heads, as axillary or terminal racemes, flower from July to October (Elliot and Jones, 1982).

A. pycnantha occurs through SA, NSW and Victoria to a height of 3-10 m and width of 2-6 m, with broad, shiny phyllodes. The profuse, scented golden globular flower heads appear in a raceme with a zigzag stem, 8-15 cm long, flowering from July to October (Elliot and Jones, 1982).

A. retinodes grows in SA to 0.5-1.5 m tall and 1-2 m wide, with bluish green, long, narrow phyllodes ending in a fine point. The lemon yellow racemes of inflorescences, shorter than the phyllodes, flower mainly between November and January but may appear all year (Elliot and Jones, 1982).

A. semilunata grows in Queensland to 2-4 m high and 1-3 m wide (Elliot and Jones, 1982), with blue-green crescent shaped phyllodes and a reddish purple tinge on new growth. Inflorescences are globular, bright yellow in axillary or terminal racemes, 5-10 cm long in July to September (Simmons, 1988).

A. vestita grows in NSW to a height of 3-6 m and width of 3-5 m (Elliot and Jones, 1982) with soft greyish, hairy, ovate-elliptical phyllodes ending in a fine point. The golden yellow inflorescences on terminally positioned racemes appear in August to October (Canberra Botanic Gardens, 1975).

A. verniciflua grows in SA and the eastern states, and is 1-2.5 m tall and 3-5 m wide (Simmons, 1988), having sickle shaped phyllodes and shiny resinous young growth. The pale to bright yellow inflorescences, 1-3 per axil, appear in July to January (Elliot and Jones, 1982).

3.4 Bipinnate species

The following bipinnate species were included in the experiments.

A. baileyana (Fig 7.7) from NSW occurs as a tree 5-8 m tall and 5-8 m wide (Elliot and Jones, 1982), with blue-green to silver-grey bipinnate leaves. The golden yellow globular inflorescences appear in dense racemes at the ends of branchlets from July to September (Boden, 1969).

A. baileyana purpurea is a form of *A. baileyana* with bright purple new foliage (Elliot and Jones, 1982).

A. drummondii ssp elegans (Fig 6.1-6.2) from WA grows 1-3 m tall and 2-3 m wide with bright green bipinnate foliage of 1-3 pinnae pairs per leaf. The large golden yellow rod shaped inflorescences occur one per axil from July to October (Elliot and Jones, 1982).

A. polybotrya (Fig 7.6) occurs in Queensland and NSW as a shrub 1-3 m tall and 1-3 m wide with grey-green bipinnate leaves with 1-4 pairs of pinnae. The masses of bright yellow globular inflorescences in racemes 3-9 cm long flower from August to October (Simmons, 1988).

Chapter 4 Materials and methods

4.1 Seedling production

4.1.1 Seed handling

Seed was obtained from Nindethana Seed Service, the Society for Growing Australian Plants (SGAP), the Adelaide Botanic Gardens and the Mt. Annan Botanic Garden in Sydney. A low form of *A. notabilis* was collected from One Tree Hill, South Australia. All seed was stored at room temperature until required. Samples of counted seeds were weighed so that estimation of seed numbers for large experiments could be made from weight (Table 4.1).

Table 4.1 Seed weight of selected *Acacia* species

Species	No seeds counted	Wt/Seed (mg)
A. buxifolia	350	24.6
A. cometes	600	2.6
A. decora	450	17.0
A. drummondii elegans	650	3.7
A. glaucoptera	650	5.0
A. imbricata	650	2.3
A. meisneri	150	52.1
A. myrtifolia	150	7.1
A. retinodes	200	13.8
A. semilunata	450	8.4
A. vestita	450	28.6

Seed weight varied from 2.3 mg for *A. imbricata* to 52.1 mg for *A. meisneri*.

4.1.2 Hot water treatment

Seeds were scarified using water heated to boiling, then allowed to cool slightly before addition of the seeds (Burrows 1991). Seeds remained in the water for about 10 minutes, after which they were removed.

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4.1.3 Germination

4.1.3.1 Seedlings for experiments

Seeds were individually planted in 15 cm diameter pots of potting mix (Mt Compass sand, peat and alulite, 1:1:1 by volume) and placed in the glasshouse. Counts of seedlings were recorded to determine germination rates. Sowing dates were 3/3/92 (Table 4.2a), 9/3/92 (Table 4.2b) and 20/3/92 and numbers of seed germinated are presented.

Table 4.2a **Cumulative numbers of *Acacia* seeds germinated from 3/3/92 sowing**

Time (days)	A. buxifolia	A. decora	A. drummondii elegans	A. meisneri
No. sown	117	113	117	130
0	0	0	0	0
10	0	32	0	0
17	6	44	0	7
22	13	50	1	16
27	15	51	32	28
31	15	54	45	29
35	21	51	66	30
37	21	49	67	32
% germination	18	43	57	25

A. drummondii elegans and *A. decora* produced greater than 40% germination by five weeks after sowing.

Table 4.2b Cumulative numbers of *Acacia* seeds germinated from 9/3/92 sowing

Time (days)	A. cometes	A. imbricata	A. glaucoptera	A. vestita
No. sown	155	103	630	120
0	0	0	0	0
11	0	0	1	1
16	0	1	12	13
21	7	13	90	37
25	13	21	139	43
29	16	36	177	49
31	17	37	181	54
% germination	11	36	29	45

From the 9/3/92 sowing, *A. imbricata* and *A. vestita* produced greater than 35% germination by five weeks after sowing. From the 20/3/92 sowing, twelve *A. notabilis* seedlings germinated from 98 seeds after 26 days, representing 12% germination.

As numbers germinating were low, lots of 25 seeds were sown into each 15 cm pot on 12/6/92, and germination recorded.

Table 4.3 Cumulative germination of *Acacia* seeds from 12.6.92 sowing

Time (days)	A. acinacea	A. baileyana	A. baileyana purpurea	A. crassuloides	A. polybotrya	A. podalyrifolia
No. sown	125	125	125	125	125	125
0	0	0	0	0	0	0
21	20	22	88	0	50	55
27	43	27	85	72	55	70
43	73	28	103	82	67	83
% germinated	58	22	82	66	54	66

Greater than 50% germination was recorded with all species after six weeks, except for *A. baileyana purpurea*. Germinated seedlings were potted on individually to 15 cm pots containing the same mix.

It was subsequently found that a glass plate over the pot of germinating seeds further reduced losses through prevention of insect attack. These methods were used for all subsequent experiments.

4.2 Plant treatments

Plants were watered every second day, and remained in a glasshouse until treatment. Fertiliser was applied approximately every six months in the form of a low phosphorus mix of 1.2 g/L ammonium sulphate, 0.3 g/L potassium nitrate, 38 mg/L mono ammonium phosphate and 3 mg/L trace elements with 300 ml applied per pot.

4.2.1 Environmental conditions

Plants were kept in the glasshouse, outside or in controlled environment cabinets. Temperature records were kept and light intensity at sites was recorded with a Li-Cor Quantum/ Radiometer/Photometer Sensor instrument (Biggs and Hansen, 1979).

4.2.1.1 Glasshouse

The glasshouse temperature was maintained at a maximum of 25°C and minimum of 15°C. During the summer the outside of the glasshouse was whitewashed. Glasshouse light intensity ranged from a mean of 97 w/m^2 in summer to 16 w/m^2 in winter. Plants were watered as required.

4.2.1.2 Outside

The outside plants were protected from wind and watered daily. Pots were placed on weed mat. **Figure 4.1** shows the mean maximum and minimum temperatures recorded during

1991-1994 for the outside plant site. Light intensities ranged between 155 w/m^2 in summer to 15 w/m^2 in winter. **Figure 4.2** shows the solar radiation and sunshine hours during 1991-1994.

4.2.1.3 Controlled environment conditions

For the high night temperature treatment, the temperature was 25°C during the night and 20°C during the day, or 25°C day 20°C night for a 12 hour period. Plants were watered every second day.

For the low temperature treatments the temperature was 15°C during the day and 10°C during the night, or 25°C day 20°C night for a 12 hour period. Watering was as necessary.

Environmental growth cabinets with sodium, fluorescent and incandescent lamps had a mean light intensity of 36 w/m^2, and were used up to September 1992. These lights induced some chlorosis and necrosis of phyllodes, as the sodium lamps may have supplied too much red light for the amount of far red from the incandescents (Templing and Verbruggen, 1977).

Thereafter growth cabinets using metal halide lights in place of half of the sodium lamps were used. These cabinets had a mean light intensity of 25 w/m^2. The spectral distribution of the blue metal halide lamp was from 320 to 840 nm wavelength, with a peak at 450 nm. The sodium lamp provided light from 400 to 750 nm with peaks at 490 and 550-600 nm but with little light at any wavelengths except the peaks. (Eye Sunlux, 1983).

4.3 Physical and chemical treatments

Plants were pruned by removal of the main stem at a measured height above the soil. A dwarfing treatment, paclobutrazol (Cultar®) was applied as a pot drench, with runoff collected and reapplied. Cultar® contains 250 gL^{-1} paclobutrazol as active ingredient (ai) and was mixed with deionised water, with 2 mgai the most frequently applied

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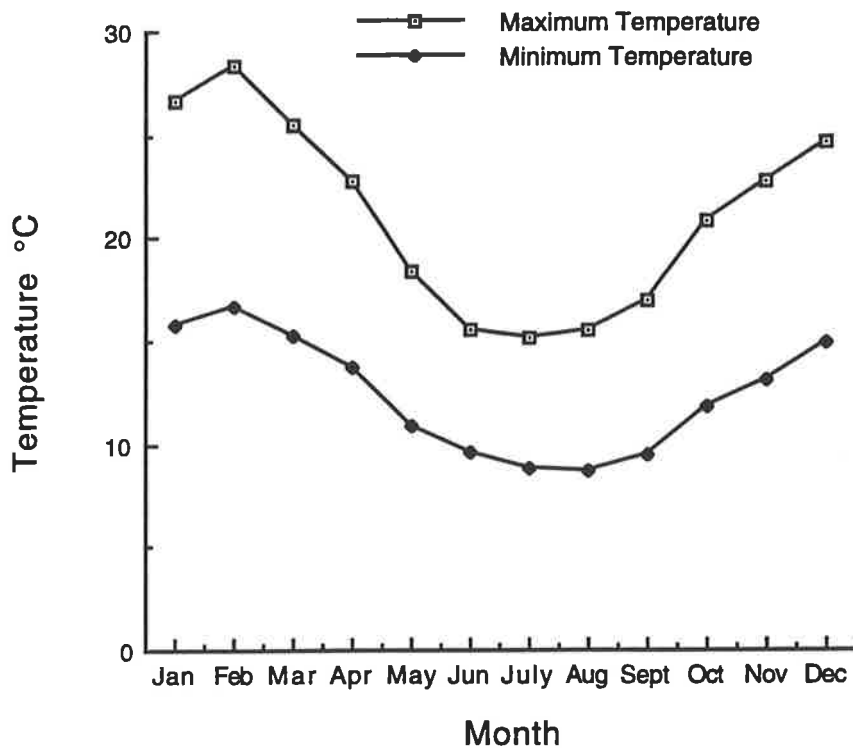
Figure 4.1 Mean maximum and minimum temperatures 1991-1994 at Waite Agricultural Research Institute, South Australia
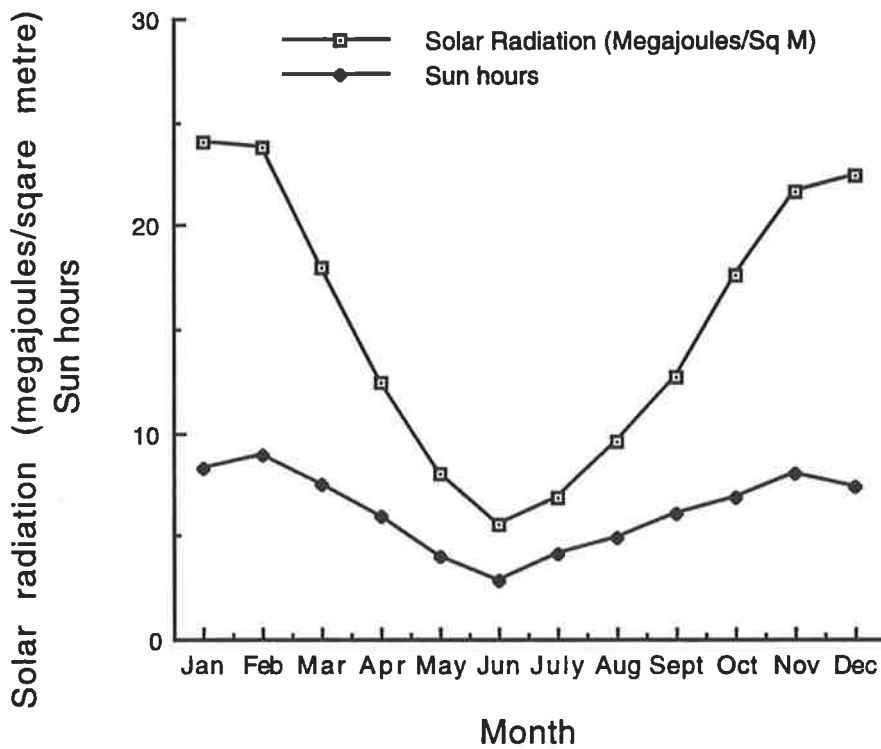
Figure 4.2 Mean light intensity and duration 1991-1994 at Waite Agricultural Research Institute, South Australia

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rate in 20 ml solution to each pot. A branching treatment, cytokinin 6, benzylamino purine (Bap) was applied as a solution sprayed onto leaves until runoff. The spray was prepared in reverse osmosis (RO) water with two drops of Tween 20, as a wetting agent. Pot volume was 1.25 L.

Treatments were applied singly, or were repeated after a period of time, or were combined with other treatments.

4.4 Measurements

In initial trials, bud number, node number and shoot development were closely examined, with records made at the commencement of the treatments, monthly for two months and after six months. In subsequent experiments measurements of plant height above the soil, width across the widest part of the plant, and a count of the number of branches longer than 1 cm were recorded. The records were at commencement, after six months and after one year.

Plants were observed for floral initiation. The time of initiation and number of plants initiating inflorescences, and the time of flowering and number of inflorescences produced were recorded. The period of flowering was calculated.

4.5 Statistical analysis of data

Experiments were set up in a completely random fashion. Analysis of data was by Analysis of Variance (ANOVA) using Genstat. Means were tested for significant differences using Tukey's conservative test at the 5% level. The significance of treatments on numbers of initiated plants and numbers of flowering plants was determined by applying a binomial model to the data. A Poisson model was used where the fit of variance of means for integral counts to the normal distribution was deemed to be inappropriate using Anova.

Chapter 5 Effect of manipulation on mature plants

5.1 Introduction

Floral buds are produced on new growth in *A. pycnantha* throughout the year, but these develop and flower only between June and December (Buttrose *et al*, 1981). A mean maximum temperature of 19°C and minimum of 8°C are required for meiosis in *A. pycnantha* (Sedgley, 1985). Plant height has been reduced and flowering increased with the growth retardant paclobutrazol applied as a soil drench to a range of plants including *Bouvardia humboldtii* and *Chrysanthemum morifolium* var. "Snow Crystal" (Wilkinson and Padgham, 1987). In these experiments, the effect of temperature and paclobutrazol treatments, alone or in combination, on potted acacias more than eighteen months of age was examined.

Two controlled environment rooms were used for the temperature treatment. One was set at 15°C day 5°C night (15/5) with a 12 hour photoperiod, and the other at 20°C day 8°C night (20/8) also with twelve hours day and night. Light was provided by high pressure sodium lamps, fluorescent tubes and incandescent lamps at a mean light intensity of 27 w/m^2 in the 15/5 room and 33 w/m^2 in the 20/8 room. The temperature and light conditions of plants kept outside are shown in Figs 4.1 and 4.2. Glasshouse trials were conducted under controlled temperatures of 25°C day and 15°C night, with light intensity ranging from a maximum 40 w/m^2 recorded in February to a minimum of 9 w/m^2 in June.

The effect of temperature on mature *A. pycnantha* plants was examined in controlled environment cabinets.

The effect of paclobutrazol (Pac) at a rate of 2 mgai was trialled on mature plants of *A notabilis* in controlled environment cabinets. Treated plants received an application of the active ingredient Pac as a soil drench dissolved in nanopure water. All plants in an experiment received the same volume of liquid.

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The low rate of 1 mgai, medium rate of 4 mgai and high rate of 20 mgai were tested in glasshouse trials on *A. imbricata*, *A. semilunata*, and *A. verniciflua*.

5.2 Effect of temperature on *A. pycnantha*

Five year old 2 m tall plants of *A. pycnantha* in 30 cm pots were pruned to 1 m, fertilized lightly with blood and bone and ammonium nitrate and maintained until new shoots appeared. The experiment was set up in February 1991, when plants were transferred to two controlled environment rooms (15/5 and 20/8), where plants remained for six months, after which they were placed outside in September, 1991. There were seven plants per treatment, and seven plants remained outside (Figs 4.1, 4.2) for the duration of the experiment.
Measurements of vegetative growth of ten shoots on each plant were recorded as shoot length (cm), node number and internode length (cm), with a bud number count (new shoots) of all visible buds less than 1 mm in length on each plant.

Statistical analysis of results was by Anova, with a log transformation of data to improve the distribution as there was considerable heterogeneity of variance in the original data. The plants in this experiment were donated by SGAP.

5.2.1 Effect of temperature on vegetative growth of A. pycnantha
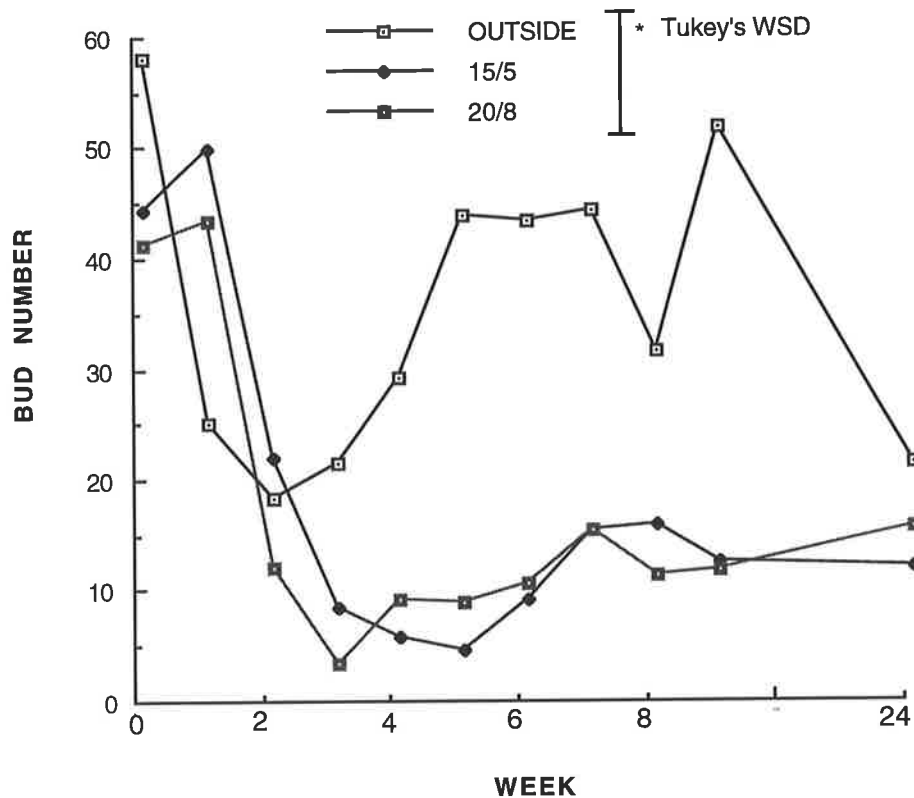
*Tukey's wholly significant difference for treatments for treatment*week is 11.0.

Figure 5.1 Effect of temperature on bud number of A. pycnantha

Plants maintained outside produced significantly more buds than either temperature treatment (P<0.01), and the interaction between treatment and time was highly significant (P<0.001). Plants displayed a high bud loss, occurring two to four weeks after commencing the experiment, and then subsequently produced a number of new buds. Bud numbers appeared to increase and decrease in a cyclical fashion for all treatments.
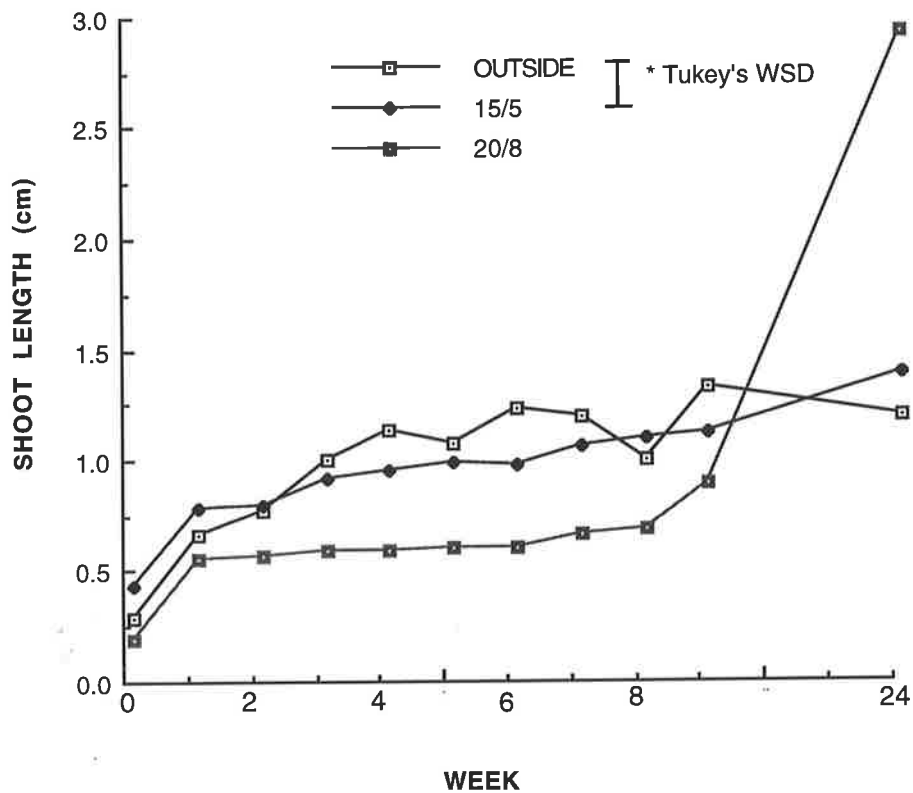
*Tukey's wholly significant difference for treatment*week for shoot
length was 0.22.

Figure 5.2 Effect of temperature on shoot length of
A. pycnantha

There was a highly significant interaction between time and
temperature treatment (P<0.01). The 20/8 treatment produced the
shortest shoots initially, then from 9 weeks shoots grew longer
than the 15/5 and outside shoots.
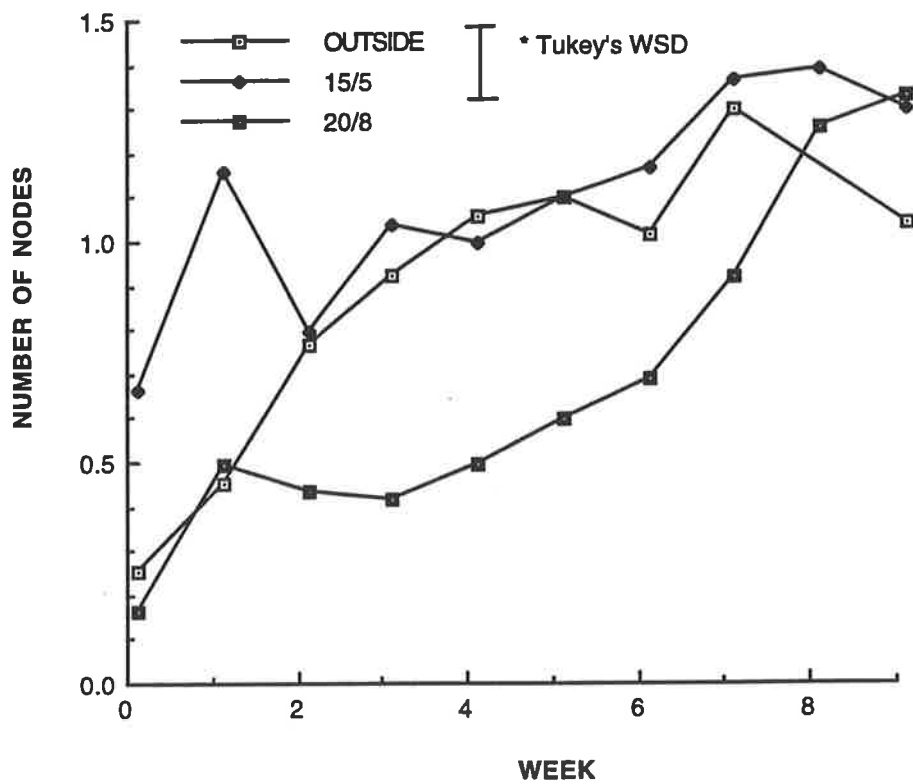
* Tukey's wholly significant difference for node number was 0.13.

Figure 5.3 Effect of temperature on number of nodes of *A. pycnantha* shoots

Temperature had a highly significant effect on node number. Plants treated with the temperature 20/8 had the least number of nodes until weeks 8 and 9, with rapid increase after week 6.
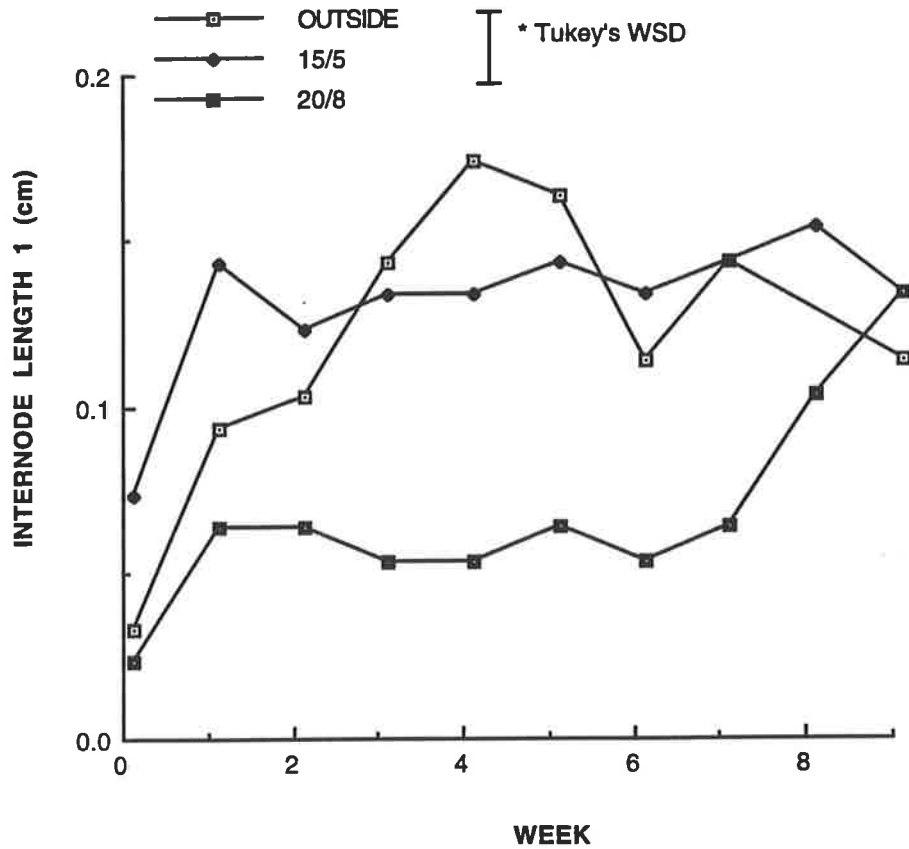
* Tukey's wholly significant difference for the data was 0.02.

Figure 5.4 Effect of temperature on the length of the first internode in shoots of *A. pycnantha*

The first internode was much shorter than subsequent internodes. Temperature had a highly significant effect on the first internode length. The 20/8 treatment produced the shortest internodal length until week 9.

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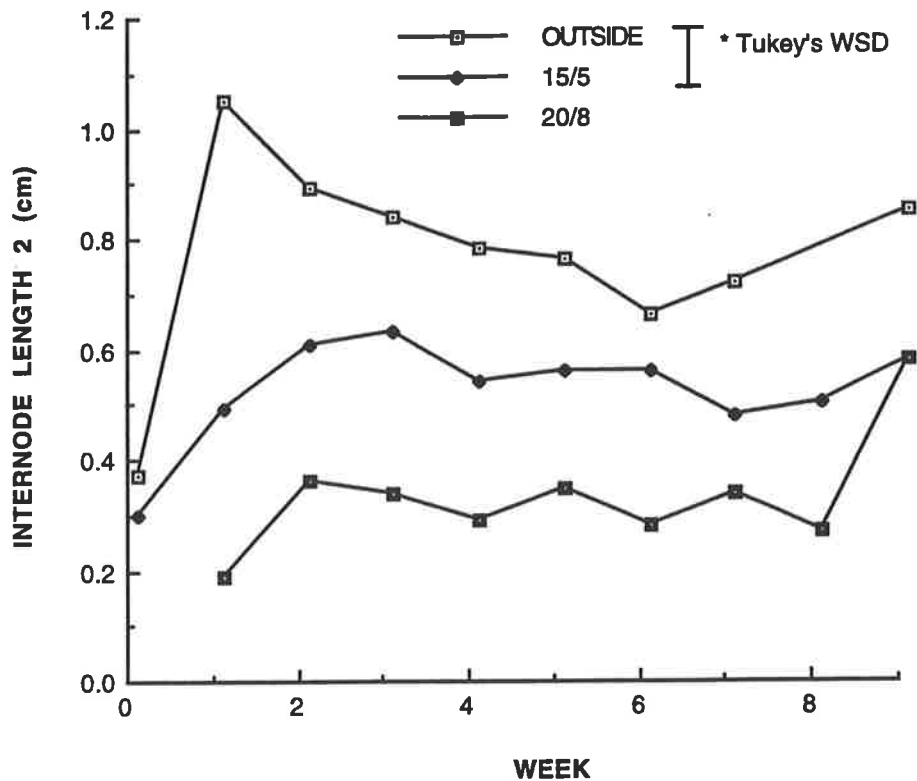
*Tukey's wholly significant difference for temperature for internode length two is 0.1.

Figure 5.5 Effect of temperature on the length of the second internode in shoots of *A. pycnantha*

Temperature had a highly significant effect on the length of the second internode. Temperature treatments reduced the length of the second internode, with 20/8 shorter than 15/5 until week 9, and outside plants had the longest internodes.
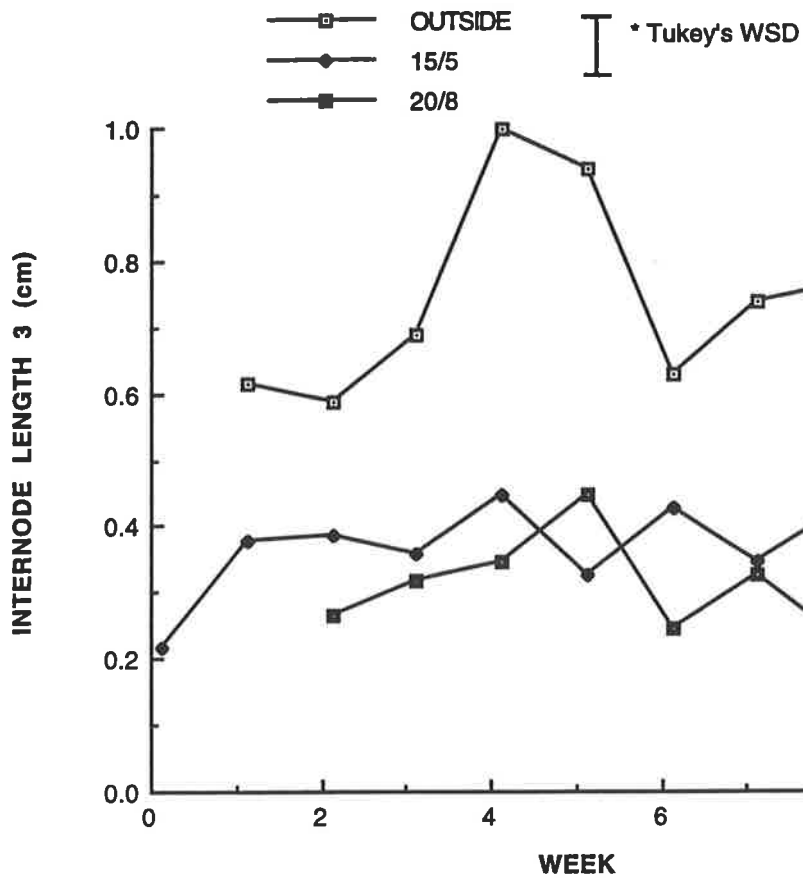
*Tukey's wholly significant difference for internode length 3 was 0.09.

Figure 5.6 Effect of temperature on the length of the third internode in shoots of *A. pycnantha*

Temperature had a highly significant effect on the third internode length, reducing the length of both 15/5 and 20/8 treatments compared to the outside treatment until week 9.
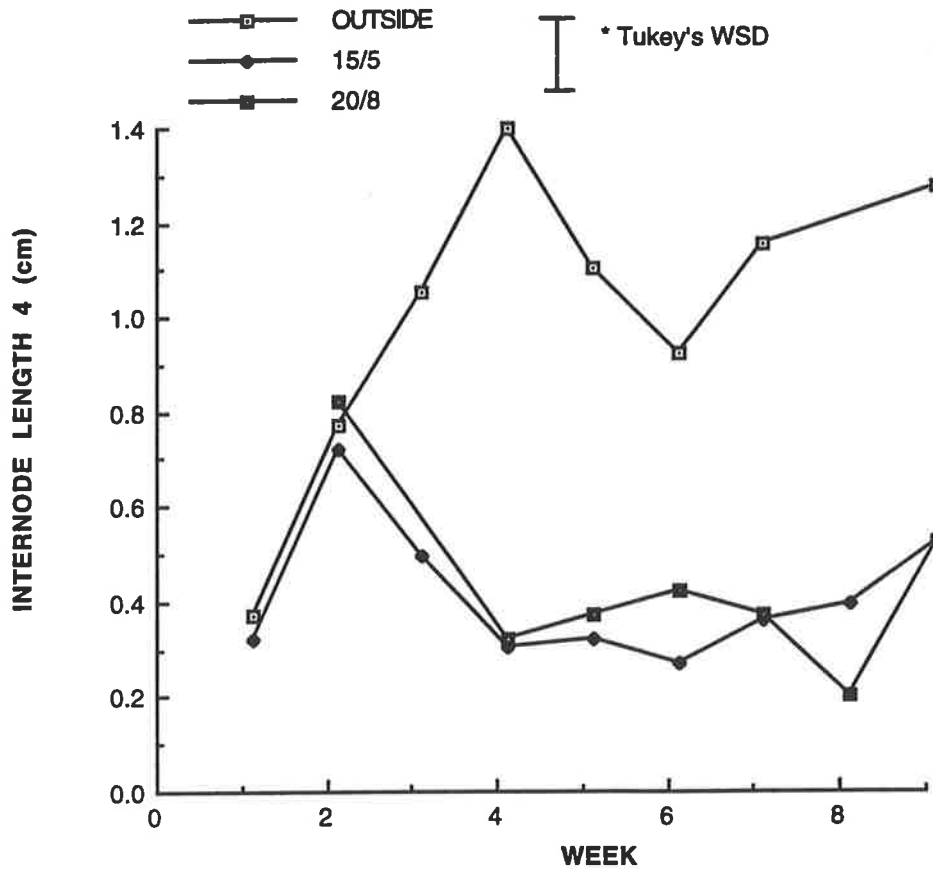
*Tukey's wholly significant difference for temperature for internode length four is 0.14.

Figure 5.7 Effect of temperature on the length of the fourth internode in shoots of *A. pycnantha*

Temperature had a highly significant effect on the fourth internode length, with both 15/5 and 20/8 treatments reduced in length compared with the outside plants.
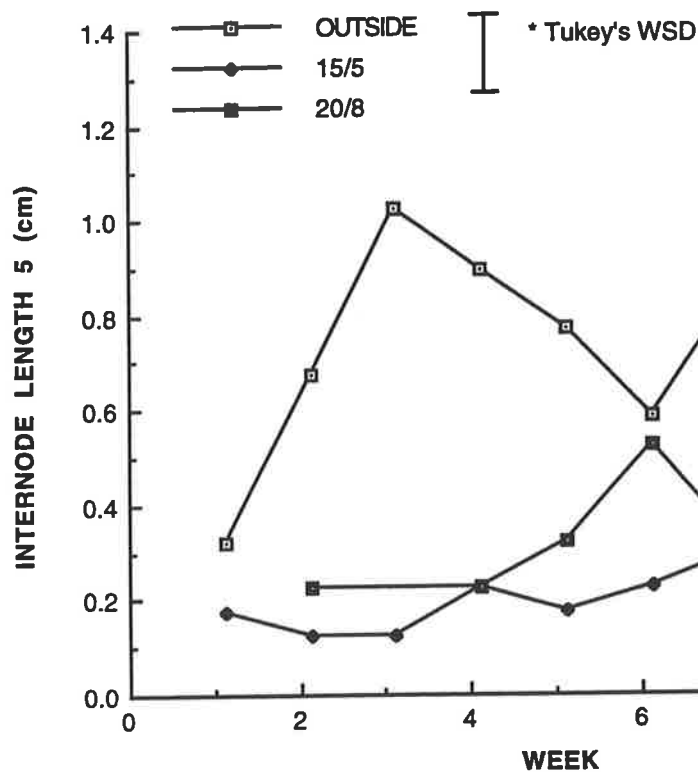
*Tukey's wholly significant difference for internode 5 was 0.15.

Figure 5.8 Effect of temperature on the length of the fifth internode in shoots of *A. pycnantha*

Temperature had a highly significant effect on the fifth internode, with both 15/5 and 20/8 treatments reduced in length compared to the outside plants.

Temperature had a highly significant effect on the length of internodes 6 and 7 (data not shown).

5.2.2 Discussion

Axillary buds developed on all plants as a result of removal of apical buds. Buds aborted after approximately four weeks, setting up cycles of initiation and abortion, indicating unsuitable conditions for bud development. Floral development in *A. pycnantha* buds is restricted during January to May (Buttrose *et al*, 1981)and by temperature (Sedgley, 1985).

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Number of nodes and internode lengths of 20/8 treatment were increasing to week 8, prior to the period of rapid shoot elongation to week 24, and could be expected to exceed numbers of nodes and internode lengths of outside and 15/5 plants if Figures 5.3 to 5.6 were extrapolated to week 24.

Plants were adversely affected by the initial heavy pruning and by the controlled environment chambers. The sodium lamps were considered to be a problem and later controlled environment chamber trials included metal halide lights, which provide more light in the blue wavelength.

5.3 Effect of temperature and Pac on *A. notabilis*

Three year old 1.5 m tall plants of *A. notabilis* were repotted into 25 cm pots, pruned to 1 metre high and fertilized lightly with blood and bone and ammonium nitrate. The experiment was set up in February 1991, when plants were transferred to two controlled environment rooms (15/5 and 20/8), where plants remained for six months. Plants within each temperature treatment were divided into two chemical treatments, with 2 mgai Pac added or with no Pac. There were nine plants per treatment. Plants were placed outside in September 1991. Nine plants remained outside for the duration of the experiment to indicate time of flowering.

Ten new vegetative shoots were selected on each plant and shoot length (cm) and internode length (cm) were measured, and number of nodes recorded. Bud number was the count of all visible buds less than 1 mm in length. Measurements were made for nine consecutive weeks and after six months. In 1992 flowering data of number of racemes, number of inflorescences and inflorescences per raceme were recorded monthly from March until July. The length of five flowering and five non-flowering racemes, their internode lengths and the number of nodes were recorded in April 1992.

Statistical analysis of data was by use of a model for completely randomised design to which data was fitted using Genstat. As a result of considerable heterogeneity of variance in original results, log scans were applied to improve the data. When insufficient counts were recorded, the chi-squared test was applied.

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5.3.1 Effect of temperature and Pac on vegetative growth of *A. notabilis*

5.3.1.1 Bud number
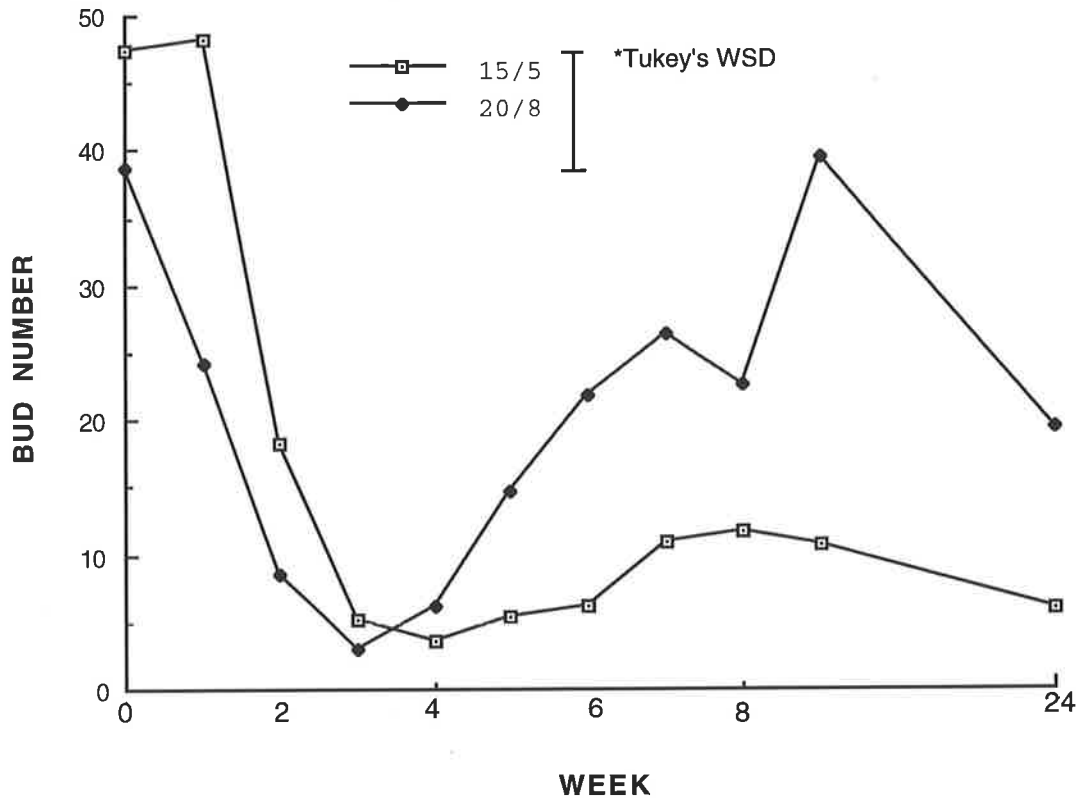
*Tukey's wholly significant difference for bud number is 8.9.

Figure 5.9 Effect of temperature on bud number of *A. notabilis*

Temperature significantly affected bud number (Fig 5.9), (P<0.05). There was a change in response of bud number to temperature with time (P<0.001), as temperature 20/8 reduced bud number before week 3, and thereafter increased bud number compared to 15/5. Pac had no effect on bud number.

5.3.1.2 Vegetative shoot length

Figure 5.10 Effect of temperature and Pac on vegetative shoot length of *A. notabilis*
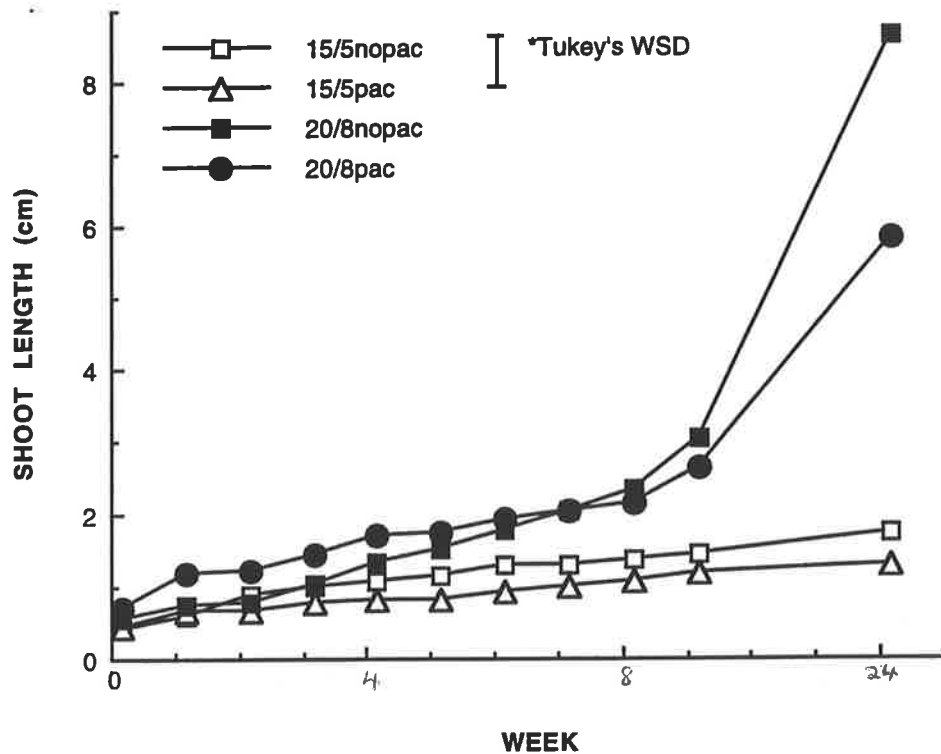
*Tukey's wholly significant difference between means for shoot length is 0.7.

Temperature had a highly significant effect on shoot length, as shown in the graph above (Figure 5.10) and photographically (Figure 5.11), and as time passed, shoot length was also affected by Pac, and the interaction between temperature and Pac ($P<0.001$). Temperature 20/8 resulted in longer shoots than 15/5 by week 24. Pac retarded shoot length at temperature 20/8 at week 24.

A.notabilis

SHOOT

INTERNODES 1-6

20°C
+PAC

20°C
NO PAC

15°C
+PAC

15°C
NO PAC

CONTROL
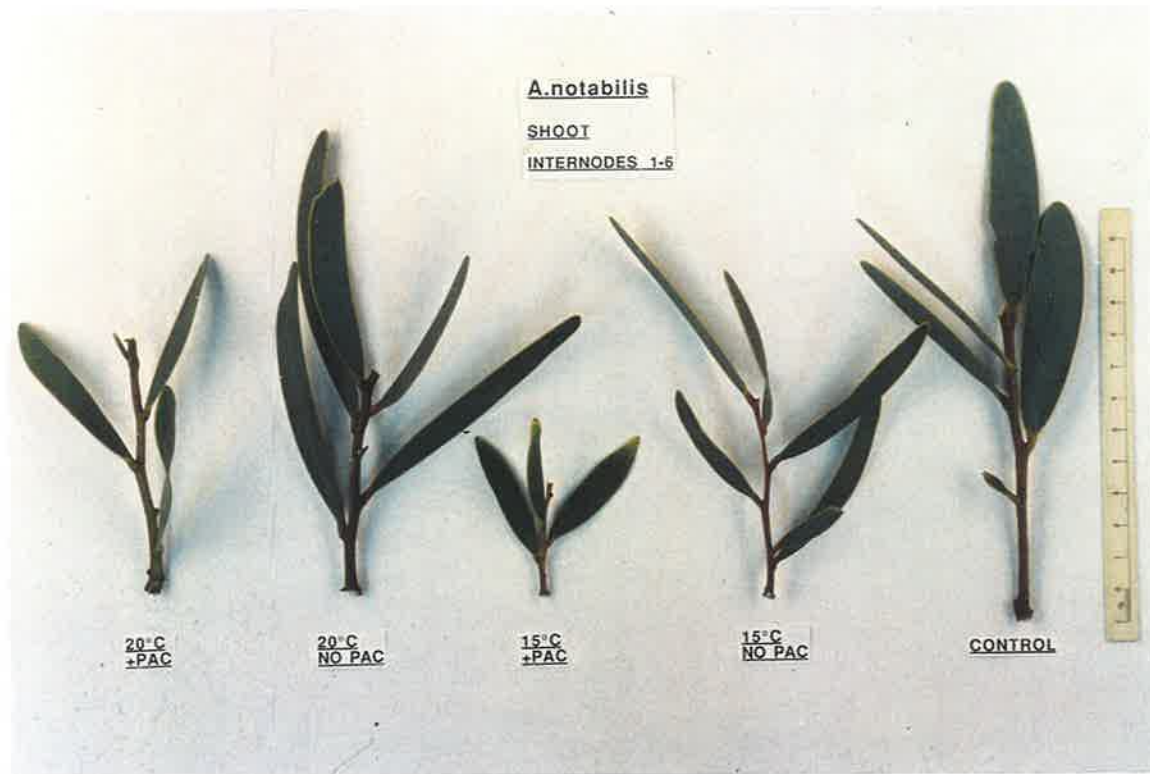
Figure 5.11 Shoot length of *A. notabilis* showing in the
first six internodes, the effect of temperature, with
with 15/5 shoots shorter than 20/8, and the
effect of Pac on internode length 1 of shoots.

5.3.1.3 Number of nodes
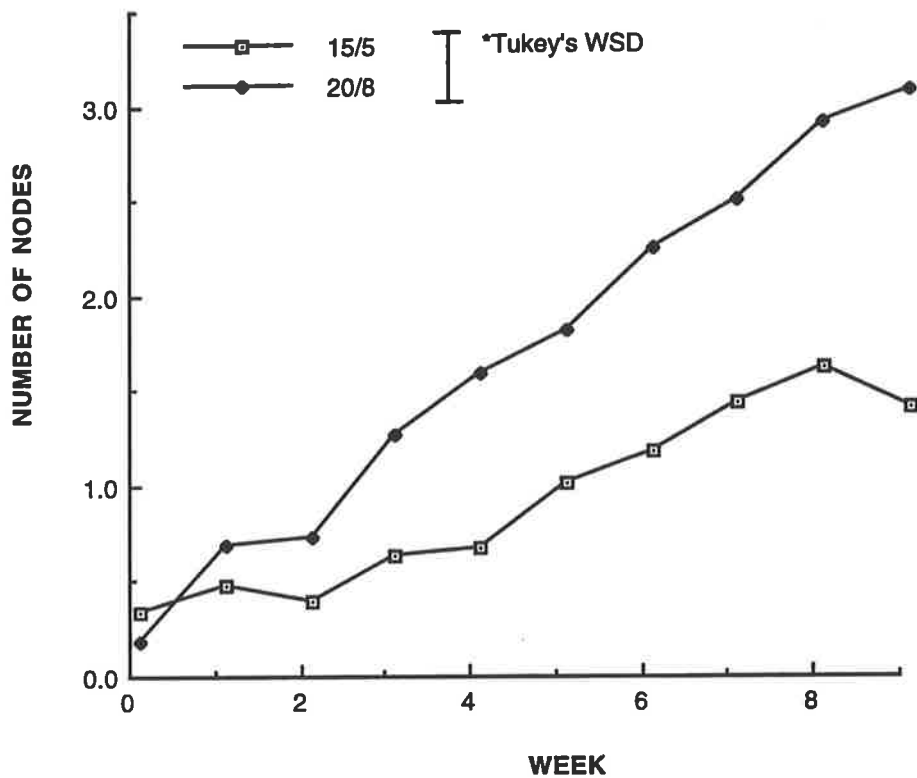
*Tukey's wholly significant difference between means for number of
nodes is 0.4.

**Figure 5.12.a Effect of temperature on number of nodes
on shoots of A. notabilis**

There was a change in the response of number of nodes on
shoots to temperature as time changed (Fig 5.12 a)
(P<0.001) with temperature 15/5 restricting development of
nodes from week 1.
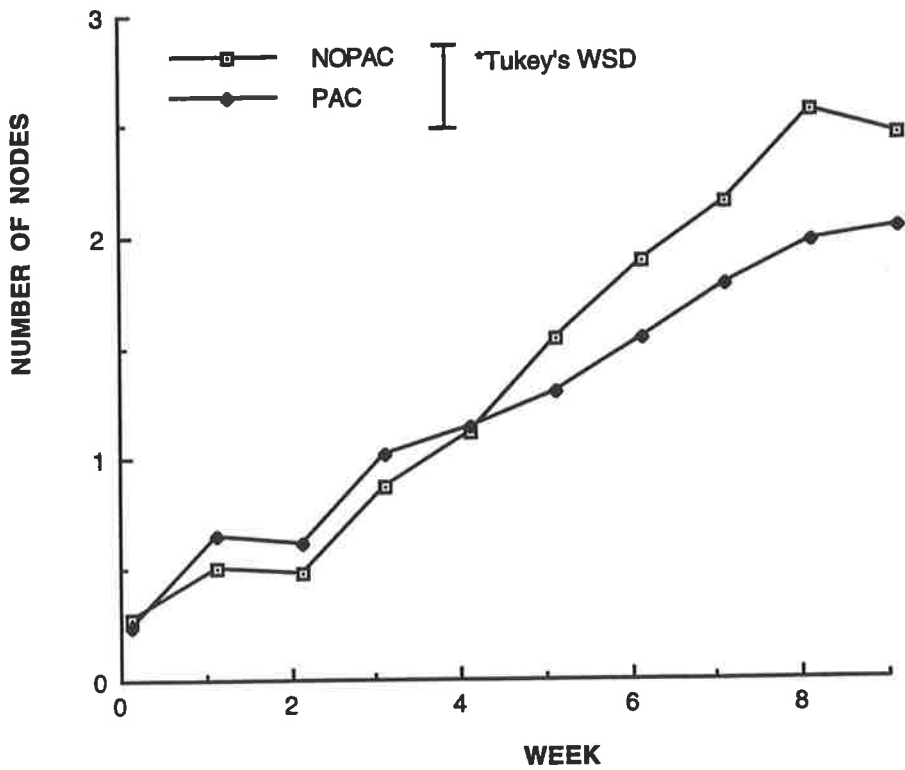
*Tukey's wholly significant difference between means for number of nodes is 0.4.

Figure 5.12 b Effect of Pac on number of nodes on shoots of *A. notabilis*

There was a change in the response of number of nodes on shoots to Pac as time changed (Fig 5.12 b) (P<0.001) with Pac restricting the number of nodes after 5 weeks.

5.3.1.4 Internode lengths
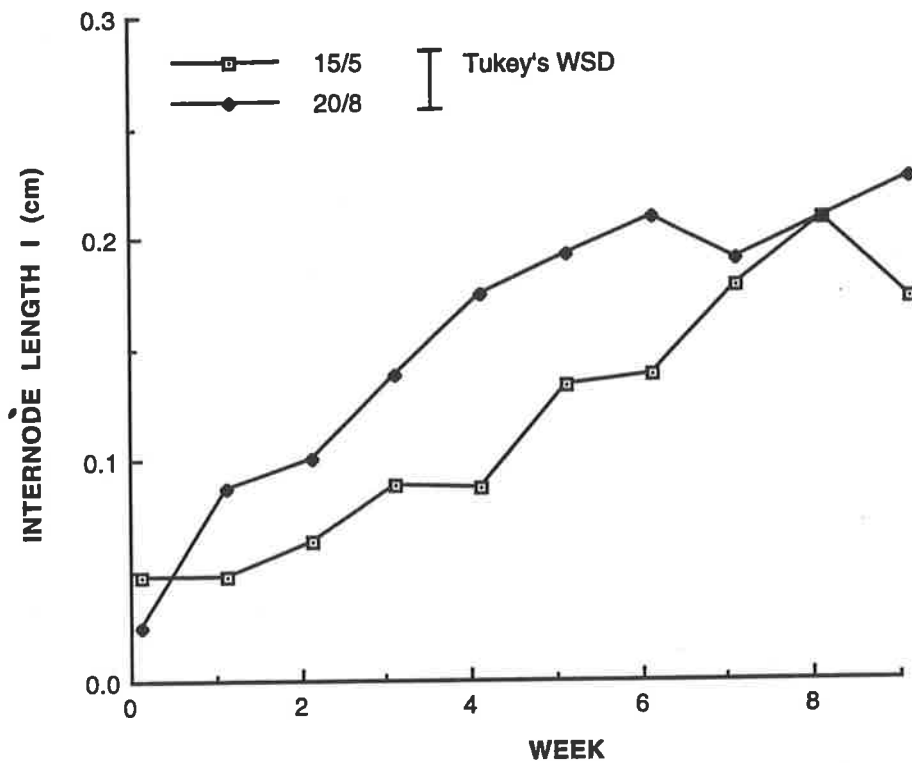
*Tukey's wholly significant difference between means for number of nodes is 0.05.

Figure 5.13 a Effect of temperature on internode length 1 of shoots of *A. notabilis*

There was a significant response to temperature of length of the first internode in shoots of *A. notabilis* ($P<0.05$) as time changed (Fig 5.13 a).
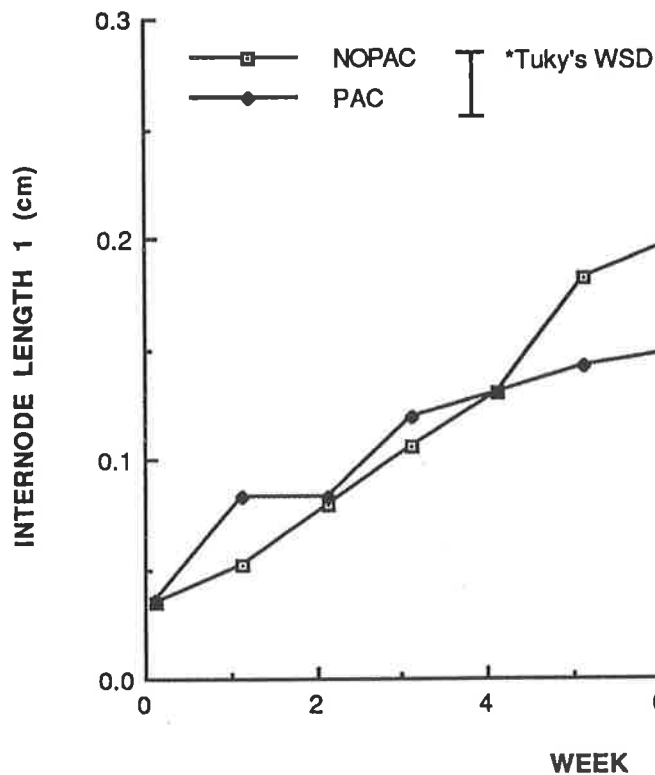
*Tukey's wholly significant difference between means for number of nodes is 0.05.

Figure 5.13 b Effect of Pac on internode · length 1 of shoots of *A. notabilis*

There was a significant response to Pac of length of the first internode in shoots of *A. notabilis* ($P<0.01$), with Pac restricting internode length development as time progressed (Fig 5.13 b).

Internode lengths 2 to 5 showed significant response to treatment if the control (outside) was included in the analysis. Analysis of data excluding the outside treatment, in recognition of differences between conditions in controlled temperature cabinets and outside ambient temperature regimes, showed no significant effect.

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Table 5.1 Internode length 2 to 5 of shoots of A. *notabilis* plants treated with temperature and Pac, and kept outside

Treatment		Internode length 2(cm)	Internode length 3(cm)	Internode length 4(cm)	Internode length 5(cm)
Time (month)	0	2	2	2	2
Outside		1.9	1.9	2.0	0.8
15/5 No Pac		0.4	0.5	0.6	0.3
15/5 Pac	0.3	0.5	0.4	0.5	0.6
20/8 No Pac		0.6	0.6	0.6	0.6
20/8 Pac		0.6	0.6	0.6	0.6
Probability		<0.05	NS	<0.05	NS

Outside plants had longer internodes 2 and 4, than treated plants. Results at two months are presented.

5.3.2 Effect of temperature and Pac on flowering of A. *notabilis*

Two plants (an outside plant with 8 inflorescence buds and one at 20/8 no Pac treatment, with 74 inflorescence buds) were observed with racemes of inflorescence buds in April 1991 but flowering did not occur. Flowering occurred from March to July 1992. All 9 outside plants flowered. Statistical analysis included fit of data as plant numbers were uneven, and the Poisson distribution was applied to node numbers to predict expected means. Analysis of inflorescence data used a log scan to produce a better fit of data.

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Table 5.2 Effect of temperature and Pac on number of racemes produced by *A. notabilis*

Treatment		Plants	Number of racemes					
Temp-erature	Chemical	flower-ing(/*)	March	April	May	June	July	Total
15/5	No Pac	8 (9)	109.9	103.9	112.4	103.8	103.3	533.1
	Plus Pac	8 (9)	91.3	91.0	96.9	90.1	95.4	464.6
20/8	No Pac	6 (6)	63.7	59.5	61.7	59.7	62.5	307.0
	Plus Pac	9 (9)	104.2	119.9	132.4	118.4	136.4	611.4

Probability   NS

* Total plants

There was no significant effect on raceme numbers of either temperature or Pac.

Table 5.3 Effect of temperature and Pac on number of inflorescences per raceme of *A. notabilis*

Treatment		Plants	Mean no of inflorescences per raceme					
Temp-erature	Chemical	flower-ing(/*)	March	April	May	June	July	All months
15/5	No Pac	8 (9)	6.9	7.2	6.6	6.8	6.6	6.8
	Plus Pac	8 (9)	8.0	7.9	7.8	7.2	7.3	7.7
20/8	No Pac	5 (6)	8.6	8.6	10.2	8.5	7.4	7.6
	Plus Pac	9 (9)	8.8	9.0	8.7	8.5	8.3	8.6
Prob-ability			<0.001 temp	<0.001 temp	<0.001 temp	<0.001 temp	<0.001 temp	<0.001 temp
			<0.05 chem	<0.05 chem	<0.001 temp*chem		<0.01 chem	<0.001 chem

* Total plants

Temperature had a significant effect on the mean number of inflorescences per raceme produced thirteen to seventeen months after treatment, with treatment 20/8 producing more inflorescences per raceme than 15/5 (Figure 5.14).

Figure 5.14 Inflorescence of *A. notabilis* treated with 15/5 and no Pac, showing the number of inflorescences per raceme

Pac increased the number of inflorescences per raceme in March, April and July. There was an interaction between temperature and Pac in May, when most inflorescences were produced on plants treated with 20/8 plus Pac (Figure 5.15).

Table 5.4 a Mean number of inflorescences produced by flowering *A. notabilis* each month

Month	March	April	May	June	July
Mean no of inflorescences	662.2 a	766.0 c	798.4 d	712.3 b	756.9 c
Probability			P<0.001		

Inflorescence numbers peaked significantly in May.

Table 5.4 b Effect of temperature and Pac on mean number of inflorescences produced by *A. notabilis*

Treatment	Number of inflorescences					
Temperature	Mar	April	May	June	July	Total
15/5 No Pac	798	748	739	711	679	3575
15/5 Plus Pac	972	751	794	688	740	3702
20/8 No Pac	1000	753	652	564	584	2928
20/8 Plus Pac	1244	1136	1209	1072	1213	5459
Probability			NS			<0.05

There were no significant differences between number of inflorescences in any month, but there was a significant interaction between temperature and Pac treatment. The greatest number of inflorescences was produced by plants treated with 20/8 and Pac.

Figure 5.15 Inflorescence of *A. notabilis* treated with 20/8 and Pac, showing the high number of inflorescences per raceme

5.3.2.1 Effect of temperature and Pac on length of flowering and non-flowering shoots of *A. notabilis*

At 16 months after the commencement of the experiment, five flowering and five non flowering shoots were selected on each plant and measured in cm.

Table 5.5 Effect of temperature and Pac on flowering and non-flowering shoot length of *A. notabilis*

*Different letters within columns indicate significant differences between means.

Treatment		Shoot length	
Temperature	Chemical	Flowering	Non-flowering
15/5	No Pac	2.7 a*	7.0 ab
	Plus Pac	3.0 a	5.7 a
20/8	No Pac	3.2 b	7.0 ab
	Plus Pac	3.5 b	8.0 b
Probability		<0.01	<0.05

Flowering shoots were significantly shorter than non-flowering shoots after both treatments (P<0.001).

Temperature significantly affected the length of flowering and non-flowering shoots ten months after plants had been placed outside, with shoots on plants exposed to 15/5 being shorter than those from plants exposed to 20/8.

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Table 5.6 Effect of temperature and Pac on number of nodes on flowering and non-flowering shoots of *A. notabilis*

Treatment		Node number	
Temperature	Chemical	Flowering	Non-flowering
15/5	No Pac	7.0	8.8
	Plus Pac	8.6	8.0
20/8	No Pac	8.0	8.5
	Plus Pac	8.7	9.9
Probability		NS	

There was no significant difference in the number of nodes on flowering or non-flowering shoots, and previously applied temperature and chemical treatments did not affect the node number at flowering.

Table 5.7 Effect of temperature and Pac on flowering and non-flowering internode length of *A. notabilis*

Treatment			Internode length (cm)	
Temperature	Chemical	No.	Flowering	Non-flowering
15/5	No Pac	1	0.5	0.5
	Plus Pac		0.4	0.5
20/8	No Pac		0.4	0.6
	Plus Pac		0.4	0.6
			NS	NS
15/5	No Pac	2	0.2	0.6
	Plus Pac		0.1	0.6
20/8	No Pac		0.2	0.7
	Plus Pac		0.2	0.5
			<0.001	NS
15/5	No Pac	3	0.3	0.8
	Plus Pac		0.3	0.6
20/8	No Pac		0.3	0.7
	Plus Pac		0.3	0.7
			NS	NS
15/5	No Pac	4	0.2	0.7
	Plus Pac		0.2	0.5
20/8	No Pac		0.2	0.7
	Plus Pac		0.2	0.7
			NS	NS
15/5	No Pac	5	0.3	0.8
	Plus Pac		0.3	0.5
20/8	No Pac		0.3	0.9
	Plus Pac		0.3	0.8
Probability			NS	<0.05

Internode lengths 6 and 8 also showed a highly significant response to temperature and Pac treatment.

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The major response of flowering internodes was to temperature (P<0.001), with an interaction between temperature and Pac (P<0.05) for internodes 2 and 8.

The response in non-flowering internode length 5 was to Pac (P<0.05).

5.3.3 Discussion

5.3.3.1 Vegetative growth

The 20/8 temperature treatment increased *A. notabilis* bud numbers and shoot length, and interacted with time to increase shoot length, number of nodes and the length of the first internode compared to the 15/5 treatment. Pac treatment interacted with time to reduce shoot length, the length of the first internode and the number of nodes. Pac continued to influence internode length 5 at flowering, seventeen months after treatment.

The effect of treatments on mature plants of *A. notabilis* was long term, extending after the period of treatment. The effect of 20/8 temperature continued to affect shoot length ten months after placement outside.

5.3.3.2 Flowering

The effect of the 20/8 temperature treatment increased both flowering and non-flowering shoot length, the number of inflorescences per raceme, and through interaction with Pac, applied seventeen months prior to flowering, the total number of inflorescences. Internode lengths 2,   6 and 8 were affected by temperature in flowering shoots.

Although flowering shoots had similar node numbers to non-flowering shoots, the length of flowering shoots was shorter, and this was reflected in the shorter internode lengths.

5.4 *A. imbricata, A. semilunata* and *A. verniciflua* treated with Pac

5.4.1 Effect of Pac on *A. imbricata*

Nineteen month old *A. imbricata* plants were potted into 13 cm pots. The experiment was set up in Feb, 1991 in the glasshouse. One group of plants received 1 mgai Pac as a pot drench and the other group received deionised water. All plants received 100 ml.
A dish was placed under each plant and drainage was reapplied to the plant. There were eight plants in each treatment. Plants were placed outside in September, 1991.

Plant height (cm) was measured weekly for two months and after six months. The number of buds were counted weekly for two months.

Statistical analysis of height measurements was by Analysis of Variance using Genstat. Use of a log scan greatly improved fit of data to the Anova model. Differences between means were judged to be significantly different using Tukey's Wholly Significant Difference at the 5% level. The chi-squared test was used on number of buds as there were small total numbers and incontinuous data.
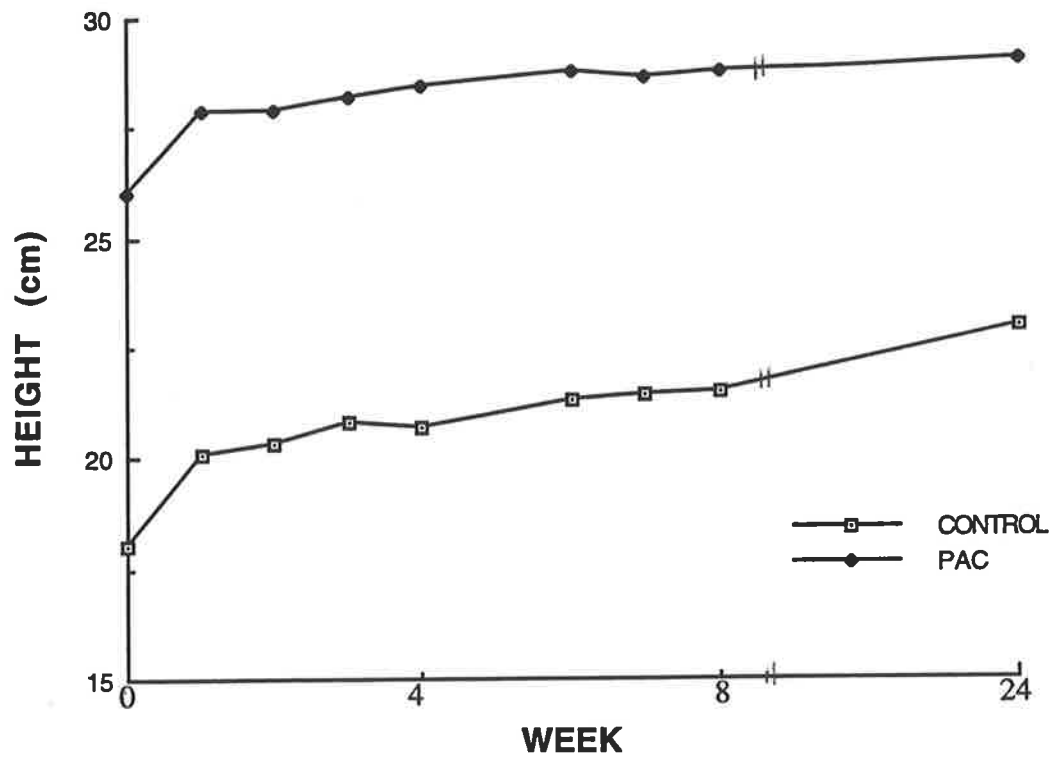
Figure 5.16 Height of *A. imbricata* treated with Pac

Pac significantly reduced the height of *A. imbricata* plants (P<0.05).

Table 5.8 Bud number of *A. imbricata* treated with Pac

No. buds produced in previous week	Week								Total
	0	1	2	3	4	6	7	8	
Control	5	2	2	2	0	7	8	7	33
Pac	0	1	1	1	0	0	6	5	14
Total	5	3	3	3	0	7	14	12	P<0.01

A. imbricata plants produced few visible buds under any treatment. Pac reduced the number of buds significantly (P<0.01), as determined by the chi-squared test.

5.4.1.1 Discussion

A. *imbricata* plants treated with 1 mgai Pac showed a significant reduction in height and bud number. There was a visual difference at the end of the experiment in plant branching.

5.4.2 Effect of Pac on A. *semilunata*

Nineteen month old plants of A. *semilunata* were potted into 13 cm pots. The experiment was set up in Feb, 1991. One group of plants received 1 mgai Pac, another received 4 mgai Pac as a pot drench and the third group received deionised water. Experimental detail was as for A. *imbricata* (5.4.1). There were nine plants in each treatment. Plants were placed outside in September, 1991.

Measurements were made as for A. *imbricata* (5.4.1).
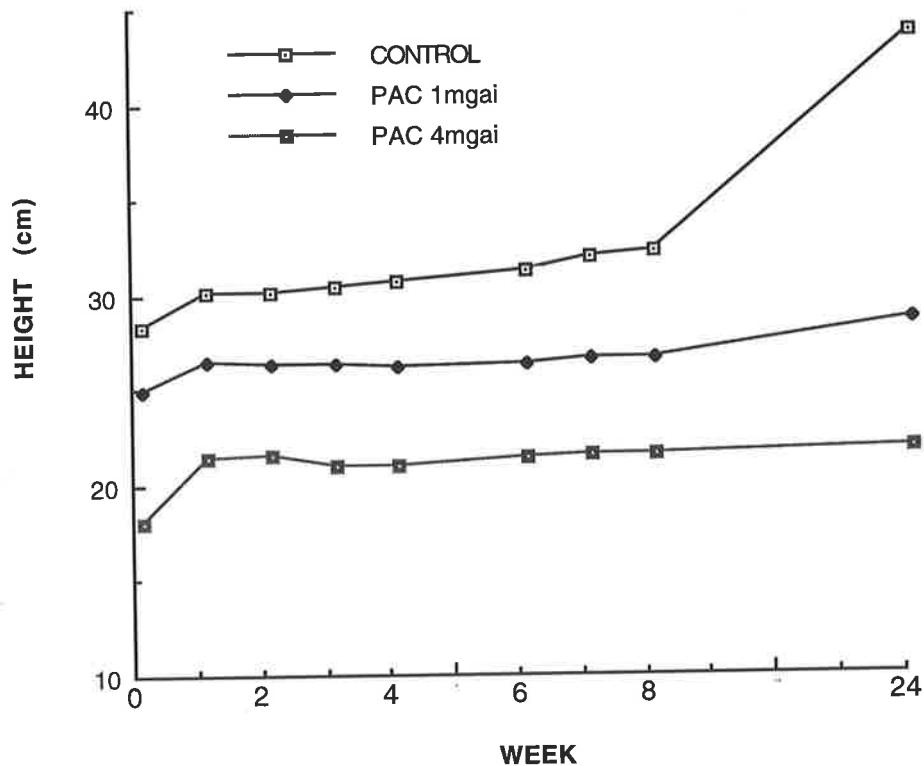
Figure 5.17 Height of A. *semilunata* treated with Pac

Pac treatment reduced height significantly within the six months period (P<0.01). Plants treated with 4 mgai Pac were significantly smaller than those with 1 mgai after six months. There was a highly significant interaction between Pac treatment and time.

Table 5.9 Bud numbers of *A. semilunata* treated with Pac

Bud number	Time (weeks)			Total
	0-6	7	8	
Control	3	21	20	44
Pac 1 mgai	0	18	13	31
Pac 4 mgai	0	5	5	10
Total	3	44	38	P<0.001

A. semilunata plants produced few buds under any treatment. There was a highly significant reduction of bud number in Pac treatments, as determined by the chi-squared test

5.4.2.1 Discussion

Pac reduced the height and numbers of buds of *A. semilunata* plants.

5.4.3 Effect of Pac on *A. verniciflua*

Nineteen month old plants of *A. verniciflua* were potted into 13 cm pots. The experiment was set up in Feb 1991. Plants received 1 mgai Pac, 4 mgai Pac or 20 mgai Pac as a pot drench and one group received deionised water. Experimental detail was as for *A. imbricata* (5.4.1). There were eight plants in each treatment and seven plants in the untreated group. Plants were placed outside in September, 1991. Measurements were made as for *A. imbricata* (5.4.1).
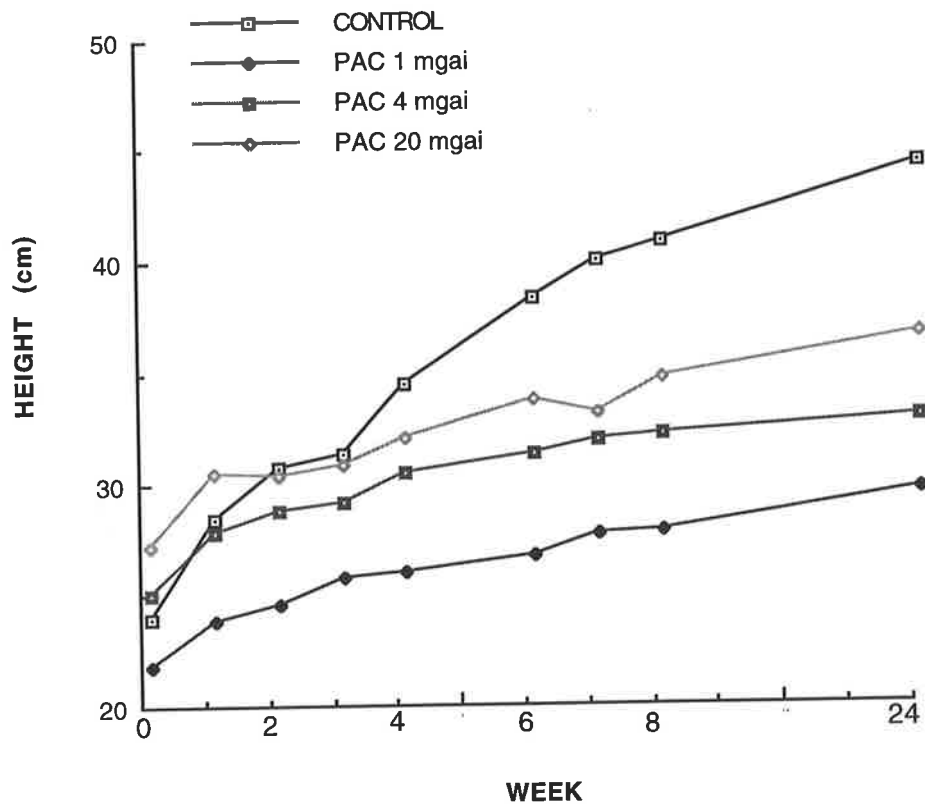
Figure 5.18 Height of *A. verniciflua* treated with Pac

There was a significant interaction between time and Pac treatment (P<0.001), with all rates of Pac reducing height over the period of the experiment. The high rate of Pac (20 mgai) caused necrosis of leaves and loss of lower leaves.
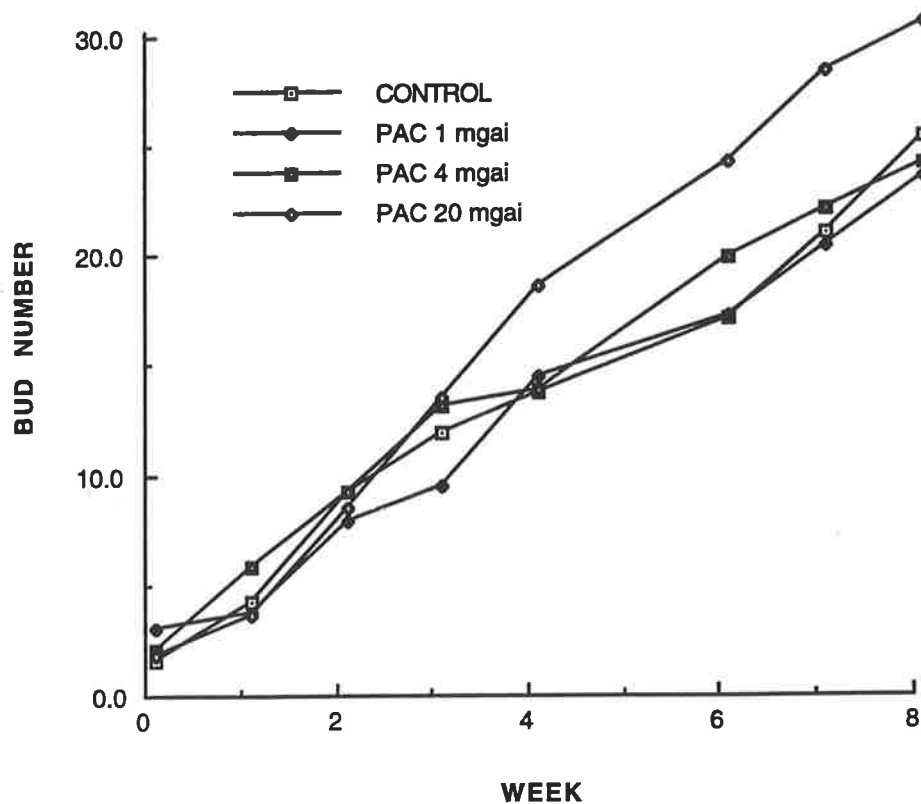
Figure 5.19 Bud numbers of *A. verniciflua* treated with Pac

There was no significant difference in bud numbers between treatments. The number of developing buds was greater for this species than for *A. imbricata* or *A. semilunata*.

5.4.3.1 Discussion

A. verniciflua responded to 1 mgai, 4 mgai and 20 mgai rates of Pac with a highly significant interaction, with reduction of height through time, but with no effect on bud numbers. The 20 mgai rate of Pac resulted in necrosis and lower leaf abscission.

Chapter 6 Controlled environment experiments

6.1 Introduction

These experiments were set up to determine if plant size and strength of flowering could be controlled by temperature.

High night temperature reduced stem elongation in a number of species including *Euphorbia pulcherrima* (poinsettia) and *Campanula isophylla*, resulting in compact pot plants at flowering (Moe *et al*, 1991b; 1992). Control of vegetative growth of acacias by temperature was examined, to determine if plant size could be reduced by a similar temperature differential. In this experiment a growth chamber was set up with a day temperature of 25°C and night temperature of 20°C and compared to a chamber with a night temperature of 25°C and day temperature of 20°C (high night temperature treatment).

Floral development of *Acacia pycnantha* is very temperature sensitive, with meiosis inhibited by a mean maximum temperature greater than 19°C despite floral initiation all year (Sedgley 1985). Many southern Australian acacias flower in the cooler periods of winter or early spring (Simmons, 1988). The use of low temperatures compared to higher temperatures was investigated to observe if flowering could be controlled for pot plant production. In this experiment a growth chamber was set up with a day temperature of 25°C and night temperature of 20°C and compared to a chamber with 15°C day and 10°C night. In addition a further set of plants was exchanged between the two cabinets after six months and subsequent floral development observed. For all experiments a group of ten plants was kept outside, at a mean annual temperature of 16°C, to provide an indication of the natural time and strength of flowering.

Statistical analysis of all results was by Analysis of Variance using Genstat. Differences between means were judged to be significantly different using Tukey's Wholly Significant Difference at the 5% level.

6.2 Control of vegetative growth with high night temperature treatment

6.2.1 *A. glaucoptera*

Seed was sown in February 1991 and all plants were pruned to 15 cm two weeks before treatment. Plants were aged thirteen months at commencement of treatment. There were ten plants per treatment. The experiment was set up in February 1992. Plants were placed in controlled environment cabinets set at 20°C day for twelve hours and 25°C night for twelve hours (20/25; high night temperature) and at 25°C day and 20°C night (25/20) also with 12:12 day:night regime. Light was supplied by yellow sodium lamps, cool fluorescent tubes and incandescent lamps at a light intensity of 60 w/m². Plant size was measured; height and width in centimetres (cm); branches longer than one cm were counted. Plant flowering data were recorded. Plants were placed outside after twelve months.

Table 6.1 Vegetative data for *A. glaucoptera* with high night temperature treatment

Time (months)	Treatment (day/night)	Height (cm)	Width (cm)	No. branches
0		17.1	11.1	6.1
6	20/25	23.1	60.1	40.4
6	25/20	31.3	65.3	29.6
Probability		NS	NS	NS
12	20/25	27.3	85.0	50.0
12	25/20	30.6	84.7	63.3
Probability		NS	NS	NS
Plants were placed outside at 12 months				
18	20/25	43.0	86.4	114.0
18	25/20	35.1	79.1	158.2
Probability		NS	NS	<0.05

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There was no significant difference in height, width and branch number between 20/25 (high night temperature) and 25/20 conditions. Plants retained at high night temperature conditions increased height rapidly after placement outside. Plants retained at high day temperatures did not increase in height as rapidly after removal from the growth cabinets but rapidly increased branch number, so that they were significantly higher than in the high night temperature treatment.

Table 6.2 Flowering data for *A. glaucoptera* with high night temperature treatment.

Treatment (day/night)	No. plants	No. plants flowering	Time of first flowering	Period of flowering (days)
20/25	2	2	30/8/93	27.0
25/20	9	9	30/8/93	30.8
Probability			NS	NS

All plants flowered after being placed outside, at eighteen months of age. There was little difference in time or period of flowering between treatments.

Table 6.3 Inflorescence numbers for *A. glaucoptera* with high night temperature treatment

Treatment (day/night)	Maximum no. of infl. per day	Total no. of infl.	No.infl: No.branches
20/25	135.5	286.5	2.5
25/20	150.7	384.1	2.4
Probability	NS	NS	

There was no significant difference between treatments. Ratios of inflorescences to branches were similar for both treatments. Plants flowered in September and October 1993 when plants were thirty one months old.

6.2.2 *A. imbricata*

Seed was sown in February 1991 and plants were pruned to 10 cm two weeks before treatment. Plants were aged thirteen months at commencement of treatment in March 1992. There were nine plants per treatment. Plants were placed in controlled environment growth cabinets with the same conditions as for *A. glaucoptera*. Chemical treatments were applied to plants in each temperature regime. Control plants received no chemical treatment. Bap treated plants were sprayed with 50 mgL^{-1} 6, benzylamino purine (Bap) and Bap-Pac treated plants were sprayed with Bap as above and received a pot drench of 2 mgai paclobutrazol (Pac). Plants were placed outside after twelve months.

Table 6.4 Vegetative data for *A. imbricata* with high night temperature treatment

Different letters within columns indicate a significant difference between means.

Time (months)	Treatment (day/night)	Height (cm)	Width (cm)	No. branches
0		7.6	2.1	0.7
	20/25			
5	Untreated	22.3 b	34.7 ab	20.7
5	Bap	21.9 ab	40.6 b	24.4
5	Bap-Pac	11.8 ab	18.4 ab	13.0
	25/20			
5	Untreated	20.5 ab	42.5 b	20.4
5	Bap	17.1 ab	44.7 b	25.6
5	Bap-Pac	11.5 a	13.1 a	11.8
Probability		<0.01	<0.001	NS
	20/25			
12	Untreated	31.4	78.4 b	58.3
12	Bap	24.1	101.4 b	59.4
12	Bap-Pac	11.9	20.5 a	22.9
	25/20			
12	Untreated	16.1	65.3 b	66.1
12	Bap	27.4	81.4 b	105.6
12	Bap-Pac	14.7	25.0 a	33.0
Probability		NS	<0.001	NS

Plants were placed outside at 12 months

Time (months)	Treatment (day/night)	Height (cm)	Width (cm)	No. branches
	20/25			
18	Untreated	53.1 b	79.2 c	112.0 ab
18	Bap	45.2 b	87.7 c	160.0 ab
18	Bap-Pac	17.0 a	24.5 a	50.1 a
	25/20			
18	Untreated	35.2 ab	65.3 bc	143.9 ab
18	Bap	39.9 b	74.9 c	173.4 b
18	Bap-Pac	18.0 a	41.5 ab	92.0 ab
Probability		<0.001	<0.001	<0.05

There was no significant difference between treatments due to temperature or a temperature and chemical interaction at any time, and all differences resulted from the chemical treatments. Untreated plants were not different from Bap treated plants in height or width at any time but there was a trend in Bap treated plants for branch number to be higher than in untreated plants at both twelve and eighteen months. Bap-Pac chemical treatment reduced plant width after five, twelve and eighteen months.

Table 6.5 Flowering data for *A. imbricata* with high night temperature treatment

Treatment (day/night)	No. plants	No. plants flowering	Date of first flowering	Period of flowering (days)
20/25				
Untreated	9	3	5/8/93	7.0
Bap	7	6	10/8/93	14.4
Bap-Pac	7	2	16/8/93	5.0
25/20				
Untreated	9	2	5/8/93	5.3
Bap	5	3	4/8/93	15.0
Bap-Pac	2	1	10/8/93	17.5
Probability		NS		NS

Flowering did not differ significantly as a result of temperature. Flowering commenced later in Bap-Pac treated plants than in the other treatments.

Table 6.6 Inflorescence numbers for *A. imbricata* with high night temperature treatment

Treatment (day/night)	Maximum no. of infl. per day	Total no. of infl.	No.infl: No.branches
20/25			
Untreated	36.9	202.0	1.8
Bap	53.3	121.1	0.8
Bap-Pac	3.7	7.6	0.2
25/20			
Untreated	37.1	64.8	0.5
Bap	150.8	445.6	2.6
Bap-Pac	47.5	145.5	1.6
Probability	NS	NS	

Flowering of *A. imbricata* subsequent to high night temperature treatment was very variable, and not significantly different from that after high temperature treatment (Table 6.6). Previous high temperature treatments did not prevent subsequent flowering.

6.2.3 *A. craspedocarpa*

Experiment 1

Seed was sown in February 1991 and plants were pruned to 10 cm two weeks before treatment. Plants were aged thirteen months at commencement of treatment when they were placed in controlled environment growth cabinets with the same treatments as described previously. There were ten plants per treatment and the experiment commenced in February 1992. The plants were placed outside after twelve months.

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Table 6.7 Vegetative data for *A. craspedocarpa* with high night temperature treatment; experiment 1

Time (months)	Treatment (day/night)	Height(cm)	Width(cm)	No. branches
0		10.3	6.3	1.6
6	20/25	11.7	23.5	14.7
6	25/20	11.6	23.2	8.4
Probability		NS	NS	<0.05
12	20/25	18.2	45.8	40.0
12	25/20	19.9	54.2	36.7
Probability		NS	NS	NS
Plants were placed outside at 12 months				
18	20/25	25.8	45.8	39.2
18	25/20	35.0	42.7	34.6
Probability		<0.05	NS	NS

A. craspedocarpa is a very slow growing plant. Plant height showed a trend to be lower in the high night temperature treatment, and was significantly lower after eighteen months. After six months branch numbers were greater in the high night temperature regime, and this trend continued throughout the experiment.

Experiment 2

Treatment was as in experiment 1 except that plants were pruned to 8 cm two weeks before treatment.

Table 6.8 Vegetative data for *A. craspedocarpa* with high night temperature treatment; experiment 2

Time(months)	Treatment (day/night)	Height(cm)	Width(cm)	No. branches
0		7.2	3.9	0.0
6	20/25	12.6	17.9	10.4
6	25/20	11.0	21.4	13.4
Probability		NS	<0.05	NS
12	20/25	14.3	34.9	21.1
12	25/20	16.3	41.4	56.8
Probability		NS	NS	<0.01
Plants were placed outside at 12 months				
18	20/25	28.2	34.2	22.9
18	25/20	31.6	37.9	50.0
Probability		NS	NS	<0.01

Plants were pruned more heavily than in the first experiment and high night temperature plants produced fewer branch numbers than plants in the 25/20 treatment after twelve and eighteen months. Height was not significantly different.

6.3 Control of flowering using low temperatures.

6.3.1 Continuous conditions

6.3.1.1 *A. drummondii elegans*

The plants were fifteen months old at the start of the experiment. There were ten plants per treatment, and the experiment commenced in April 1993. Plants were selected which had never flowered at the commencement of treatment and were kept at either 25°C day 20°C night or 15°C day 10°C night. Plants remained in the treatment for ten months. Other conditions and plant measurements were as in the high

night temperature experiments. Flowering data included examination of fresh inflorescence buds from both 25°C and 15°C treatments by Environmental Scanning Electron Microscopy (ESEM) at 15 kV, temperature between 4-6°C and Relative humidity 100%, and observation of the development of stamens.

Table 6.9 Vegetative data for A. drummondii elegans with low temperature treatment

Time (months)	Treatment (day/night)	Height(cm)	Width(cm)	No. branches
0		25.1	8.2	1.4
6	15/10	53.0	27.8	11.8
6	25/20	94.1	52.7	19.6
Probability		<0.001	<0.01	<0.05

Plant height, width and branch number in plants in the 15/10 treatment were lower than in the 25/20 treatment.

Table 6.10 Floral data for A. drummondii elegans with low temperature treatment

Treatment (day/night)	No. plants	No. plants initiating buds at 6 months	No. plants flowering at 10 months
15/10	10	7	4
25/20	10	4	0

Some plants initiated floral buds after 3-4 months under both temperature treatments. Four plants which had initiated buds in the 15/10 treatment had flowered by the end of the experiment. Plants in the 25/20 treatment did not flower. Plants flowered when aged twenty one months.

Table 6.11 Inflorescence numbers of *A. drummondii* *elegans* with low temperature treatment

Treatment (day/night)	No. buds initiated at 6 months	No. open infl.	Flowering period (days)
15/10	8.2	14.4	7.3
25/20	19.6	0.0	0.0
Probability	NS	<0.05	<0.05

Only plants in the 15/10 treatment flowered and floral buds which formed on plants in the 25/20 treatment did not develop into mature inflorescences. **Figure 6.1** compares a flowering branch of the high and low temperature plants and **Figure 6.2** shows the relative size of the floral buds after six months. Examination of these buds by Environmental Scanning Electron Microscopy (ESEM) showed that in the 25/20 treatment inflorescences remained small and stamens did not develop **(Figure 6.3(2))**, in contrast to normal inflorescence at 15/10 **(Figure 6.3(1))**, and stamen development at 15/10 **(Figure 6.3(3))**. Inflorescences at 25/20 aborted.

6.3.1.2 *A. glaucoptera*

The plants were fourteen months old at the start of the experiment. Methodology was as described for *A. drummondii* *elegans*.

Table 6.12 Vegetative data for *A. glaucoptera* with low temperature treatment

Time (months)	Treatment (day/night)	Height(cm)	Width(cm)	No. branches
0		27.6	24.3	4.6
6	15/10	25.7	52.8	24.9
6	25/20	39.0	57.5	39.3
Probability		<0.01	NS	NS

Figure 6.1 Flowering branches of *A. drummondii elegans* treated with temperatures 15/10 and 25/20

Figure 6.2 Floral buds of *A. drummondii elegans* treated with temperatures 15/10 and 25/20

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A.drummondii elegans

15°C10°C   25°C 20°C
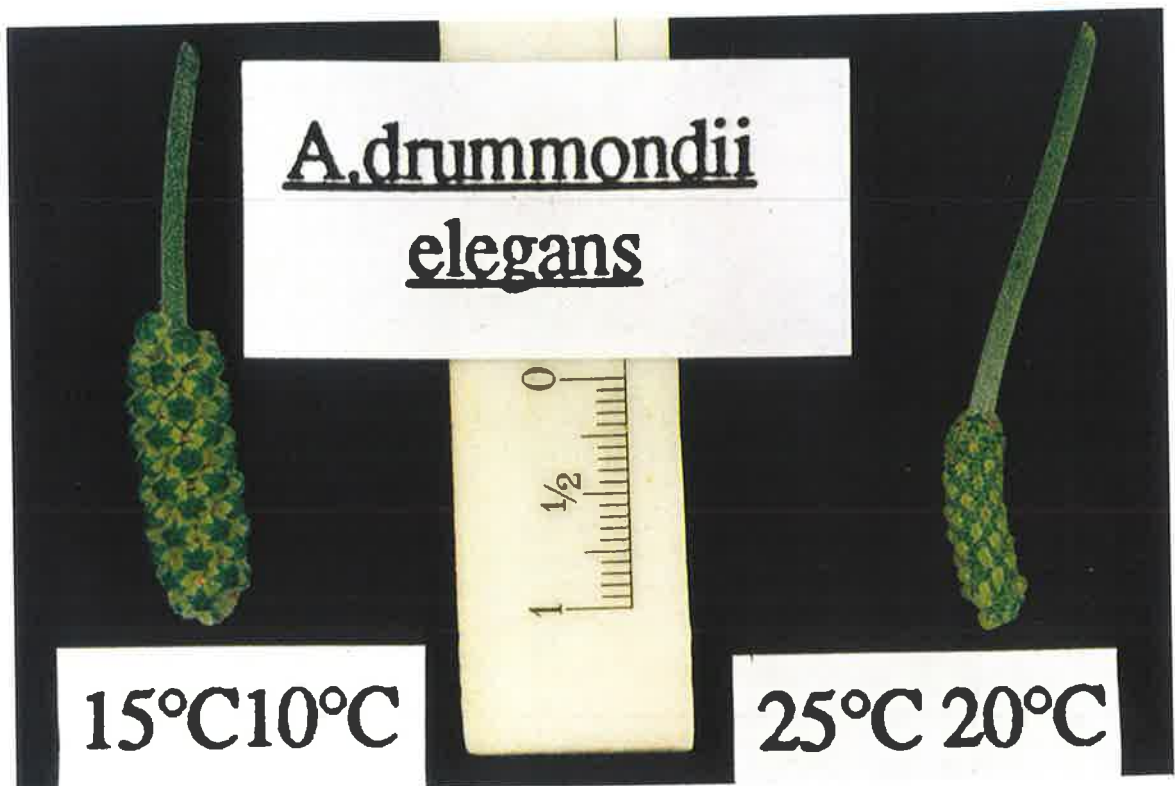
Figure 6.3(1) Floral bud showing normal development of a stamen of *A. drummondii elegans* treated with 15/10, as observed by ESEM

Size to be compared to

Figure 6.3(2) Floral bud showing lack of development of stamens of *A. drummondii elegans* treated with 25/20, as observed by ESEM

Figure 6.3(3) Stamen development of *A. drummondii elegans* treated with 15/10 showing polyads in dehisced anther, as observed by ESEM
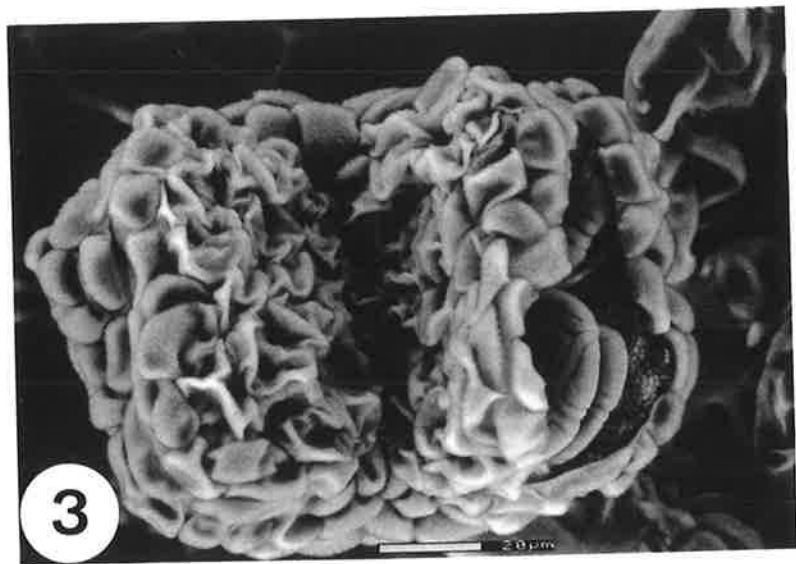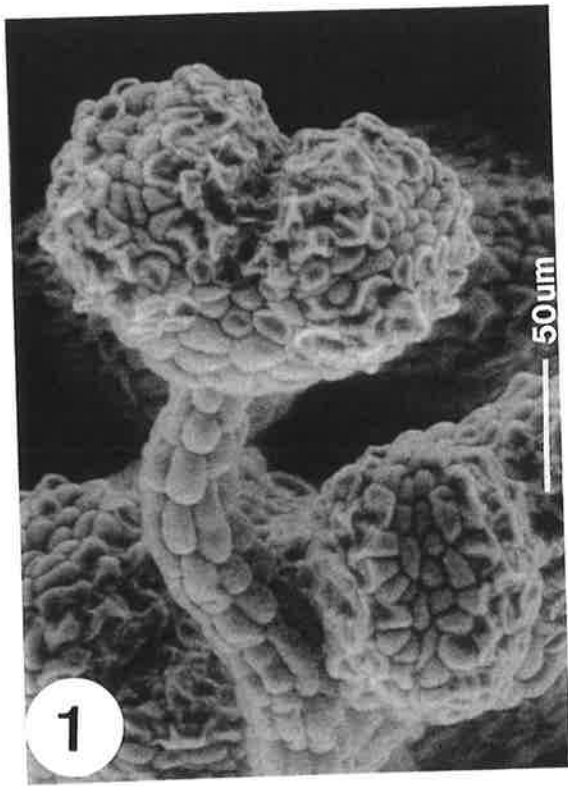
Plants in the 15/10 treatment were shorter than the 25/20 plants. One plant in the 15/10 treatment flowered briefly and sporadically in August after four months when aged eighteen months. Plants in the 25/20 treatment did not flower.

6.3.1.3 *A. baileyana*

The plants were twelve months old at the beginning of the experiment. Methodology was as described previously.

Table 6.13 Vegetative data for *A. baileyana* with low temperature treatment

Time (months)	Treatment (day/night)	Height(cm)	Width(cm)	No. branches
0		27.2	39.3	0.9
6	15/10	70.1	21.8	6.1
6	25/20	74.8	34.3	8.7
Probability		NS	<0.01	NS

Plant height and branch number in both high and low temperature treatments were similar, while width was lower in the plants in the 15/10 treatment than in the 25/20 treatment due to reduced shoot length at 15/10. Plants did not flower during the experiment.

6.3.1.4 *A. podalyrifolia*

The plants were nine months old at the start of the experiment. Methodology was as described previously.

Table 6.14 Vegetative data for *A. podalyrifolia* with low temperature treatment

Time (months)	Treatment (day/night)	Height (cm)	Width (cm)	No. branches
0		22.2	12.1	1.4
6	15/10	41.9	27.1	9.2
6	25/20	58.8	33.3	7.3
Probability		<0.01	NS	NS

Plants kept at 15/10 were shorter than those in the 25/20 treatment. Plants did not flower during the experiment.

6.3.1.5 *A. semilunata*

The plants were fourteen months at the start of the experiment. Methodology was as previously described. There were eight plants in each treatment.

Table 6.15 Vegetative data for *A. semilunata* with low temperature treatment

Time (months)	Treatment (day/night)	Height(cm)	Width(cm)	No. branches
0		46.3	29.0	1.8
6	15/10	73.5	59.8	16.9
6	25/20	60.0	56.3	21.6
Probability		NS	NS	NS

There was no difference between the treatments in height, width or number of branches, and no plants flowered during the experiment.

6.3.2 Transfer experiments

6.3.2.1 A. drummondii elegans

Most plants in the previous experiments did not flower, so for this experiment plants were selected from glasshouse stock which showed floral initiation. Ten plants were placed in the 25°C day 20°C night treatment and ten in the 15°C day 10°C night with 12 hours day and 12 hours night. Light was from blue metal halide lamps as well as sodium lamps, fluorescent tubes and incandescent lights at a light intensity of 18 w/m^2. The experiment was set up in March 1994 and plants remained in these treatments for six months until September 1994, at which time they were transferred to the other cabinet. Plants remained in the new temperature regimes for three months until December 1994. Inflorescence numbers were recorded during the experiment, and numbers of buds were recorded at six months and at nine months at the end of the experiment.

Table 6.16 Floral data for A. drummondii elegans with low temperature treatment

Time (months)	Treatment (day/night)	Infl. no.	Days to flowering	Period of flowering(days)	Bud no.
6	15/10	320.3	124.2	42.2	121.9
6	25/20	0.0	-	0.0	45.9
Probability		<0.001		<0.001	0.06
Plants were transferred between environments at 6 months					
9	15/10 to 25/20	9.2	5.6	5.8	167.4
9	25/20 to 15/10	48.1	80.8	5.0	161.7
Probability		NS	<0.001	NS	NS

- Did not flower

The number of inflorescences opening, the time to flowering and the period of flowering in plants in the 15/10 treatment in the initial six month period was significantly greater than for the 25/20 treatment plants, which did not flower.

Bud numbers remaining at the end of six months was greater for the low temperature treatment. After the transfer of plants, those in the 25/20 to 15/10 treatment produced more inflorescences than in the 15/10 to 25/20 treatment. Plants in the 15/10 to 25/20 treatment flowered within a significantly shorter time period, almost immediately after transfer, while plants in the 25/20 to 15/10 treatment flowered after a longer period. The period of flowering was not different. Similar bud numbers remained on plants of both temperature treatments at the end of the experiment.

6.3.2.2 A. glaucoptera

Plants were selected from glasshouse stock which showed floral initiation. Eight plants were placed in 25/20 and 15/10 as described previously. The experiment was set up in March 1994 and plants were treated with these temperatures until September 1994 and then treatments were reversed. Plants remained in the new temperature regimes until January 1995. Inflorescence numbers were recorded during the experiment, and numbers of buds were recorded in September 1994.

Table 6.17 Floral data for A. glaucoptera with low temperature treatment

Time (months)	Treatment (day/night)	Infl. no.	Days to flowering	Period of flowering (days)	Bud no.
6	15/10	1060.5	108.5	60.4	0.5
6	25/20	10.3	73.5	24.3	28.6
Probability		<0.05	<0.05	<0.01	<0.05
Plants were transferred between environments at 6 months					
10	15/10 to 25/20	29.6	6.1	9.3	-
10	25/20 to 15/10	550.8	70.3	23.4	-
Probability		<0.05	<0.01	<0.01	

- No data

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Plants grown under low temperature produced more inflorescences and had fewer remaining buds after six months than those grown under high temperature. The time to flowering and period of flowering of the 15/10 treatment plants were greater than for plants in the 25/20 treatment. After the reversal of plants, the inflorescence number, time to flowering and period of flowering were greater for the plants transferred from 25/20 to 15/10 than for those transferred from 15/10 to 25/20, which produced inflorescences for only a very short time.

6.3.2.3 *A. acinacea*

There were ten plants per treatment. Conditions and measurements were as described for *A. glaucoptera*.

Table 6.18 Floral data for *A. acinacea* with low temperature treatment

Time (months)	Treatment (day/night)	Infl. no.	Days to flowering	Period of flowering (days)	Bud no.
6	15/10	173.9	106.7	53.4	0.8
6	25/20	0.3	0.4	0.0	74.5
Probability		<0.001	<0.001	<0.001	<0.05
Plants were transferred between environments at 6 months					
10	15/10 to 25/20	77.6	5.6	7.4	-
10	25/20 to 15/10	190.0	40.4	14.0	-
Probability		NS	<0.05	NS	

- No data

Plants receiving the 15/10 treatment produced significantly more inflorescences and had fewer buds remaining after six months than plants in the 25/20 treatment, which had a very short time to flowering and period of flowering. After reversal of plants, those transferred from 25/20 to 15/10 temperature took significantly longer to commence flowering and produced

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more inflorescences after four months than those transferred from 15/10 to 25/20.

6.3.2.4 *A. buxifolia*

Methodology was as for *A. acinacea*.

Table 6.19 Floral data for *A. buxifolia* with low temperature treatment

Time (months)	Treatment (day/night)	Infl. no.	Days to flowering	Period of flowering (days)	Bud no.
6	15/10	1531.6	109.8	58.8	265.3
6	25/20	0.0	†	0.0	6.2
Probability		<0.001		<0.001	<0.001
Plants were transferred between environments at 6 months					
10	15/10 to 25/20	3.3	2.8	1.9	—
10	25/20 to 15/10	228.7	99.2	23.4	—
Probability		<0.001	<0.001	<0.001	

— No data
† Did not flower

Plants treated with 15/10 flowered strongly over an extended period while plants treated with 25/20 did not flower and produced very few inflorescence buds. **Figure 6.4** shows the strong floral display of the low temperature treatment in *A. buxifolia*. After the reversal of the treatments, the plants transferred from 15/10 to 25/20 produced very few inflorescences over a restricted period, and flowered almost immediately following transfer. Plants transferred from 25/20 to 15/10 produced large numbers of inflorescences.

A. buxifolia

25 C 20 C   MEAN 18 C   15 C 10 C

Figure 6.4 Flowering plants of *A. buxifolia* treated with temperatures (L to R) 25/20, kept outside, and 15/10

6.3.2.5 A. myrtifolia

Methodology was as for *A. glaucoptera*.

Table 6.20 Floral data for *A. myrtifolia* with low temperature treatment

Time (months)	Treatment (day/night)	Infl. no.	Days to flowering	Period of flowering(days)	Bud no.
6	15/10	1447.1	97.5	65.8	556.3
6	25/20	13.6	78.0	32.9	33.9
Probability		<0.001	0.06	<0.001	<0.001
Plants were transferred between environments at 6 months					
10	15/10 to 25/20	7.4	7.0	4.4	1376.3
10	25/20 to 15/10	982.0	40.4	46.3	142.3
Probability		<0.001	<0.001	<0.001	<0.001

Plants treated with 15/10, after a longer time to flowering, produced more inflorescences over a longer flowering period than plants treated with 25/20. **Figure 6.5** shows the relative size and number of buds and inflorescences of *A. myrtifolia* plants. After six months there were large numbers of buds on the 15/10 treatment. After reversing the temperature treatments, plants in the 25/20 to 15/10 treatment produced more inflorescences after a longer time to flowering and over a longer period of flowering than plants in the 15/10 to 25/20 treatment. The 15/10 to 25/20 treatment had produced a large number of buds after four months.

A. myrtifolia
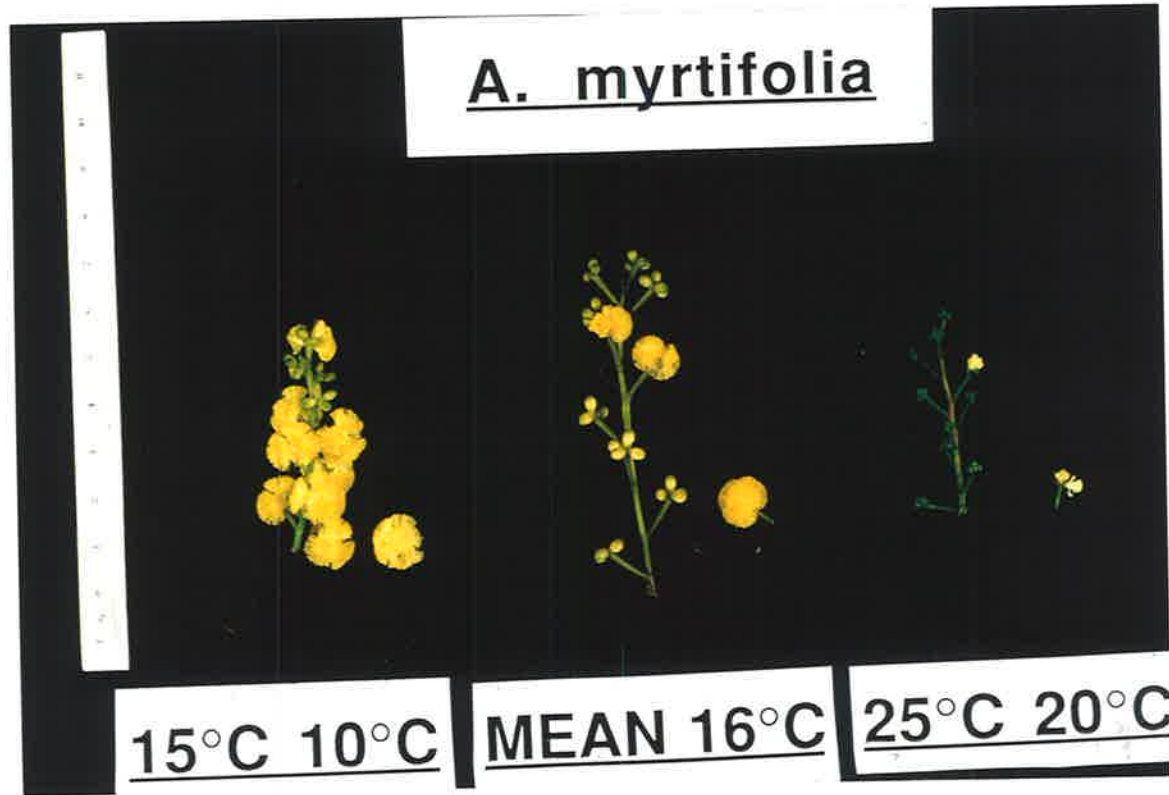
15°C 10°C MEAN 16°C 25°C 20°C

Figure 6.5 Racemes and inflorescences of *A. myrtifolia* treated with temperatures (L to R) 15/10, kept outside, and 25/20

6.4 Discussion

6.4.1 Control of vegetative growth using high night temperature treatment

There was no significant effect of high night temperature on *A. glaucoptera* or *A. imbricata*, and there was no interaction with the effect of paclobutrazol in either temperature treatment for *A. imbricata*. *A. craspedocarpa* was only slightly affected by high night temperature. Flowering was not affected by treatment in any of the species tested. These results do not support the use of high night temperature to reduce the plant height of acacias. Most previous research with high night temperature has been successful with herbaceous plants (Moe *et al*, 1991a, 1991b, 1992). It is possible that woody plants are less responsive to this treatment.

6.4.2 Control of flowering using low temperatures

Flowering occurred in the 15/10 treatment of *A. drummondii elegans* but not at 25/20. Scanning electron microscopy confirmed that stamen development was inhibited by the high temperature. This inhibition was reported previously for *A. pycnantha* by Sedgley (1985). The results for this experiment suggest that low temperature could be used to control the flowering of *A. drummondii elegans* pot plants. *A. baileyana*, *A. glaucoptera*, *A. podalyrifolia* and *A. semilunata* produced few or no flowers during the experimental period.

In the transfer experiments with initiated plants, flowering in all species was stronger in the 15/10 treatment than the 25/20 treatment. In the higher temperature treatment only *A. glaucoptera* and *A. myrtifolia* produced a few flowers, with a shorter period to flowering than in the low temperature treatment. After the reversal of temperature treatments, the plants placed from high to low temperature treatment flowered more strongly after a longer period than plants placed from low to high temperature. Plants transferred from low to high temperature treatment flowered briefly within seven days. The results for this experiment show that high temperature

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inhibition of flowering is characteristic not only of *A. pycnantha* (Sedgley 1985), but also occurs in a range of southern Australian acacias, both phyllodinous and bipinnate. Thus the time of flowering of *Acacia* pot plants on which floral buds are present can be controlled by low temperature treatment regardless of the prior treatment temperature of the plants. If plants are placed from low temperature to high temperature there may be a brief rapid flowering response depending on the species.

Chapter 7 Manipulation of juvenile plants

7.1 Introduction

Control of vegetative growth of juvenile acacia plants by chemical and physical methods was examined to determine suitability for pot plant production. Reduction of plant size by application of the growth retardant paclobutrazol (Pac) was tested, as was pruning (prune) as an alternative to chemical means. The effect of the cytokinin 6-benzylamino purine (Bap) was investigated for shoot stimulation. Combination treatments and multiple treatments, as described in Chapter 4, were also assessed in selected species to determine if this produced a stronger response. Plants kept in the glasshouse were at a mean temperature of 20°C, and plants maintained outside were at temperatures as shown in Figure 4.1.

Plant size was measured as height and width in centimetres (cm), and branches longer than one centimetre were counted. Time 0 (months) in results refers to the time at treatment. Flowering data were recorded as time of initiation, inflorescence bud numbers, time of flowering, period of flowering (days) and total number of inflorescences produced. The floral cover, or ratio between inflorescence number and branch number, was calculated to compare effect of treatment on density of the flower mass. The date of first flowering was recorded but not statistically analysed. Statistical analysis of results was by Analysis of Variance using Genstat. Differences between means were judged to be significantly different using Tukey's Wholly Significant Difference at the 5% level. The binomial model was used for numbers of plants flowering.

The tabulated results of treatment of the following range of species are presented;
A. glaucoptera, A. imbricata, A. acinacea, A. podalyrifolia,
A. crassuloides, A. cometes, A. vestita, A. decora, A. buxifolia,
A. meisneri, A. notabilis, A. craspedocarpa, A. semilunata,
A. drummondii elegans, A. polybotrya, A. baileyana and
A. baileyana purpurea.

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7.2 Phyllodinous acacias which flowered within two years

7.2.1 *A. glaucoptera*

7.2.1.1 *A. glaucoptera* with single treatments

Seed was sown in February 1991. All plants were pruned to 15 cm prior to treatment. Plants were thirteen months old when the experiment was set up on 20/2/92. Ten plants received a single treatment of Bap (50 mgL^{-1}), and another ten plants were treated with Pac (2 mgai). Plants were kept in a glasshouse for twelve months, after which they were placed outside. Ten plants were maintained outside with no other treatment for the duration of the experiment.

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Table 7.1 Vegetative data for *A. glaucoptera* with single treatments

Different letters within columns indicate significant differences between means at the same time.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		17.4	12.8	5.7
6	Outside Glasshouse	24.4 a	34.9 a	21.3
6	Control	45.1 b	68.4 b	20.9
6	Bap	31.4 a	63.1 b	20.7
6	Pac	30.0 a	59.3 b	13.0
Probability		<0.05	<0.001	NS
12	Outside Glasshouse	33.6 a	53.7 a	46.7
12	Control	54.1 b	79.4 b	32.0
12	Bap	42.8 a	74.7 b	34.9
12	Pac	38.8 a	77.0 b	27.8
Probability		<0.05	<0.05	NS
18	Outside Glasshouse to outside	31.4 a	49.0 a	60.9 a
18	Control	49.7 b	81.1 b	113.7 a
18	Bap	41.8 a	81.9 b	181.9 b
18	Pac	43.1 a	74.8 a	93.0 a
Probability		<0.05	<0.01	<0.01

Keeping the plants outside reduced height and width at all times compared to the glasshouse control. Bap reduced height at all times and increased the number of shoots at eighteen months. Pac reduced height at all times and width after eighteen months.

Table 7.2 Flowering data for *A. glaucoptera* with single treatments

Treatment	No. plants	No. plants flowering	Period of flowering (days)	Date of first flowering
Outside	7	7	25.9	3/9/93
Glasshouse to outside				
Control	10	9	22.4	7/9/93
Bap	10	9	22.9	30/8/93
Pac	8	8	27.3	30/8/93
Probability			NS	

Plants were thirty one months at flowering, and most plants in all treatments flowered for an extended period.

Table 7.3 Mean bud and flower numbers for *A. glaucoptera* with single treatments

Treatment	No. buds at 18 months	Maximum no. infl. open in one day	Total no. infl.	No.infl: No.branches
Outside	-	86.1	187.0	3.1
Glasshouse to outside				
Control	301.9	107.0	224.3	2.0
Bap	300.2	126.0	312.1	1.7
Pac	323.9	97.0	273.8	2.9
Probability	NS	NS	NS	

- No data

Plants flowered in September and October 1993, and there was no significant difference between treatments.

Pot plant suitability

Only plants grown entirely outside were pot plant size. These flowered well but suffered leaf browning, possibly from the winter conditions.

7.2.1.2 *A. glaucoptera* with single, combination and repeated treatments

As none of the treatments applied in 7.1.1.1 produced results suitable for pot plant production, combination and repeated treatments were tested.

Seed was sown in March 1992 and plants were six months old when treated on 19/9/92. Ten plants were maintained outside with no other treatment for the duration of the experiment. Twenty plants were placed in each treatment in the glasshouse. After six months half of each treatment was transferred outside while half remained in the glasshouse and after twelve months all remaining plants were placed outside.

Glasshouse plants received the treatments; pruning to 10 cm, repeated after four weeks; 100 mgL^{-1} Bap applied once only at start of the experiment; 2 mgai Pac applied at the start and repeated after four weeks (total 4 mgai Pac); Bap-Pac was a combination application of both Bap and Pac, including a repeat application of Pac after four weeks; prune-Bap-Pac was a combination application of pruning and Bap at the start, with Pac applied after two weeks, pruning repeated after four weeks then Pac reapplied after six weeks (a total of 100 mgL^{-1}Bap, 4 mgai Pac and two prunes).

Table 7.4 Vegetative data for *A. glaucoptera* with single, combination and repeated treatments

Different letters within columns indicate significant differences between means at the same time.

Time(months)	Treatment	Height(cm)	Width(cm)	No.branches
0		10.6	16.4	1.9
6	Outside Glasshouse	31.1 bcd	39.5 a	14.0 a
6	Control	39.6 d	70.7 cd	43.7 c
6	Prune	38.8 cd	78.9 d	34.2 bc
6	Bap	34.7 cd	60.6 bcd	38.7 c
6	Pac	18.7 a	57.3 abcd	13.3 a
6	Bap-Pac	24.2 abc	46.4 ab	18.1 ab
6	Prune-Bap-Pac	21.9 ab	52.6 abc	14.7 a
Probability		<0.001	<0.001	<0.001
12	Outside* Glasshouse	32.2	45.2	69.4
12	Control	47.6 b	78.0 bc	110.1 b
12	Prune	47.6 b	83.8 c	70.1 a
12	Bap	44.0 b	71.6 abc	68.4 a
12	Pac	21.0 a	61.9 ab	40.4 a
12	Bap-Pac	28.4 a	61.8 ab	49.6 a
12	Prune-Bap-Pac	25.5 a	55.7 a	35.8 a
Probability		<0.001	<0.001	<0.001
	Glasshouse to outside			
12	Control	40.6 b	76.3 b	84.0 ab
12	Prune	36.4 b	85.4 b	56.9 ab
12	Bap	34.9 b	66.1 ab	100.6 b
12	Pac	17.9 a	60.5 ab	52.9 ab
12	Bap-Pac	18.3 a	45.1 a	37.9 a
12	Prune-Bap-Pac	20.7 a	60.6 ab	34.7 a
Probability		<0.001	<0.001	<0.01

Compared with the glasshouse, the plants outside had reduced width and branch number at six months, and height and width

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at twelve months. *Plants remaining outside at twelve months could not be included in the statistical analysis.

Prune and Bap plants were not significantly dwarfed at any time. Pac reduced height and branch number at both six and twelve months in the glasshouse treatment, and height only in plants which were transferred from the glasshouse to outside. Bap-Pac reduced height and shoot number at six and twelve months in glasshouse plants, and reduced height and width in plants transferred from the glasshouse to outside.

Prune-Bap-Pac reduced height and branch number at six and twelve months in glasshouse plants, and reduced height in plants transferred from the glasshouse to outside.

Table 7.5 Flowering data for *A. glaucoptera* with single, combination and repeated treatments

Different letters within columns indicate significant differences between means.

Treatment	No. plants	No. plants flowering	Date of first flowering	Period of flowering (days)	No. Infl: No.branches
Outside	10	7	30/8/93	12.9 ab	0.8
Glasshouse					
Control	9	3	30/8/93	4.3 a	0.0
Prune	10	6	3/9/93	8.3 ab	0.1
Bap	10	5	4/8/93	12.5 ab	0.4
Pac	10	5	24/8/93	13.2 ab	0.5
Bap-Pac	9	6	4/8/93	39.1 b	2.1
Prune-Bap-Pac	10	2	3/9/93	1.7 a	0.0
Glasshouse to outside					
Control	10	5	10/8/93	17.0 ab	0.0
Prune	10	4	3/9/93	5.4 a	0.3
Bap	8	2	4/8/93	4.6 a	0.0
Pac	10	2	24/8/93	8.7 ab	0.5
Bap-Pac	10	5	4/8/93	23.7 ab	0.7
Prune-Bap-Pac	10	6	24/8/93	11.7 ab	0.2
Probability		NS		<0.05	

Pruning delayed flowering while Bap induced earlier flowering

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alone or in combination with Pac. The Bap-Pac treatment produced the most extended flowering, with a significantly longer flowering period in plants which remained in the glasshouse for twelve months.

Table 7.6 Mean number per month of inflorescences of *A. glaucoptera* with single, combination and repeated treatments

Different letters within columns indicate significant differences between means.

Treatment	Aug	Sept	Oct	Nov	Dec	Total no. infl.
Outside	0.3	52.8	0.2	0.0	0.0	53.3 ab
Glasshouse						
Control	0.1	3.6	0.0	0.0	0.0	3.7 a
Prune	0.0	9.5	0.1	0.1	0.4	9.6 a
Bap	26.0	4.6	0.0	0.0	0.2	30.6 ab
Pac	1.9	14.7	3.1	0.6	0.0	19.7 ab
Bap-Pac	42.6	52.4	2.3	0.3	1.1	102.1 b
Prune-Bap-Pac	0.0	0.1	0.8	0.0	0.0	0.9 a
Mean	12.2	13.7	1.1	0.2	0.1	
Glasshouse to outside						
Control	0.3	0.6	7.3	4.5	1.3	8.2 a
Prune	0.0	1.1	18.1	5.9	0.8	19.2 ab
Bap	5.3	0.4	0.8	0.0	0.0	6.4 a
Pac	2.6	12.0	9.5	1.0	0.0	24.1 ab
Bap-Pac	18.2	7.8	2.2	0.6	0.4	28.2 ab
Prune-Bap-Pac	0.7	3.5	3.2	0.0	0.0	7.4 a
Mean	4.5	4.4	6.7	2.1	0.4	
Probability	0.055	<0.05	NS	NS	NS	<0.05

Plants kept outside throughout the experiment flowered mainly in September. Plants kept in the glasshouse throughout the experiment flowered mainly in August and September. Flowering in plants kept in the glasshouse and then transferred outside spread from August to December.

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Glasshouse control plants and those treated with prune-Bap-Pac had consistently reduced inflorescence number, with prune-Bap-Pac treatment almost completely preventing flowering. Bap treated plants flowered in August under both temperature regimes, whereas Pac plants flowered in September, with plants transferred from the glasshouse to outside continuing to flower in October. In Bap-Pac plants, flowering commenced in August and continued until September, with glasshouse plants (for the experiment duration) producing the highest overall total inflorescence number ($P<0.05$). **The frontispiece** shows a glasshouse plant after treatment with Bap-Pac, showing the development of inflorescences along the phyllodes. The plant had subsequently received low temperature treatment.

Plants were aged seventeen months at flowering, with flowering plants in this experiment being fourteen months younger than those in the previous experiment. The main time of flowering was September.

Pot plant suitability

Bap-Pac treated plants were the most suitable for pot plant culture as these flowered more strongly than the other treatments, especially in the twelve month glasshouse treatment. Pac plants and Prune-Bap-Pac plants were of suitable size, but with less floral development.

7.2.2 *A. imbricata*

7.2.2.1 *A. imbricata* with a combination treatment

Seed was sown in January 1991 and plants were thirteen months old when treated. All plants were initially pruned to 10 cm two weeks before treatment with a combination of 50 mgL^{-1} Bap and 2 mgai Pac on 23/2/92. There were ten plants per treatment, and plants were kept in a glasshouse for twelve months following treatment, then placed outside.

Table 7.7 Vegetative data for *A. imbricata* with a combination treatment

Time (months)	Treatment	Height(cm)	Width(cm)	No.branches
0		13.3	8.2	11.4
6	Control	65.7	69.1	30.7
6	Bap-Pac	18.9	19.4	19.6
Probability		<0.001	<0.001	NS
12	Control	117.0	78.1	80.6
12	Bap-Pac	23.9	17.9	37.4
Probability		<0.001	<0.001	<0.001

Control plants grew extremely tall, branching high up along the main stem and Bap-Pac reduced height and width at six months and height, width and shoot number at twelve months ($P<0.001$).

Table 7.8 Flowering data for *A. imbricata* with a combination treatment

Treatment	No. plants	No. plants flowering	Date of first flowering	Period flowering (days)	Total no. infl.	No.infl: No.branches
Control	3	3	10/8/93	18.7	191.3	1.1
Bap-Pac	10	6	4/8/93	9.4	149.0	1.3

There were no significant differences between treatments. The plants flowered in August 1993, when they were thirty one months old.

Pot plant suitability

Bap-Pac treated *A. imbricata* plants were suitable as pot plants, being less than 35 cm in height and producing a high density of inflorescences along short branches. **Figure 7.1** shows a flowering plant of *A. imbricata* in August 1993.

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Figure 7.1 Flowering plant of *A. imbricata* eighteen months after a combination treatment with Bap-Pac
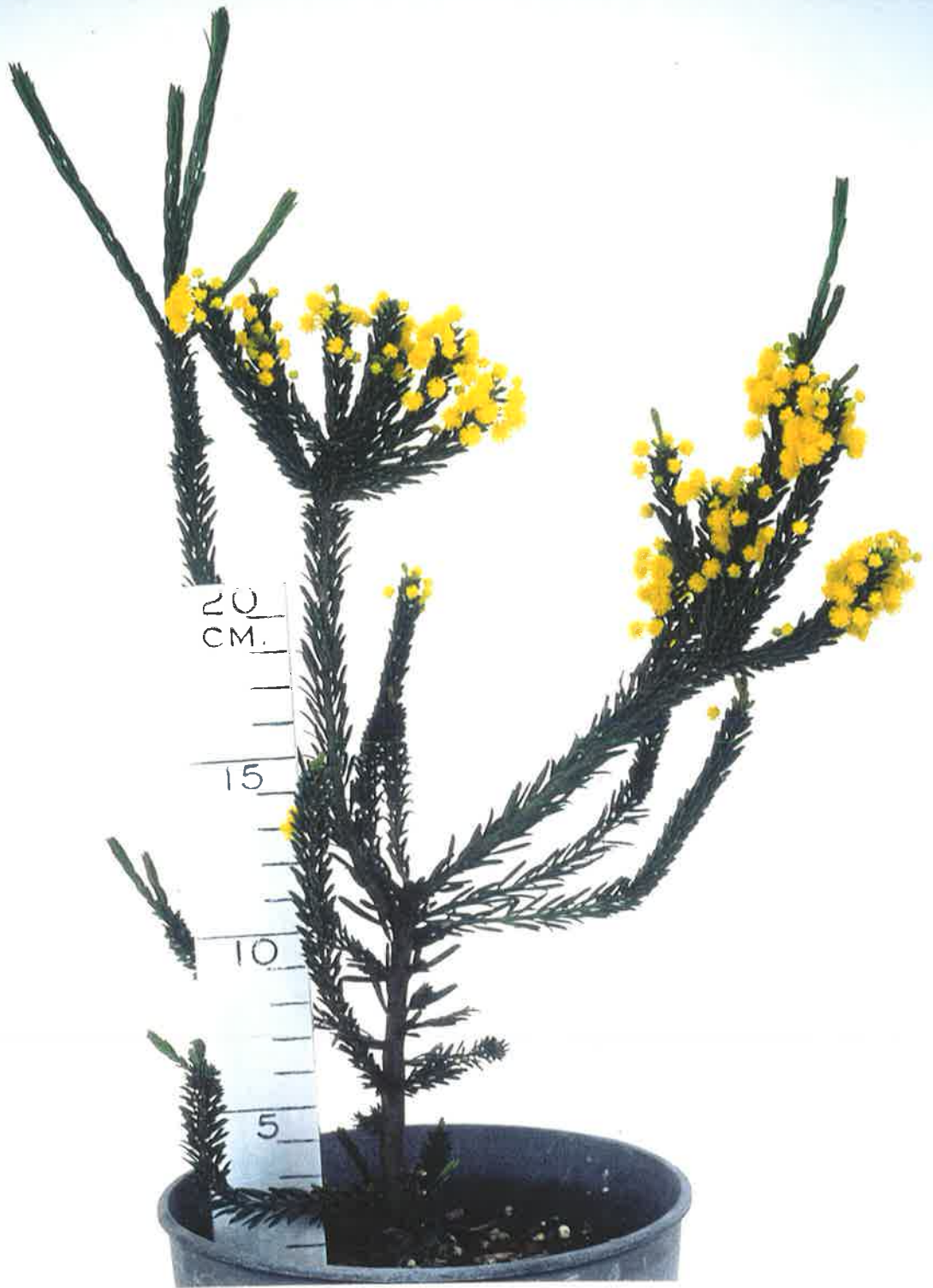
A. imbricata
BAPPAC

7.2.2.2 *A. imbricata* with single and combination treatments

This experiment tested younger seedlings than those used in 7.2.2.1. Seed was sown in March 1992, and plants were four months old when treated. There were ten plants per treatment and the experiment was set up on 9/7/92. The prune treatment was a terminal tip prune when the plants were at least five cm tall. The Pac treatment was a pot drench of 2 mgai paclobutrazol. The Bap treatment was a spray with 100 mgL^{-1} Bap, and the combination treatment Bap-Pac was a drench and spray at the same time. Plants remained in the glasshouse for ten months then were placed outside.

Table 7.9 Vegetative data for *A. imbricata* with single and combination treatments

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		9.3	7.6	0.5
6	Control	50.9 b	33.0	18.2
6	Prune	46.0 b	35.2	26.3
6	Bap	47.8 b	53.2	29.1
6	Pac	25.6 a	32.5	17.3
6	Bap-Pac	21.4 a	40.3	13.8
Probability		<0.001	NS	NS
12	Control	84.4 b	44.5	49.6 b
12	Prune	75.1 b	46.3	61.3 c
12	Bap	81.1 b	42.0	41.8 ab
12	Pac	30.9 a	38.6	35.8 ab
12	Bap-Pac	31.7 a	37.6	26.9 a
Probability		<0.001	NS	<0.01

Control plants branched above 15 cm height. Pruning increased shoot number at twelve months. Pac reduced height at both six and twelve months. Bap-Pac reduced height at six months, and

the height and shoot number at twelve months.

Table 7.10 Flowering data for *A. imbricata* with single and combination treatments

Treatment	No. plants	No. plants flowering	Date of first flowering	Period of flowering (days)
Control	9	1	4/8/93	3.8
Prune	10	4	4/8/93	9.0
Bap	10	5	4/8/93	7.4
Pac	10	2	12/8/93	1.5
Bap-Pac	10	1	4/8/93	2.0
Probability		NS		NS

Although there were no significant differences, Pac treated plants were noted to commence flowering later than the other treatments.

Table 7.11 Inflorescence numbers for *A. imbricata* with single and combination treatments

Treatment	No. of buds at 12 months	Total no. of inflorescences	No.infl: No.branches
Control	60.1	110.7	2.2
Prune	26.9	52.6	0.9
Bap	50.1	110.8	2.7
Pac	0.4	1.0	0.0
Bap-Pac	2.0	6.2	0.2
Probability	NS	NS	

Few plants produced buds, and Bap treatment produced the highest inflorescence:shoot ratio. The plants flowered in August 1993 when they were seventeen months old.

Pot plant suitability

The Pac and the Bap-Pac treated plants were of suitable size, but insufficient flowering for a pot plant. These treatments

were the youngest *A. imbricata* plants flowering.

7.2.2.3 *A. imbricata* with combination and repeated treatments

Combination and repeated treatments were applied. Seed was sown in August 1992 and all plants were eight months old when treated. The prune treatment was pruning the main stem to 10 cm, which was repeated after eight weeks. Prune-Pac was pruning to 10 cm, then application of 2 mgai Pac after eight weeks, repeating the Pac application after a further four weeks. The Bap-Pac-1 treatment was a spray with 100 mgL^{-1} of Bap, then after eight weeks 4 mgai Pac was applied. Bap-Pac-2 treatment was a spray with 100 mgL^{-1} Bap, then after eight weeks an application of 2 mgai Pac, with a repeated application of 2 mgai Pac after a further four weeks. Prune-Bap-Pac treatment was pruned to 10 cm and sprayed with 100 mgL^{-1} of Bap, then after eight weeks an application of 2 mgai Pac, with a repeated application of 2 mgai Pac after four weeks. All Pac treatments consisted of 4 mgai Pac in total. There were ten plants per treatment and plants were treated on 3/4/93. Plants were maintained in a glasshouse for twelve months after which they were moved outside.

Table 7.12 Vegetative data for *A. imbricata* with combination and repeated treatments

Different letters within columns at each time indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		26.6	5.7	1.3
6	Control	94.1 b	62.9 b	58.4 b
6	Prune	30.7 a	35.0 ab	26.7 a
6	Prune-Pac	20.7 a	42.8 ab	27.3 a
6	Bap-Pac-1	37.4 a	51.9 ab	15.1 a
6	Bap-Pac-2	32.6 a	24.8 a	13.0 a
6	Prune-Bap-Pac	20.6 a	36.8 ab	20.0 a
Probability		<0.001	<0.01	<0.001
12	Control	127.5 c	66.7 b	102.2 b
12	Prune	86.9 b	48.6 ab	58.3 a
12	Prune-Pac	31.6 a	48.7 ab	37.1 a
12	Bap-Pac-1	56.6 a	45.4 ab	51.3 a
12	Bap-Pac-2	32.9 a	42.4 ab	40.8 a
12	Prune-Bap-Pac	34.4 a	39.0 a	44.3 a
Probability		<0.001	0.051	<0.001
18	Control	122.2 c	63.5 ab	119.8
18	Prune	79.6 b	76.2 b	86.8
18	Prune-Pac	36.3 a	50.3 ab	130.7
18	Bap-Pac-1	44.5 a	56.1 ab	110.4
18	Bap-Pac-2	30.9 a	49.6 ab	108.1
18	Prune-Bap-Pac	43.0 a	39.7 a	158.7
Probability		<0.001	<0.05	NS

Control plants grew upright, with branches radiating above 15 cm. After eighteen months plants stems were not as erect, and branches spread out from the main stem. Pruning, prune-Pac and both Bap-Pac treatments reduced height and branch number. Prune-Bap-Pac reduced height, width, and branch number. **Figure 7.2** shows the effects of the treatments applied in this experiment, with Pac reducing size and

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A.imbricata

Figure 7.2 Effect on *A. imbricata* of the range of combination and repeated treatments

increasing intensity of colour.

Table 7.13 Flowering data for _A. imbricata_ with combination and repeated treatments

Treatment	No. plants	No. plants flowering	Date of first flowering	Period of flowering (days)
Control	7	5	19/6/94	30.3
Prune	7	6	19/6/94	32.6
Prune-Pac	9	9	19/6/94	32.2
Bap-Pac-1	8	6	18/7/94	19.9
Bap-Pac-2	9	4	10/7/94	15.8
Prune-Bap-Pac	9	7	1/8/94	23.0
Probability				NS

There were no significant differences between treatments. Flowering was delayed in the Prune-Bap-Pac treatment.

Table 7.14 Inflorescence numbers of _A. imbricata_ with combination and repeated treatments

Different letters within columns indicate significant differences between means.

Treatment	July	Aug	Sept	Total no. infl.	No.infl: no.branches
Control	0.4	375.4	137.6 b	513.6	4.3
Prune	5.0	396.7	31.3 a	433.0	5.0
Prune-Pac	47.3	130.6	27.6 a	205.4	1.6
Bap-Pac-1	22.3	248.1	20.3 a	290.6	2.6
Bap-Pac-2	1.8	309.0	13.8 a	324.5	3.0
Prune-Bap-Pac	2.1	126.9	63.9 ab	192.9	1.2
Mean	13.8	254.9	46.8	315.4	
Probability	NS	NS	<0.01	NS	

Plants flowered in July, August and September 1994, with August the main flowering month. In September, control plants showed greater flowering than all treatments except prune-Bap-Pac ($p < 0.01$). The total mean number of inflorescences was not significantly different between treatments. Bap-Pac treated plants, with a short flowering period and high number of

inflorescences, although not significantly different than other treatments, produced a pot plant sized flowering plant. Plants were twenty four months old when they flowered in August, 1994.

Pot plant suitability

Bap-Pac treated plants produced a pot plant sized flowering plant. Prune-Bap-Pac plants were of suitable size but produced flowering requiring investigation of effect of time of pruning.

7.2.3 *A. acinacea*

7.2.3.1 *A. acinacea* with single and combination treatments

Seed was sown June 1992, and all plants were three months old when treated. The prune treatment was a terminal prune to 10 cm. Pac was a pot drench of 2 mgai Pac. Prune-Pac was a terminal prune to 10 cm followed two weeks later by 2 mgai Pac. Plants remained in the glasshouse for ten months after which they were placed outside. Some plants were maintained outside with no other treatment for the duration of the experiment. There were ten plants per treatment and the experiment was set up on 19/9/92.

Table 7.15 Vegetative data for *A. acinacea* with single and combination treatments

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		6.3	8.5	2.8
6	Outside Glasshouse	35.6 a	22.1 a	17.3 a
6	Control	58.0 b	68.5 d	51.8 b
6	Prune	56.7 b	61.5 cd	42.1 ab
6	Pac	28.9 a	44.1 b	38.7 ab
6	Prune-Pac	22.9 a	49.6 bc	42.3 ab
Probability		<0.001	<0.001	<0.01
12	Outside Glasshouse	37.2 ab	23.9 a	57.1 a
12	Control	47.3 b	79.4 d	187.3 b
12	Prune	46.3 b	75.2 cd	192.3 b
12	Pac	34.8 ab	56.1 b	182.9 b
12	Prune-Pac	25.6 a	60.6 bc	202.6 b
Probability		<0.05	<0.001	<0.01

Prune compared to the glasshouse control had no effect on height and width. Pac reduced height at six months, and width at six and twelve months. Prune-Pac reduced height and width at six and twelve months. Plants maintained outside were smaller in height after six months, and in width and branch number after six and twelve months than glasshouse control plants. **Figure 7.3** shows the effect of the combination of prune and Pac at six months on an *A. acinacea* plant.

15cm

12.5cm

10cm

7.5cm

5.0cm

A. acinacea
PRUNEPAC

Figure 7.3 Effect on the flowering plant *A. acinacea* of the combination of prune and Pac

Table 7.16 Flowering data for *A. acinacea* with single and combination treatments

Different letters within columns indicate significant differences between means.

Treatment	No. plants	Plants with flower buds at 10 months	No. plants flowering	Date of first flowering	Period of flowering (days)
Outside	9	1	1	30/8/93	1.0 a
Glasshouse to outside					
Control	10	7	7	5/8/93	16.8 b
Prune	10	6	7	10/8/93	14.4 ab
Pac	10	6	7	10/8/93	13.3 ab
Prune-Pac	10	4	6	12/8/93	10.7 ab
Probability					<0.05

Table 7.17 Inflorescence numbers for *A. acinacea* with single and combination treatments

Different letters within columns indicate significant differences between means.

Treatment	Maximum no. infl. per day	Total no. infl.	No. infl: No branches
Outside	0.2 a	0.4 a	0.0
Glasshouse to outside			
Control	125.4 b	257.0 b	1.4
Prune	48.7 ab	147.6 ab	0.8
Pac	32.2 ab	55.6 a	0.3
Prune-Pac	37.5 ab	98.1 ab	0.5
Probability	<0.05	<0.01	

Only one outside plant flowered, with a very short flowering period. Glasshouse control plants tended to have the longest period of flowering, the greatest inflorescence number per day, the highest total inflorescence number and the highest ratio of inflorescences to branches. Pac reduced the total number of inflorescences produced, but the plants were of a suitable size, with sufficient inflorescences for a pot plant. Prune-Pac plants, despite a trend to lower total inflorescence numbers, were also of a suitable size, with a good flowering display. Pruned plants

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were not significantly different from glasshouse control plants in flowering behaviour. Few plants grown outside from the commencement of the experiment flowered, and they had a low number of inflorescences. Plants were fifteen months old when they flowered in August and September 1993.

Pot plant suitability

Pac and prune-Pac treatments which were grown in the glasshouse produced a pot plant sized flowering plant, with prune-Pac plants superior in appearance.

7.2.4 *A. podalyrifolia*

7.2.4.1 *A. podalyrifolia* with combination and repeated treatments

Seed was sown in July 1992 and plants were three months old when treated. Prune treatment was a terminal prune to 10 cm repeated after four weeks. Pac was a pot drench of 2 mgai Pac followed by a repeat treatment after four weeks. Prune-Pac was a terminal prune to 10 cm followed two weeks later by a pot drench with 2 mgai Pac, then a repeat prune after two weeks and repeat application with 2 mgai Pac after a further two weeks. Plants remained in the glasshouse for twelve months and were then moved outside. Some plants were maintained outside with no other treatment for the duration of the experiment. There were ten plants per treatment and the experiment was set up on 7/10/92.

Table 7.18 Vegetative data for *A. podalyrifolia* with combination and repeated treatments

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		6.6	10.2	0.0
6	Outside Glasshouse	36.1 a	20.1 a	2.5 a
6	Control	85.5 b	54.5 b	16.6 c
6	Prune	86.1 b	61.8 b	14.3 bc
6	Pac	24.7 a	18.9 a	6.6 ab
6	Prune-Pac	20.8 a	28.2 a	9.1 abc
Probability		<0.001	<0.001	<0.001
12	Outside Glasshouse	46.5 b	23.9 a	6.0 a
12	Control	98.6 c	55.1 c	26.0 bc
12	Prune	97.9 c	63.8 c	29.8 c
12	Pac	28.0 a	29.2 ab	18.3 b
12	Prune-Pac	33.3 ab	46.2 bc	23.4 bc
Probability		<0.001	<0.001	<0.001
	Glasshouse to outside			
24	Control	107.6 ab	68.6 b	-
24	Prune	113.7 b	55.3 ab	-
24	Pac	83.8 ab	44.7 a	-
24	Prune-Pac	79.0 a	76.7 b	-
Probability		<0.05	<0.01	-

- No data

Plants retained outside were reduced in height, width and shoot number compared to glasshouse controls. Until twelve months, pruned plants were not significantly different from glasshouse control plants. Pac reduced height and width of plants and prune-Pac plants had reduced height. Pac plants had the smallest width, and tended to be short. Prune-Pac plants were the shortest, and in balance with their diameter, so that these plants were the best in appearance as a pot plant. At twenty

four months most of these differences were not apparent.

Table 7.19 Flowering data for *A. podalyrifolia* with combination and repeated treatments

Different letters within columns indicate significant differences between means.

Treatment	No. plants	No. plants Flowering	Date of first flowering	Period of flowering (days)	Total no. infl.
Glasshouse to outside					
Control	5	2	10/7/94	14.0	107.6
Prune	7	3	1/7/94	13.7	61.9
Pac	5	1	10/7/94	6.2	36.0
Prune-Pac	6	1	19/7/94	5.0	15.0
				NS	NS

Plants flowered in July and August 1994 after twenty four months.

Pot plant suitability

Pac and Prune-Pac plants at twelve months looked attractive as foliage plants. Prune-Pac treated plants had the best size and appearance, but inflorescences were too few in number.

7.2.5 *A. crassuloides*

7.2.5.1 *A. crassuloides* with single and combination treatments

Seed was sown in June 1992, plants were six months old when treated, and were kept in the glasshouse for twelve months then moved outside. Pruned plants were tip pruned to 10 cm. Pac was a treatment of 2 mgai and Prune-Pac combined a prune treatment followed after two weeks by a Pac treatment. There were ten plants per treatment and the experiment was set up on 15/12/92.

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Table 7.20 Vegetative data for *A. crassuloides* with single and combination treatments

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		7.2	8.8	1.2
6	Control	14.3	20.6	6.1
6	Prune	18.2	25.4	7.2
6	Pac	13.2	20.7	7.8
6	Prune-Pac	8.9	15.8	7.3
Probability		NS	NS	NS
12	Control	41.9 b	29.8	26.8
12	Prune	39.9 ab	31.6	28.3
12	Pac	29.7 ab	32.0	17.8
12	Prune-Pac	26.1 a	38.5	28.8
Probability		<0.01	NS	NS
	Glasshouse to outside			
24	Control	50.8	34.8	152.3 b
24	Prune	51.3	32.7	105.7 ab
24	Pac	46.6	42.1	77.7 a
24	Prune-Pac	40.8	33.8	133.5 ab
Probability		NS	NS	<0.05

Prune-Pac treated plants were reduced in height after twelve months compared to the control, but this advantage was not maintained to twenty four months. The Pac treatment shoot number was less than the control after twenty four months. **Figure 7.4** shows the range of *A. crassuloides* plant size eighteen months after treatment.
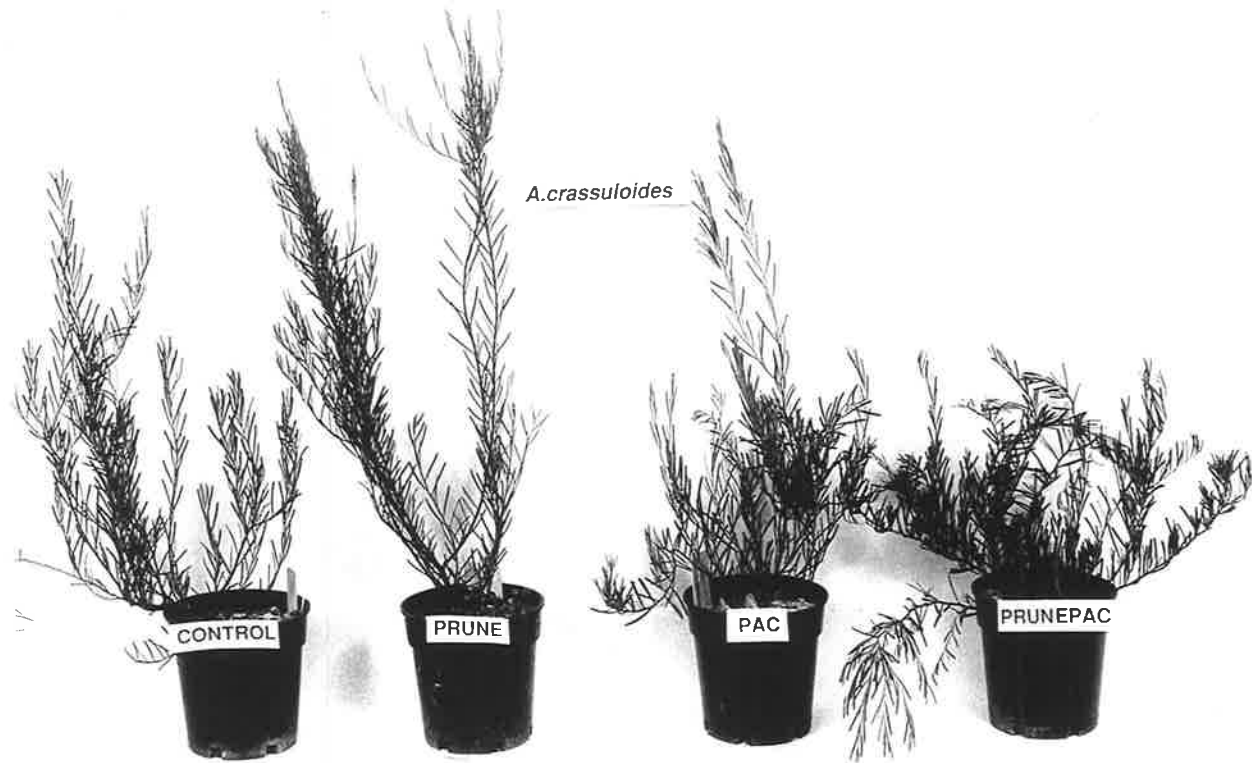
A.crassuloides

CONTROL   PRUNE   PAC   PRUNEPAC

Figure 7.4 Effect on plant size of *A. crassuloides* of single and combination treatments

Table 7.21 Flowering data for *A. crassuloides* with single and combination treatments

Different letters within columns indicate significant differences between means.

Treatment	No. plants	No. plants flowering	Date of first flowering	Period of flowering	Total no. infl.
Control	4	2	19/6/94	28.4 b	67.8 b
Prune	8	0	-	0.0 a	0.0 a
Pac	9	1	3/8/94	4.6 ab	1.8 a
Prune-Pac	5	0	-	0.0 a	0.0 a
Probability				<0.05	<0.05

Control plants flowered for an extended period, but the number of plants flowering was small. Flowering was restricted to three plants and so was not a good indicator of floral behaviour. Plants flowered between June and September 1994 after twenty four months

Pot plant suitability

A. crassuloides is a slow growing acacia and control plants were a suitable pot plant size throughout the experiment. The foliage is bright green, low in the pot and of dense appearance.

7.2.6 *A. cometes*

7.2.6.1 *A. cometes* with a single treatment

All plants were pruned to eight cm two weeks prior to treatment with 2 mgai Pac, and plants were aged thirteen months when treated on 20/2/92. They were kept in a glasshouse for twelve months, after which they were placed outside and there were ten plants per treatment.

Table 7.22 Vegetative data for *A. cometes* with a single treatment

Time(months)	Treatment	Height(cm)	Width(cm)	No.branches
0		9.8	7.4	6.9
6	Control	18.2	28.2	19.8
6	Pac	15.6	17.6	15.7
Probability		NS	<0.001	NS
12	Control	24.9	34.4	36.3
12	Pac	18.6	23.6	30.1
Probability		<0.05	<0.05	NS

Pac reduced plant width at six months and height and width at twelve months. Plants did not flower within twenty four months.

Pot plant suitability

Both treated and untreated plants produced plants of size suitable for pot plants.

7.2.6.2 *A. cometes* with single and combination treatments

A. cometes plants produced good vegetative attributes for pot plant culture so were further investigated. Younger seedlings than those used in 7.2.6.1 were tested with single and combination treatments. Seed was sown in June 1992 and plants were five months old when treated. They were kept in a glasshouse for twelve months after which they were placed outside. The prune treatment consisted of a tip prune. Pac was applied at a rate of 2 mgai. Plants which were treated with Prune-Pac were tip pruned initially then Pac was applied four weeks later. There were seven plants per control and prune-Pac treatments, and eight plants per prune and Pac treatments, and the experiment commenced on 15/12/92.

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Table 7.23 Vegetative data for *A. cometes* with single and combination treatments

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No.branches
0		3.9	5.6	0.5
6	Control	13.8 b	20.8	5.2 a
6	Prune	17.2 c	26.5	5.8 a
6	Pac	7.4 a	16.6	2.7 a
6	Prune-Pac	8.2 ab	15.8	9.4 b
Probability		<0.001	NS	<0.001
12	Control	19.3 b	42.7	27.7
12	Prune	21.5 b	34.5	36.5
12	Pac	16.5 ab	32.7	16.1
12	Prune-Pac	9.7 a	24.6	41.6
Probability		<0.05	NS	NS
24	Control	22.7 b	49.7 b	81.7
24	Prune	23.8 b	35.5 ab	62.8
24	Pac	15.0 ab	35.0 ab	58.3
24	Prune-Pac	10.3 a	22.3 a	67.3
Probability		<0.05	<0.01	NS

Pruning increased the height of *A. cometes* at six months. Pac reduced height at six months, with less effect at twelve and twenty four months. A combination Prune-Pac treatment increased the number of branches at six months, reduced height at twelve months, and height and width of *A. cometes* after two years. **Figure 7.5** shows the range of size of *A. cometes* plants seventeen months after treatment.

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A.cometes

CONTROL   PRUNE   PAC   PRUNEPAC
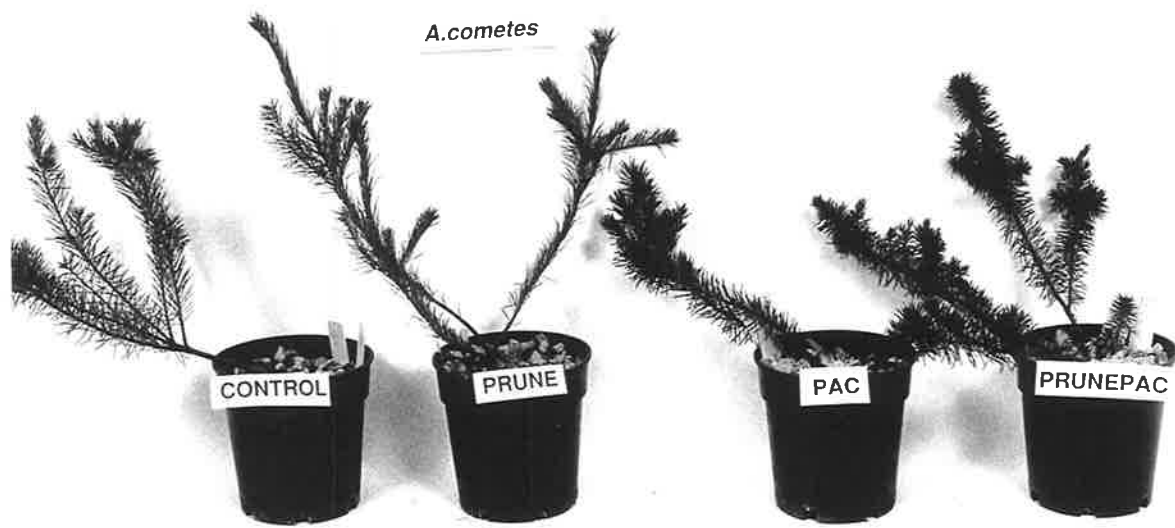
Figure 7.5 Effect on plant size of *A. cometes* of
single and combination treatments

Table 7.24 Flowering data for *A. cometes* with single and combination treatments

Treatment	No. Plants	No. Plants flowering	Date of first flowering	Period of flowering (days)	Total no. infl.
Control	3	1	19/7/94	29.7	106.7
Prune	4	0	-	0	0
Pac	2	0	-	0	0
Prune-Pac	5	0	-	0	0
Probability				NS	NS
- No data					

Only one control plant flowered in September and October 1994.

Pot plant suitability

A. cometes is a very attractive plant with dark green foliage and small size when treated with Pac. Although attractive as potential foliage pot plant, there were insufficient flowers within two years to be considered as a flowering pot plant.

7.2.7 *A. vestita*

7.2.7.1 *A. vestita* with single and combination treatments

Seed was sown in March 1992, and plants were treated when four months old. Plants were grown under glasshouse conditions for twelve months then placed outside. Prune consisted of removal of the terminal shoot to a height of 10 cm. Pac consisted of 2 mgai Pac as a pot drench. Bap consisted of 100 mgL-1 benzylamino purine applied as a spray and Bap-Pac was a dual treatment of Bap and Pac applied on the same day. There were ten plants per treatment and the experiment was set up on 1/7/92.

Table 7.25 Vegetative data for *A. vestita* with single and combination treatments

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		11.4	12.5	3.5
6	Control	33.2 bc	41.4 b	15.9
6	Prune	25.5 ab	46.4 b	13.2
6	Bap	35.1 c	44.6 b	17.2
6	Pac	27.1 ab	26.5 a	9.5
6	Bap-Pac	26.3 a	21.4 a	11.0
Probability		<0.001	<0.001	NS
12	Control	52.4 c	54.2 b	31.9
12	Prune	43.2 b	56.3 b	27.2
12	Bap	44.2 b	55.8 b	26.3
12	Pac	30.6 a	32.3 a	20.4
12	Bap-Pac	32.2 a	29.9 a	23.4
Probability		<0.001	<0.001	NS

Pruning and Bap reduced the height of the plants after twelve months. Pac reduced height after twelve months and width of plants after six and twelve months. Bap-Pac reduced height and width after both six and twelve months.

Table 7.26 Flowering data for *A. vestita* with single and combination treatments

Different letters within columns indicate significant differences between means.

Treatment	No. plants	No. plants flowering	Date of first flowering	Period of flowering (days)
Control	5	1	7/10/94	7.2 a
Prune	7	6	7/10/94	24.0 b
Bap	8	5	7/10/94	12.6 ab
Pac	10	0	-	0.0 a
Bap-Pac	7	1	7/10/94	4.4 a
Probability		<0.01		<0.001

Prune treatment had the greatest period of flowering (P<0.001) and number of plants flowering. Pac prevented flowering altogether.

Table 7.27 Inflorescence numbers in *A. vestita* with single and combination treatments

Different letters within columns indicate significant differences between means.

Treatment	July	Aug	Sept	Total no. infl.	No. infl: No. branches
Control	33.2	0.8	0.0	34.0 ab	1.1
Prune	51.9	53.0	9.3	122.7 c	4.5
Bap	38.8	14.3	1.6	55.1 bc	2.1
Pac	0.0	0.0	0.0	0.0 a	0.0
Bap-Pac	3.1	71.9	0.0	75.0 ab	0.3
Mean	23.3	26.8	2.1	53.9	
Probability	NS	NS	NS	<0.001	

Pruned plants had the greatest number of inflorescences (P<0.001), with flowering through July to September. Pac plants did not flower. Minimal flowering occurred in August-September 1993 (data not presented). The July to September 1994 flowering commenced at twenty four months.

Pot plant suitability

Pac treated plants were of good size and appearance after twelve months, but did not flower. Plants would be suitable for foliage pot plants.

7.2.8 *A. decora*

7.2.8.1 *A. decora* with single and combination treatments.

Seed was sown in March 1992 and plants were treated when four months old. Plants were grown under glasshouse conditions for twelve months then placed outside. Prune consisted of removal of the terminal shoot to a height of 10 cm. Pac

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consisted of two mgai Pac as a pot drench. Bap consisted of 100 mgL-1 benzylamino purine applied as a spray. Bap-Pac was a dual treatment of 100 mgL-1 Bap and two mgai Pac applied on the same day. There were ten plants per treatment and the experiment was set up on 1/7/92.

Table 7.28 Vegetative data for *A. decora* with single and combination treatments

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		13.4	5.8	1.1
6	Control	48.2 b	14.8	5.0
6	Prune	32.3 a	33.8	8.1
6	Bap	46.0 b	17.3	3.4
6	Pac	45.5 b	21.4	4.4
6	Bap-Pac	41.3 ab	22.2	5.4
Probability		<0.01	NS	NS
12	Control	72.4	23.0	6.9
12	Prune	56.2	46.7	11.8
12	Bap	69.3	29.3	6.7
12	Pac	60.3	30.9	6.4
12	Bap-Pac	57.3	34.6	8.5
Probability		NS	NS	NS
27	Control	94.8	45.2	-
27	Prune	82.6	70.9	-
27	Bap	102.9	52.9	-
27	Pac	87.6	51.1	-
27	Bap-Pac	83.4	57.2	-
Probability		NS	NS	

- No data

Pruning reduced the height of plants at six months, but there were no further differences between treatments even after 27 months. The appearance of pruned plants was slightly bushier, but all plants were too tall for pot plants.

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Table 7.29 Flowering data for *A. decora* with single and combination treatments

Treatment	No. plants	No. plants flowering	Date of first flowering	Period of flowering (days)
Control	9	9	1/7/94	27.1
Prune	9	6	27/7/94	20.8
Bap	10	9	27/7/94	23.8
Pac	9	9	27/7/94	17.8
Bap-Pac	10	7	10/7/94	20.2
Probability				NS

There were no significant differences between treatments.

Table 7.30 Inflorescence numbers of *A. decora* with single and combination treatments

Different letters within columns indicate significant differences between means.

Treatment	July	Aug	Sept	Total no. infl.	No. infl: No. branches
Control	76.4 b	217.4	64.9	352.1	51.0
Prune	2.0 a	158.9	85.3	246.2	20.9
Bap	41.1 ab	248.2	100.3	389.6	58.1
Pac	0.2 a	107.9	36.3	144.3	22.5
Bap-Pac	11.8 ab	215.9	46.6	274.3	32.3
Mean	26.3	191.4	67.0	283.5	
Probability	<0.05	NS	NS	NS	

Total numbers of flowers in *A. decora* was not significantly different between treatments. The ratio of inflorescences to branches in *A. decora* was high compared to other species. In July, prune and Pac plants did not flower as well as the control (P<0.05). Plants commenced flowering when they were twenty eight months old.

Pot plant suitability

A. decora plants were too tall for small potted plants, but

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could be considered for a large potted plant.

7.2.9 A. buxifolia

7.2.9.1 A. buxifolia with a single treatment

Seed was sown in March 1992, and plants were treated when four months old. Plants were grown under glasshouse conditions for twelve months then placed outside. Pruning consisted of removal of the terminal shoot to a height of 15 cm. There were seven control plants and eight prune plants, and the experiment was set up on 2/7/92.

Table 7.30 Vegetative data for A. buxifolia with a single treatment

Time(months)	Treatment	Height(cm)	Width(cm)	No. Branches
0		19.7	11.7	4.8
6	Control	55.6	35.9	21.0
6	Prune	58.0	45.3	23.3
Probability		NS	NS	NS
12	Control	79.1	53.4	31.4
12	Prune	77.0	56.1	26.9
Probability		NS	NS	NS

The prune treatment had no effect on this species.

Table 7.31 Flowering data for A. buxifolia with a single treatment

Treatment	No. plants	No. plants flowering	Date of first flowering	Period of flowering (days)
Control	7	5	4/8/93	18.0
Prune	8	6	4/8/93	15.3
Probability				NS

There was no difference between control and pruned plants in commencement time or period of flowering.

Table 7.32 Bud and inflorescence data for *A. buxifolia* with a single treatment

Treatment	No. buds at 6 months	No. buds at 12 months	Total no. Infl.	No. infl: No. branches
Control	19.3	342.9	376.4	31.4
Prune	2.9	209.8	128.0	26.9
Probability		NS	NS	

There were no differences between treatments. Plants flowered from August to September 1993, at seventeen months.

Pot plant suitability

Although too large for small pot plants, the cascading nature of the plants produced a gracious appearance as a tub specimen.

7.2.10 *A. meisneri*

7.2.10.1 *A. meisneri* with a single treatment

Seed was sown in March 1992, and plants were treated when four months old. Plants were grown under glasshouse conditions for twelve months then placed outside. Pruning consisted of removal of the terminal shoot to a height of 10 cm. There were nine control and ten pruned plants, and the experiment was set up on 1/7/92.

Table 7.33 Vegetative data for *A. meisneri* with a single treatment

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		13.1	4.9	0.2
6	Control	49.8	30.8	12.2
6	Prune	46.0	53.1	17.3
Probability		NS	<0.01	NS
12	Control	79.3	38.3	19.7
12	Prune	74.4	46.0	22.5
Probability		NS	NS	NS

The prune treatment resulted in wider plants after six months.

Table 7.34 Flowering data for *A. meisneri* with a single treatment

Treatment	No. plants	No. plants flowering	Date of first flowering	Period of flowering (days)
Control	8	5	12/10/93	18.9
Prune	10	5	25/10/93	14.2
Probability				NS

There was no difference between plant numbers at flowering and period of flowering. Control plants commenced flowering prior to pruned plants.

Table 7.35 Mean inflorescence numbers for *A. meisneri* with a single treatment

Treatment	No. buds at 12 months	Oct	Nov	Dec	Total no. infl.	No. infl: No. branches
Control	10	15.5	65.9	60.3	141.6	7.2
Prune	1	1.3	17.5	16.8	36.6	1.6
Probability		NS	NS	NS	NS	

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There was no significant difference between the number of inflorescences of the plants. Plants flowered from October to December 1993, after nineteen months.

Pot plant suitability

A. meisneri was not suitable for pot plant production using these treatments. It may prove suitable as a larger tub plant.

7.2.11 *A. notabilis*

7.2.11.1 *A. notabilis* with single and repeated treatments

Seed was sown in March 1992, and plants were treated when four months old. Plants were grown under glasshouse conditions for twelve months then placed outside. Pruning consisted of removal of the terminal shoot by tip pinching, and repeated tip pinching after four weeks. Pac consisted of 2 mgai Pac as a pot drench. Bap consisted of 100 mgL-1 benzylamino purine applied as a spray. There were ten plants per treatment and the experiment was set up on 2/7/92.

Table 7.36 Vegetative data for *A. notabilis* with single and repeated treatments

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		7.7	8.2	0.0
6	Control	61.9 b	26.3 a	5.4
6	Prune	55.3 a	49.2 c	5.6
6	Bap	61.9 b	37.1 b	5.3
6	Pac	37.4 a	20.4 a	4.1
Probability		<0.001	<0.001	NS
12	Control	97.1 bc	36.3 a	3.9
12	Prune	87.9 b	43.4 b	2.9
12	Bap	101.2 c	38.8 ab	2.6
12	Pac	57.9 a	39.5 ab	3.7
Probability		<0.001	<0.001	NS

Pruning reduced height at six months, and increased width at both six and twelve months. Bap increased width after six months. Pac reduced height at six and twelve months.

Table 7.37 Flowering data for *A. notabilis* with single and repeated treatments

Treatment	No. plants	No. plants flowering	Date of first flowering	Period of flowering (days)	Total no. infl.
Control	7	2	22/7/94	3.9	30.0
Prune	7	2	22/7/94	3.1	14.0
Bap	7	2	22/7/94	3.4	26.1
Pac	7	3	10/7/94	6.4	46.8
Probability				NS	NS

Flowering was inconsistent, with small numbers of plants flowering and few inflorescences. Plants flowered from July to September 1994, after twenty eight months.

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Pot plant suitability

Plants were considered unsuitable as pot plants because of the rapid increase in height, replacement of the pruned main stems by a fast growing new shoot, and the large size of phyllodes under the glasshouse conditions.

7.3 Phyllodinous acacias which did not flower within two years

7.3.1 *A. craspedocarpa*

7.3.1.1 *A. craspedocarpa* with single treatments kept outside

Plants were pruned to eight to ten cm before treatment and were thirteen months old at the commencement of treatment on 23/2/92. Ten plants were treated with a single treatment of Bap (50 mgL^{-1}), and ten plants with Pac (2 mgai), then control and treated plants were placed outside for the duration of the experiment.

Table 7.38 Vegetative data for *A. craspedocarpa* with single treatments kept outside

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		10.5	5.8	1.9
6	Control	14.2 a	8.9 a	3.7
6	Bap	14.0 a	9.1 a	4.2
6	Pac	9.3 b	5.8 b	4.1
Probability		<0.001	<0.05	NS
12	Control	19.7 a	12.5 b	7.2
12	Bap	21.1 a	17.0 a	7.7
12	Pac	11.8 b	7.2 c	6.1
Probability		<0.001	<0.001	NS
18	Control	24.0 a	14.6 a	6.9
18	Bap	23.8 a	19.7 a	8.3
18	Pac	12.9 b	8.8 b	6.1
Probability		<0.001	<0.001	NS

Pac reduced the height and width of *A. craspedocarpa* at six, twelve and eighteen months.

Pot plant suitability

Plants grew very slowly with little branching, and remained too small for pot plants.

7.3.1.2 *A. craspedocarpa* with single treatments in the glasshouse.

Plants were pruned to 10 cm before treatment and were aged thirteen months at the commencement of treatment on 23/2/92. Ten plants were treated with a single treatment of Bap (50 mgL^{-1}), and ten plants with Pac (2 mgai), then plants were kept in a glasshouse for twelve months, after which they were placed outside. Statistical analysis was by log scan to

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improve the fit to the model.

Table 7.39 Vegetative data for A. *craspedocarpa* with single treatments in the glasshouse

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		9.9	5.7	1.8
6	Control	19.8	10.3	4.6
6	Bap	18.5	10.8	3.2
6	Pac	17.4	9.4	5.1
Probability		NS	NS	NS
12	Control	35.6 a	16.5	8.0 a
12	Bap	27.7 ab	14.1	3.2 b
12	Pac	23.5 b	12.4	6.7 a
Probability		<0.01	NS	<0.01
18	Control	41.1 a	27.4 a	18.8
18	Bap	32.2 ab	19.8 ab	13.2
18	Pac	28.4 b	17.3 b	13.1
Probability		<0.01	<0.05	NS

Pac reduced the height of A *craspedocarpa* at twelve and eighteen months.

Pot plant suitability.

Plants grew much more vigorously in the glasshouse than outside, but all were very slow growing. The size was suitable for pot plants, with an interesting appearance with round, regular grey leaves on brown woody stems, but the plants did not flower within two years.

7.3.2 A. semilunata

7.3.2.1 A. semilunata with single and combination treatments

Seed was sown in July 1992 and plants were six months old when treated on 2/7/92. Pruned plants were pruned to 10 cm. Pac was a treatment of 2 mgai Pac and prune-Pac combined a pruning treatment to 10 cm followed after two weeks by a Pac treatment of 2 mgai Pac. Bap was a spray of 100 mgL^{-1} benzylamino purine. Plants were kept in the glasshouse for twelve months and then placed outside. There were eight plants in the control group and nine plants in each treatment.

Table 7.40 Vegetative data for A. semilunata with single and combination treatments

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		17.0	10.8	0.6
6	Control	49.5	64.1	8.0
6	Prune	55.8	66.3	10.8
6	Bap	46.3	64.1	13.9
6	Pac	41.3	50.7	4.6
6	Prune-Pac	37.8	54.0	6.7
Probability		NS	NS	NS
12	Control	86.7	51.7	20.0
12	Prune	80.3	61.6	18.2
12	Bap	92.0	52.5	28.5
12	Pac	76.4	51.6	26.3
12	Prune-Pac	64.8	55.4	22.9
Probability		NS	NS	NS

Plants grew vigorously and no treatment overcame strong apical growth. Pac showed a trend to curtail growth but the effect was not significant. Plants did not flower within two years of treatment.

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Pot plant suitability

Plants of *A. semilunata* were unsuitable as pot plants.

7.4 Bipinnate acacias which flowered within two years

7.4.1 *A. drummondii elegans*

7.4.1.1 *A. drummondii elegans* with single and combination treatments

Seed was sown in March 1992 and plants were treated when four months old. They were grown under glasshouse conditions for twelve months then placed outside. Prune consisted of removal of the terminal shoot to a height of approximately 15 cm, leaving some leaves on the pruned plant. Pac consisted of 2 mgai Pac as a pot drench. Bap consisted of 100 mgL^{-1} benzylamino purine applied as a spray. Bap-Pac was a dual treatment of 100 mgL^{-1} Bap and 2 mgai Pac applied on the same day. There were ten plants per treatment and the experiment was set up on 5/7/92.

Table 7.41 Vegetative data for *A. drummondii elegans* with single and combination treatments

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		14.3	7.0	1.6
6	Control	56.7 b	15.6 ab	11.9 ab
6	Prune	54.1 b	24.1 ab	14.8 ab
6	Bap	62.3 b	26.6 b	18.7 b
6	Pac	28.6 a	12.9 a	6.7 a
6	Bap-Pac	47.2 b	14.0 a	8.8 a
Probability		<0.001	<0.01	<0.001
12	Control	85.9 b	28.5 ab	13.0 abc
12	Prune	81.2 b	44.1 b	22.0 bc
12	Bap	90.5 b	37.5 ab	23.1 c
12	Pac	49.0 a	21.8 a	7.4 a
12	Bap-Pac	77.2 b	34.7 ab	10.8 ab
Probability		<0.001	<0.05	<0.001

The prune treatment was not significantly different from the control but showed a trend to greater branch number and width. The appearance of pruned plants was different from the controls in width and bushiness. Pac significantly reduced the height of plants at six and twelve months and Pac treated plants had fewer shoots than Bap treated plants at both six and twelve months.

Table 7.42 Flowering data for *A. drummondii elegans* with single and combination treatments

Different letters within columns indicate significant differences between means.

Treatment	Plant no. in flower	Bud no. at 6 months	Bud no. at 12 months	Date of first flowering	Period of flowering (days)	Total no. infl.
Control	10	1.4	61.8	16/8/93	26.9 b	85.7 b
Prune	9	10.8	74.7	16/8/93	26.6 b	98.0 b
Bap	10	20.5	85.7	16/8/93	21.2 ab	136.9 b
Pac	5	0.1	10.3	24/8/93	9.1 a	14.3 a
Bap-Pac	9	5.7	54.4	20/8/93	15.5 ab	51.5 ab
Probability		NS	NS		=0.01	<0.01

There were ten plants in each treatment. Pac significantly reduced the number of inflorescences and had the shortest period of flowering. Buds developed from January until August and plants flowered in August and September 1993.

Pot plant suitability

Plants which were suitable in size and appearance for pot plant culture prior to flowering grew too tall during flowering, with rapid internode elongation. Floral appearance was particularly attractive. Plants may be suitable for tub culture.

7.4.2 *A. polybotrya*

7.4.2.1 *A. polybotrya* with single and combination treatments

Seed was sown in June 1992, and plants were three months old when treated. The prune treatment was a terminal prune to 10 cm. Pac was a pot drench of 2 mgai Pac. Prune-Pac was a terminal prune to 10 cm followed two weeks later by 2 mgai Pac. Plants remained in the glasshouse for twelve months after which they were moved outside. Some plants were held outside throughout the experiment. There were ten plants per treatment and the experiment was set up on 19/9/92.

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Table 7.43 Vegetative data for *A. polybotrya* with single and combination treatments

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		6.2	9.6	1.2
6	Outside Glasshouse	27.4 a	28.1 a	5.8 a
6	Control	78.4 c	64.3 c	22.6 b
6	Prune	80.8 c	70.7 c	21.1 b
6	Pac	41.9 ab	46.3 b	20.0 b
6	Prune-Pac	52.6 b	49.1 b	26.9 b
Probability		<0.001	<0.001	<0.001
12	Outside Glasshouse	32.0 a	31.7 a	8.4 a
12	Control	83.9 c	73.8 c	28.6 b
12	Prune	86.3 c	77.4 c	27.0 b
12	Pac	53.0 b	54.0 b	29.7 bc
12	Prune-Pac	63.3 b	56.7 b	37.6 c
Probability		<0.001	<0.001	<0.001

Pac and prune-Pac treatments reduced height and width of glasshouse plants after six and twelve months. Plants kept outside remained smaller than plants kept in the glasshouse at six and twelve months.

Table 7.44 Flowering data for *A. polybotrya* with single and combination treatments

Treatment	No. plants	No. plants flowering	Date of first flowering	Period of flowering (days)
Outside	10	0	-	0.0
Glasshouse				
Control	10	6	30/8/93	5.0
Prune	10	5	16/8/93	7.2
Pac	10	4	20/8/93	2.0
Prune-Pac	10	6	20/8/93	6.8
Probability				NS

- No data

All plants had a short flowering period.

Table 7.45 Mean bud and inflorescence numbers in *A. polybotrya* with single and combination treatments

Different letters within columns indicate significant differences between means.

Treatment	No. buds at 6 months	No.infl. at 7 months	Maximum no. infl. per day	Total no. infl.
Outside	0.0	0.0 a	0.0	0.0
Glasshouse				
Control	30.2	35.1 b	98.0	147.7
Prune	12.1	10.9 ab	40.5	95.0
Pac	11.8	11.8 ab	80.7	97.9
Prune-Pac	11.7	10.5 ab	45.8	80.8
Probability	NS	<0.05	NS	NS

Plants retained outside did not flower during the period of the experiment. Plants flowered in August and September 1993, when they were fourteen months old. **Figure 7.6** shows *A. polybotrya* treated with Pac with a few inflorescences six months after the start of the experiment.

A. polybotrya
PAC

A.baileyana

PAC PRUNE CONTROL PRUNEPAC

Figure 7.6 Effect on a flowering plant of
A. *polybotrya* of Pac treatment

Figure 7.7 Effect on plant size of A. *baileyana* of
range of combination and repeated treatments

Pot plant suitability

Pac and prune-Pac plants had good shape and colour but were too large with insufficient inflorescences.

7.4.3 *A. baileyana*

7.4.3.1 *A. baileyana* with single, combination and repeated treatments

Seed was sown in June 1992, and plants were three months old when treated. Prune treatment was a terminal prune to 10 cm repeated after four weeks. Pac was a pot drench of 2 mgai followed by a repeat treatment after four weeks. Prune-Pac was a terminal prune to 10 cm followed two weeks later by application of 2 mgai Pac, then a repeat prune after two weeks and repeat application of 2 mgai Pac after a further two weeks. Plants remained in the glasshouse for twelve months and then were moved outside. One treatment remained outside throughout the experiment. There were ten plants per treatment, and the experiment was set up on 19/9/92.

Table 7.46 Vegetative data for _A. baileyana_ with single, combination and repeated treatments

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		5.3	8.1	0.0
6	Outside Glasshouse	29.1 ab	34.5 a	1.0 a
6	Control	74.5 c	63.8 b	5.4 b
6	Prune	66.1 c	95.1 c	5.3 b
6	Pac	38.7 b	45.6 a	5.5 b
6	Prune-Pac	11.5 a	34.1 a	6.9 b
Probability		<0.001	<0.001	<0.001
12	Outside Glasshouse	50.8 b	13.2 a	2.3 a
12	Control	77.5 c	84.2 c	15.5 b
12	Prune	69.5 c	91.0 c	16.2 b
12	Pac	46.4 b	57.7 b	16.0 b
12	Prune-Pac	19.9 a	39.6 b	12.5 b
Probability		<0.001	<0.001	<0.001
	Glasshouse to outside			
24	Control	99.7	28.0 a	-
24	Prune	90.5	62.8 b	-
24	Pac	74.0	65.3 b	-
24	Prune-Pac	79.0	62.5 b	-
Probability		NS	<0.05	

- No data

Plants retained outside were reduced in height, width and shoot number compared to glasshouse control plants until twelve months, and plant shape and appearance was unsuitable for potted plant culture. Pac and prune-Pac reduced height and width of glasshouse plants at six and twelve months, with a trend to reduce height until twenty four months.

Figure 7.7 shows the range of size in _A. baileyana_ at six months after treatment.

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Table 7.47 Flowering data for *A. baileyana* with single, combination and repeated treatments

Different letters within columns indicate significant differences between means.

Treatment	No. plants	No. flowering plants	Date of first flowering	Period of flowering (days)	Maximum no. infl. per day	Total no. infl.
Outside	0	0	-	0.0	0.0	0.0
Glasshouse to outside						
Control	4	0	-	0.0 a	0.0	0.0 a
Prune	4	3	8/8/94	8.0 ab	51.3	58.3 ab
Pac	3	1	22/7/94	8.0 ab	162.0	233.3 ab
Prune-Pac	4	3	22/7/94	14.8 b	68.5	97.0 b
Probability				<0.05	NS	<0.05

- No data

Untreated plants did not flower within two years of the commencement of the experiment. Plant numbers surviving and flowering were low. The one Pac treated plant which flowered produced the most inflorescences on a particular day and in total. Flowering occurred during July and August 1994, when plants were twenty two months old.

Pot plant suitability

Prune-Pac treated plants were of suitable size and foliage density until twelve months for a foliage pot plant.

7.4.4 *A. baileyana purpurea*

7.4.4.1 *A. baileyana purpurea* with combination and repeated treatments

Seed was sown June 1992 and plants were three months old when treated. The prune treatment was a terminal prune to 10 cm repeated after four weeks. Pac was a pot drench of 2 mgai followed by a repeat treatment after four weeks.

Prune-Pac was a terminal prune to 10 cm followed two weeks later by 2 mgai Pac, then a repeat prune after two weeks and repeat application of 2 mgai Pac after a further two weeks. Plants remained in the glasshouse for twelve months and then were moved outside. There were seven plants per treatment and the experiment was set up on 2/10/92.

Table 7.48 Vegetative data for *A. baileyana purpurea* with combination and repeated treatments

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		10.6	10.9	0.0
6	Control	69.4 b	64.0 d	6.4
6	Prune	50.7 b	82.3 d	6.4
6	Pac	16.7 a	32.1 c	6.9
6	Prune-Pac	11.8 a	27.6 c	7.4
Probability		<0.001	<0.001	NS
12	Control	79.4 b	65.0 b	17.3
12	Prune	79.1 b	76.6 b	13.4
12	Pac	36.4 a	37.0 a	12.6
12	Prune-Pac	33.1 a	37.9 a	9.7
Probability		<0.001	<0.001	NS

Control and pruned plants grew quickly in height, with few branches, to twelve months. Pac and prune-Pac reduced height and width throughout the experiment.

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Table 7.49 Flowering data for *A. baileyana purpurea* with combination and repeated treatments

Treatment	No. plants	No. plants flowering	Date of first flowering	Period of flowering (days)	Total no. infl.
Control	6	2	22/7/94	3.2	25.0
Prune	3	0	-	0.0	0.0
Pac	5	1	22/7/94	3.0	10.8
Prune-Pac	5	2	22/8/94	1.6	0.6
Probability				NS	=0.56
- No data					

Control plants had the greatest number of inflorescences. Plants flowered to only a limited extent in July and August 1994 after twenty four months.

Pot plant suitability

Plants treated with Prune-Pac were excellent foliage pot plants.

7.4.4.2 *A. baileyana purpurea* with single, combination and repeated treatments

Seed was sown August 1992 and plants were four months old when treated. Pac consisted of a treatment of 2 mgai of Pac repeated after four weeks. Bap was applied at 100 mgL^{-1} as a single spray application. Bap-Pac was a treatment of Bap followed after two weeks by a treatment of 2 mgai Pac, then a repeat treatment of Pac after another four weeks. There were nine plants per treatment and the experiment was set up on 6/1/93. Plants were kept in the glasshouse for twelve months then placed outside.

Table 7.50 Vegetative data for *A. baileyana purpurea* with single, combination and repeated treatments

Different letters within columns indicate significant differences between means.

Time(months)	Treatment	Height(cm)	Width(cm)	No. branches
0		18.9	15.6	0.2
6	Control	39.1 b	48.4 ab	4.0
6	Bap	41.9 b	62.1 b	5.3
6	Pac	26.2 ab	34.0 a	5.9
6	Bap-Pac	17.4 a	31.7 a	6.7
Probability		<0.01	<0.001	NS
12	Control	65.7	62.3	11.7
12	Bap	69.7	49.8	15.3
12	Pac	62.7	44.3	14.6
12	Bap-Pac	57.1	61.8	13.3
Probability		NS	NS	NS
21	Control	68.4	55.1	-
21	Bap	73.0	52.8	-
21	Pac	91.4	40.4	-
21	Bap-Pac	80.9	58.5	-
Probability		NS	NS	

- No data

A. baileyana purpurea grew erect with little development of side shoots. Bap-Pac reduced height to six months and Pac and Bap-Pac reduced width to six months, but after this did not retard growth.

Table 7.51 Flowering data for *A. baileyana purpurea* with single, combination and repeated treatments

Different letters within columns indicate significant differences between means.

Treatment	No. plants	No. plants flowering	Date of first flowering	Period of flowering (days)	Total no. infl.
Control	7	1	8/8/94	0.6 a	0.3 a
Bap	6	0	-	0.0 a	0.0 a
Pac	9	2	10/7/94	9.4 b	48.2 b
Bap-Pac	8	0	-	0.0 a	0.0 a
Probability				<0.01	<0.05

- No data

Plants showed limited flowering from July to August 1994, when they were eighteen months old. Pac treated plants showed earliest flowering, most inflorescences and the longest period of flowering.

Pot plant suitability

Plants treated with Pac were suitable foliage pot plants six months after treatment.

7.5 Discussion

Treatment of the various species of *Acacia* has resulted in some promising flowering pot plants, some foliage pot plants and some suitable as flowering plants for larger tubs.

7.5.1 Flowering pot plant *Acacia* species and treatments

The flowering pot plant species of most interest are *A. glaucoptera* and *A. imbricata*, with *A. acinacea* also showing promise. *A. imbricata* was the most successful species tested. The mature plants at thirty one months were very floriferous and attractive, with the heavy pruning of the more mature plants producing a good plant shape for the floral display.

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Younger plants at twenty four months also produced an attractive display, but some of the younger plants were not as firm in the main stem. *A. glaucoptera* produced a flowering pot plant. The more mature plants kept outside produced a superior floral display, but an excellent shape was achieved in glasshouse tests with younger plants receiving a combination of Bap-Pac. Allowing glasshouse grown plants to mature slightly longer prior to flowering may induce a stronger floral display with the Bap-Pac treatment. A combination of prune and Pac application produced an attractive drooping plant of *A. acinacea* within a short period of time. An improved floral display would produce a suitable potted plant. The following table summarises the potential flowering pot plant species and the treatments applied to produce the effect.

Table 7.52 Summary of flowering pot plant *Acacia* species and treatments

Species	Month of sowing	Age at treatment (months)	Treatment; conditions	Time to production (months)	Thesis section
A. glaucoptera	Feb	13	Prune to 15cm; outside all the time	31	7.2.1.1
A. glaucoptera	Mar	6	Bap-Pac; glasshouse, outside Oct	17	7.2.1.2
A. imbricata	Jan	13	Prune Bap-Pac; glasshouse, outside Feb	31	7.2.2.1
A. imbricata	Aug	8	Bap-Pac-1, Bap-Pac-2, Prune-Bap-Pac; glasshouse, outside Mar	24	7.2.2.3
A. acinacea	Jun	3	Prune-Pac, Pac; glasshouse, outside Sept	15	7.2.3.1

7.5.2 Foliage pot plant *Acacia* species and treatments

A number of *Acacia* species produced a plant of size and foliage suitable for a potted plant but did not flower within two years. The foliage of *A. craspedocarpa, A. baileyana , A podalyrifolia and A. vestita* is unusual and different from that of foliage plants currently available, and *A. crassuloides* and *A. cometes* have delicate and dense foliage which covers the pot plant. *A podalyrifolia* produced dense soft, blue round

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phyllodinous foliage when treated with Pac or the combination prune-Pac six to twelve months from treatment, with the total production time from seed being a minimum of nine months.

A. *baileyana* treated with combination and repeated treatments of prune-Pac, produced a very attractive blue-green, bipinnate foliage pot plant twelve months after treatment, with a total time of production of fifteen months. A. *vestita* has attractive wedge-shaped green phyllodes and rapidly formed a pot plant sized product after treatment with Pac, retaining suitable size for at least six months. A. *craspedocarpa* has grey round foliage and a brown corky stem, and was suitable for both pot plant production when grown in the glasshouse and small pots when treated with Pac. The period of suitability extends from nineteen months to thirty one months with Pac treatment.

A. *crassuloides* produced a bright green foliage pot plant at six months with untreated plants and twelve months from Pac treated plants. A. *cometes* plants at nineteen months produced a dense, bright green mass in the untreated plant, while Pac treated plants continued to be of suitable size for pot plants to twenty-five months. Treatment of younger plants extended the period of suitability as pot plants until twenty nine months of age. The A. *cometes* plant treated with Pac would make a miniature pot plant in less than 15 cm pots at an earlier age.

Table 7.53 Summary of foliage pot plant *Acacia* species and treatments

Species	Month of sowing	Age at treatment (months)	Treatment; conditions	Time to production (months)	Thesis section
A. podalyrifolia	Jul	3	Pac, Prune-Pac; glasshouse, outside Oct	6-12	7.2.4.1
A. baileyana	Jun	3	Prune-Pac; glasshouse, outside Sept	12	7.4.3.1
A. crassuloides	Jun	6	Control, Pac, Prune-Pac; glasshouse, outside Dec	12-18	7.2.5.1
A. cometes	Jan	13	Control, Pac; glasshouse, outside Feb	19	7.2.6.1
A. cometes	Jun	5	Control, Pac, Prune-Pac; glasshouse, outside Dec	11-17	7.2.6.2
A. vestita	Mar	4	Pac; glasshouse, outside Jul	10	7.2.7.1
A. craspedocarpa	Jan	13	Control, Bap, Pac; glasshouse, outside Feb	25	7.3.1.2

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7.5.3 Large flowering pot plant *Acacia* species and treatments

Although the most popular pot plant size is small, some exceptionally attractive *Acacia* plants of larger size were produced within a short period of time. Larger tub plants often command a premium price for patios, hotels and shopping centres. *A. decora*, *A. buxifolia* and *A. drummondii elegans* produced flowering plants which suit tub culture. *A. decora* plants at flowering were suitable as large potted plants, and flowered well when treated with Bap. *A. buxifolia* produced a gracious cascading pot plant in a shorter time than *A. decora*. The bipinnate *A. drummondii elegans* produced an attractive dark green foliage plant with many inflorescences at flowering. Bap treated plants produced more inflorescences than those untreated, and were larger with more branches.

Table 7.54 Summary of large flowering pot plant *Acacia* species and treatments

Species	Month of sowing	Age at treatment (months)	Treatment and conditions	Time to production (months)	Thesis section
A. decora	Mar	4	Control, Bap; glasshouse, outside Jul	28	7.2.8.1
A. buxifolia	Mar	4	Control; glasshouse, outside Jul	21	7.2.9.1
A. drummondii elegans	Mar	4	Bap; glasshouse, outside Jul	17	7.4.1.1

Chapter 8 Manipulation of flowering by sequential planting

8.1 Introduction

These experiments were set up to determine if time to flowering of a potted *Acacia* plant could be minimised by selection of sowing time. The age or maturity of *Acacia* plants determines if they will flower, and this study has shown that the period of juvenility is less than two years for glasshouse grown plants of some species, such as *A. glaucoptera*. Given that under natural conditions flowering generally occurs at a particular time of year, in late winter or early spring, this study aims to determine the minimum holding time prior to flowering, to reduce the time to production of a flowering potted *Acacia*.

Statistical analysis of number of plants with inflorescence buds or flowers used a binomial model, and flowering data were subjected to Analysis of Variance using Genstat. Differences between means were judged to be significantly different using Tukey's Wholly Significant Difference at the 5% level.

8.2 *A. drummondii elegans*

Seed was germinated in October 1992, December 1992, February 1993 and May 1993, and plants were grown in the glasshouse until October 1993 when they were placed outside. Each treatment contained ten plants. They were observed for floral initiation, and inflorescence data were recorded.

Limited floral initiation was recorded in November 1993 on one plant each of the October 1992, December 1992 and February 1993 treatments. More floral initiation was recorded in June 1994, and flowering commenced in August 1994.

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Table 8.1 Floral data for *A. drummondii elegans* with sequential planting

Different letters within columns indicate significant differences between means.

| Time of sowing | No. plants flowering (of 10) | Age at flowering (months) | No. of inflorescences | | | |
			Aug	Sept	Oct	Total
Oct 92	6	22	4.6 a	46.3	4.4	55.3
Dec 92	9	20	8.8 ab	53.3	2.7	64.8
Feb 93	10	18	19.2 b	79.8	5.0	104.0
May 93	8	15	0.6 a	43.6	12.5	56.7
Probability	NS		<0.01	NS	NS	NS

There was no significant difference between planting dates in total number of inflorescences, although the February 1993 plants produced significantly more inflorescences in August.

A. drummondii elegans flowered after nine months from seed, but with stronger flowering after fifteen months.

8.3 *A. glaucoptera*

Seed was germinated in October 1992, December 1992, February 1993 and May 1993, and plants were grown in the glasshouse until October 1993 when they were placed outside. Each treatment contained ten plants. They were observed for floral initiation, and inflorescence data were recorded.

Floral initiation occurred between June and September, 1994 and flowering commenced in September 1994.

Table 8.2 Floral data for *A. glaucoptera* with sequential planting

Different letters within columns indicate significant differences between means.

Time of sowing	No. plants flowering (of 10)	Age at flowering (months)	No. inflorescences		
			Sept	Oct	Total
Oct 92	9	23	30.4 bc	7.0	37.4 ab
Dec 92	9	21	61.3 c	17.6	78.9 b
Feb 93	6	19	2.4 a	6.9	9.3 a
May 93	6	16	3.9 ab	9.1	13.0 ab
Probability	NS		<0.01	NS	<0.05

Plants aged twenty one months from seed sown in December 1992 had significantly more inflorescences than plants aged nineteen months, and significantly more inflorescences in September than plants aged sixteen and nineteen months.

A. glaucoptera flowered after sixteen months from seed.

8.4 *A. cometes*

Seed was germinated in August 1992, September 1992, October 1992 and February 1993, and plants were grown in the glasshouse until October 1993 when they were placed outside. August, September and February treatments contained ten plants while the October treatment contained four plants. They were observed for floral initiation, and inflorescence data were recorded.

Flowering was brief and commenced in September 1994.

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Table 8.3 Floral data for *A. cometes* with sequential planting

Time of sowing	No. plants flowering (of 10)	Age at flowering (months)	No. infl. Sept
Aug 92	3	25	20.3
Sept 92	1	24	0.2
Oct 92	1	23	13.8
Feb 93	0	19	0.0
Probability	NS		NS

Inflorescence numbers were low and plants aged nineteen months did not initiate or flower.

A. cometes flowered after twenty three months from seed.

8.5 *A. meisneri*

Seed was germinated in October 1992, February 1993 and May 1993, and plants were grown in the glasshouse until October 1993 when they were placed outside. Each treatment contained ten plants. They were observed for floral initiation, and inflorescence data were recorded.

Floral initiation was recorded in October 1994 but flowering was insignificant.

Table 8.4 Floral data for *A. meisneri* with sequential planting

Time of sowing	No. plants with initiated buds (of 10)	Age at flowering (months)
Oct 92	1	24
Feb 93	5	20
May 93	2	17
Probability	NS	

8.6 Other species

A. *decora*, A. *vestita* and A. *semilunata* were tested in sequential plantings but did not initiate or flower during the period of experimentation.

8.7 Discussion

The species which initiated and flowered within the experimental period were A. *drummondii elegans* after nine months, A. *glaucoptera* after sixteen months, A. *cometes* after twenty three months, and A. *meisneri* after seventeen months. The other species tested required longer than the twenty six month experimental period for initiation and flowering.

The most important factor was probably the age of plants before being receptive to floral stimuli. Some species tested did not appear to be mature enough to initiate flower buds or produce inflorescences. Thus different species of *Acacia* appear to differ in their period of juvenility, and this is an important factor in their suitability as flowering pot plants grown from seed. The species with the shortest juvenility period of those tested was A. *drummondii elegans*.

It was concluded that holding time to flowering could be minimised by selection of sowing time for the species A. *drummondii elegans* and A. *glaucoptera*. The other species did not produce sufficient numbers of inflorescences for conclusions to be drawn.

Chapter 9 Production protocols for *Acacia* pot plant species.

9.1 Introduction

The development of a protocol to describe culture of an *Acacia* species through a sequence of steps resulting in a flowering pot product, would facilitate development as an ornamental by the nursery industry. Such predetermined procedures are available for azalea, chrysanthemum, poinsettia and a range of other potted products (McDaniel, 1982). Documented procedures for Australian native potted plant production would improve the quality of product through increased uniformity of production, with scheduling of the time of availability.

Experiments with selected species, which flowered in less than two years or produced an acceptable potted plant during preliminary treatment, were repeated to a time scale in order to develop a protocol for growth of these plants. Species selected for pruning and paclobutrazol treatment were *A. buxifolia, A. decora, A. drummondii elegans, A. myrtifolia, A. retinodes* and *A. vestita*. A wider range of treatments was applied to *A. acinacea, A. imbricata* and *A. drummondii elegans*.

Statistical analysis of number of plants with flowers involved fitting a binomial model. Flowering data were subjected to Analysis of Variance using Genstat. Differences between means were judged to be significantly different using Tukey's Wholly Significant Difference at the 5% level.

9.2 Production schedules with pruning and Pac treatments

Plants were kept in the glasshouse and treatment was commenced in June 1993 with repeat treatment in August 1993. Experimental treatments were prune to 10 cm with a repeat prune to 15 cm after 8 weeks, and prune-Pac, with prune to 10 cm then application of 2 mgai Pac as a soil drench after 8 weeks. Ten plants were not treated and there were ten plants in each treatment. Vegetative data of height

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and width in cm, and number of branches longer than 1 cm were recorded six months after initial treatment in December 1993, after which plants were placed outside. Flowering data for number of plants flowering, inflorescence numbers and time of flowering were recorded

9.2.1 *A. buxifolia* production schedule with prune and prune-Pac treatments

A. buxifolia seed was sown in October 1992 and plants were potted on in February 1993 and retained in the glasshouse. At the commencement of the experiment the average height of the plants was 15 cm.

Table 9.1 Vegetative data for *A. buxifolia* six months after initial prune and prune-Pac treatments

Different letters within columns indicate significant differences between means.

Treatment	Height (cm)	Width (cm)	No. branches
Control	118.0 b	37.9	46.2
Prune	76.1 a	44.7	60.0
Prune pac	65.3 a	47.4	58.2
Probability	<0.001	NS	NS

The height of plants was significantly reduced by both prune and prune-Pac treatments.

Table 9.2 Floral data for *A. buxifolia* fourteen months after initial prune and prune-Pac treatments

Treatment	Mean no. inflorescences				Mean period of flowering
	July	Aug.	Sept.	Total	
Control	15.9	208.3	249.2	473.4	32.1
Prune	12.0	121.2	324.9	458.1	36.0
Prune pac	2.3	232.9	113.6	348.4	28.7
Probability	NS	NS	NS	NS	NS

Flowering data were recorded from July to September 1994 and all plants flowered for an extended period. There were no differences between treatments.

The protocol for *A. buxifolia* was:

SOWN(10/92)---REPOT(2/93)---TREAT(6-8/93)---OUTSIDE(12/93)---FLOWER(7-9/94)

9.2.2 *A. drummondii elegans* production schedule with prune and prune-Pac treatments

A. drummondii elegans seed was sown between October and December 1992, with potting on in February 1993. At the commencement of the experiment the average height of the plants was 17.6 cm.

Table 9.3 Vegetative data for *A. drummondii elegans* six months after initial prune and prune-Pac treatments

Different letters within columns indicate significant differences between means.

Treatment	Height (cm)	Width (cm)	No. branches
Control	113.3 b	32.7	14.4 bc
Prune	43.5 a	31.8	15.7 bc
Prune pac	35.6 a	31.6	7.4 a
Probability	<0.001	NS	<0.001

Both prune and prune-Pac treatment significantly reduced the height of the plants, but the prune-Pac treatment reduced the number of branches.

Table 9.4 Floral data for *A. drummondii elegans* fourteen months after initial prune and prune-Pac treatments

Different letters within columns indicate significant differences between means.

Treatment	Total mean no. inflorescences
Control	5.6
Prune	7.4
Prune pac	4.1
Probability	NS

Limited flowering occurred in August and September 1994.

The protocol for *A. drummondii elegans* was:

SOWN(10-12/92)—REPOT(2/93)—TREAT(6-8/93)—OUTSIDE(12/93)—FLOWER(8-9/94)

9.2.3 *A. myrtifolia* production schedule with prune treatment

A. myrtifolia seed was sown in December 1992 and potted on in April 1993. Mean plant height was 17.9 cm at commencement of treatment.

Table 9.5 Vegetative data for *A. myrtifolia* six months after initial prune treatment

Treatment	Height (cm)	Width (cm)	No. branches
Control	135.0	53.7	13.0
Prune	91.2	69.9	22.7
Probability	<0.001	NS	NS

Treatment significantly reduced the height of the plants.

Table 9.6 Floral data for *A. myrtifolia* fourteen months after initial prune treatment

Treatment	Mean no. flowers				Mean period
	July	Aug	Sept	Total	of flowering
Control	314.5	369.8	108.5	792.8	59.9
Prune	90.6	462.1	120.9	673.6	55.6
Probability	<0.05	NS	NS	NS	NS

Flowering occurred between July and September 1994. Treatment reduced the number of flowers in July but did not affect the number in other months, the total number or the period of flowering.

The protocol for *A. myrtifolia* was:

SOWN(12/92)—REPOT(4/93)—TREAT(6-8/93)—OUTSIDE(12/93)—FLOWER(7-9/94)

9.2.4 Production schedules for other species

Most *A. decora* plants did not flower, with only one prune and one prune-Pac treated plant flowering. *A. retinodes* and *A. vestita* plants failed to flower within 24 months.

9.3 Production schedules with a range of treatments

A range of treatments was applied to *A. acinacea*, *A. drummondii elegans* and *A. imbricata*. Seed was sown in May 1993 and plants were potted into 15 cm pots in September 1993, with initial treatment in October 1993. Repeat treatments were applied in December 1993. Plants remained in the glasshouse for six months after initial treatment and then were placed outside. Treatments were:
- pruned to 10 cm, with a repeat prune to 15 cm
- 2 mgai paclobutrazol as a soil drench
- 100 mgL^{-1} Bap as a spray to the leaves
- pruned to 10 cm in October, then 2 mgai Pac as a soil drench in December

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- combination of Bap and Pac treatments in October
- A group of plants remained untreated.
There were ten plants per treatment. Time and period of flowering, number of inflorescences and number of flowering plants were recorded.

9.3.1 *A. acinacea* with a range of treatments

Table 9.7 Floral data for *A. acinacea* with a range of treatments

Different letters within columns indicate significant differences between means.

| Treatment | No. plants flowering | Mean no. inflorescences | | | | Mean period of flowering |
		Aug	Sept	Oct	Total	
Control	10	15.1 ab	335.0 c	2.8	352.9 b	34.2 b
Prune	5	0.1 a	15.3 a	0.0	15.4 a	6.8 a
Pac	7	12.1 ab	45.5 ab	0.0	56.6 ab	20.2 ab
Bap	9	68.5 b	239.5 bc	0.6	308.6 ab	33.3 b
Prune pac	6	7.7 ab	138.0 abc	0.0	145.7 ab	15.3 ab
Bap pac	10	29.7 b	62.6 abc	0.6	92.3 ab	23.1 ab
Probability	<0.01	<0.05	0.001	NS	<0.001	<0.001

A. acinacea flowered in August, September and October 1994. Prune treatment significantly reduced the number of plants flowering, the number of inflorescences produced and the period of flowering.

The protocol for *A. acinacea* was:

SOWN(5/93)—REPOT(9/93)—TREAT(10-12/93)—OUTSIDE(3/94)—FLOWER(8-10/94)

9.3.2 *A. drummondii elegans* with a range of treatments

Table 9.8 Floral data for *A. drummondii elegans* with a range of treatments

Different letters within columns indicate significant differences between means.

Treatment	No. plants flowering	Aug	Sept	Oct	Total	Mean period of flowering
Control	10	4.2	105.9 b	16.3	124.8 b	39.7 ab
Prune	8	0.0	22.5 a	10.1	32.6 a	21.2 a
Pac	10	18.5	81.5 b	8.6	108.6 ab	48.4 b
Bap	10	16.5	96.0 b	14.9	125.9 b	40.7 b
Prune pac	10	19.0	84.0 b	8.6	111.6 ab	37.6 ab
Bap pac	10	1.1	55.0 ab	10.6	66.7 ab	38.0 ab
Probability	<0.001	NS	<0.01	NS	<0.01	<0.01

(Columns Aug, Sept, Oct, Total fall under the heading "Mean no. inflorescences".)

Flowering occurred between August and October 1994.
Prune treatment delayed flowering and significantly reduced the inflorescence number.

The protocol for *A. drummondii elegans* was:

SOWN(5/93)---REPOT(9/93)---TREAT(10-12/93)---OUTSIDE(3/94)---FLOWER(8-10/94)

9.3.3 *A. imbricata* with a range of treatments

Table 9.9 Floral data for *A. imbricata* with a range of treatments

Treatment	No. plants flowering	Mean no. of inflorescences			Mean period of flowering (days)
		Aug	Sept	Total	
Control	3	3.9	3.3	7.2	3.3
Prune	0	0.0	0.0	0.0	0.0
Pac	3	123.1	55.0	178.1	7.3
Bap	4	150.4	44.1	194.5	9.5
Prune pac	0	0.0	0.0	0.0	0.0
Bap pac	0	0.0	0.0	0.0	0.0
Probability	<0.01	<0.05	<0.05	<0.05	<0.05

Flowering occurred in August and September 1994. Plants treated with prune, prune-Pac and Bap-Pac did not flower.

The protocol for *A. imbricata* was:

SOWN(5/93)---REPOT(9/93)---TREAT(10-12/93)---OUTSIDE(3/94)---FLOWER(8-9/94)

9.4 Discussion

The development of protocols for production of flowering *Acacia* pot plants achieved mixed success (Table 9.10). Some treatments which had not proved deleterious to flowering in previous experiments assumed greater influence in these protocols, with pruning greatly reducing flowering of *A. acinacea* and *A. imbricata*. In contrast pruning did not depress the flowering of *A. buxifolia* and *A. myrtifolia*, and both pruning and paclobutrazol reduced plant height to less than 1 m in these species. The reduction of flowering in some species may be related to the time of year in which pruning is applied, so the use of pruning in a specific month requires further investigation. Avoidance of use of dwarfing chemicals would be an advantage in gaining acceptance of these protocols.

Table 9.10 Summary of production protocols for selected *Acacia* pot plants

Species	Sown	Repotted	Treated	Placed outside	Flowering occurred	Age at flowering (months)
A. buxifolia	10/92	2/93	6-8/93	12/93	7-9/94	22
A. drummondii elegans	10/92	2/93	6-8/93	12/93	8-9/94	22
A. myrtifolia	12/92	4/93	6-8/93	12/93	7-9/94	19
A. acinacea	5/93	9/93	10-12/93	3/94	8-10/94	15
A. drummondii elegans	5/93	9/93	10-12/93	3/94	8-10/94	16
A. imbricata	5/93	9/93	10-12/93	3/94	8-9/94	15

The period of time from seed to flowering plant was twenty two months for *A. buxifolia*, with strong flowering of all plants. This compares to time from seed to flowering of seventeen months when sown in March (Chapter 7). Thus more work on the optimum time of seeding for strongest flowering needs to be conducted on this species.

A. drummondii elegans sown in October required twenty two months before flowering and sixteen months when the seed was sown in May. This compared well with the result that seeds sown in May flowered within seventeen months (Chapter 7).

A. myrtifolia plants flowered within twenty one months and all plants flowered well.

A. acinacea plants flowered within sixteen months when sown in May, which compares with eighteen months from a June seeding in a previous experiment (Chapter 7). Prune treatment reduced flowering.

A. imbricata plants produced very poor results under this protocol. In previous experiments plants sown in March have flowered within seventeen months, while those sown in August flowered in twenty four months (Chapter 7). It would appear

that investigation of the sowing time for this species needs to be linked to plant age, treatment and time of flowering to determine a better protocol.

In all species, flowering occurred in the same months as in previous experiments on the same species.

9.5 Conclusion

Protocols which include time of sowing, time of treatment and time of removal from the glasshouse will result in a flowering plant at the time at which that species normally flowers for a site. This is the July to October period in Australia, but is the popular Christmas and New Year time in Europe. Thus the protocol could supply this lucrative market.

A successful protocol for a flowering pot plant of *A. acinacea* using pruning and paclobutrazol was developed. *A. buxifolia* and *A. myrtifolia* produced satisfactory results for a larger flowering plant with a prune treatment only, thus avoiding the need for chemical use. *A. drummondii elegans* may be successfully treated with either paclobutrazol or a combination of pruning and paclobutrazol according to the protocol developed for May sowing, to produce a larger flowering plant. Previous results on time to flowering from seed of *A. drummondii elegans* and *A. acinacea* were confirmed by these experiments. The aim of future work should be to determine the minimum time to flowering for a treatment.

These protocols were developed using the facilities available to most nurseries of controlled temperature glasshouses and outside holding areas under ambient conditions. Under glasshouse conditions plants attain the desired shape and size, then ambient winter conditions are used to promote flowering. The results presented in Chapter 6 show that it would be possible to alter the time of flowering by imposing low

temperatures during the warmer months. This would allow change to the timing of the production protocol, and further research is needed to incorporate such treatments.

Chapter 10 General Discussion

In recent years native plants of Australia (Bennett, 1992), and New Zealand (Harris and Heenan, 1992), have been considered with a view to filling demand in Europe and Japan for unusual and innovative horticultural products. Investigation of growth, flowering and product quality for native plants, with the intention of domestication of such species, has resulted in research into the genus *Acacia*, as well as into other native species such as *Blandifordia grandiflora* (Goodwin *et al*, 1995), and the banksias *B. baxteri* and *B. hookeriana* (Rohl et al, 1994). Future development of such products must include selection (McDaniel, 1982) and genetic manipulation, which is currently being applied to more traditional floricultural crops (Hutchinson *et al*, 1992).

The removal of the dominant apical meristem by pruning allows development of lateral buds, promoting branching in conjunction with height reduction in many horticultural species. Application of pruning alone to acacias did not overcome strong apical dominance, with lateral branch replacement of the main stem, usually within six months. Where pruning was combined with paclobutrazol treatment, the growth retardant controlled lateral development so that pruning suppressed apical dominance effectively. Pruning was found to be deleterious to flowering in 5 year old *A. pycnantha,* and 3 year old *A. notabilis* plants, with heavy pruning in February resulting in little floral development in July to October. Bud loss was noted in these species after pruning, and may be related to the lack of flowering. In previous research *A. pycnantha* plants suffered bud abortion during June to October, with floral development only from buds produced from November to May (Buttrose *et al*, 1981). Pruning in the months during which buds abort naturally may not affect subsequent flowering. Pruning was found to be effective for size control in conjunction with other treatments, without affecting flowering, in *A. imbricata* (pruned February, flowered August; pruned April, flowered June) and *A. acinacea* (pruned September, flowered August next year). Thus timing of pruning must avoid periods of floral bud development.

In previous research *A. pycnantha* was found to require temperatures of mean maximum 19°C and minimum 8°C for floral development with meiosis in the anthers inhibited by higher temperatures (Sedgley, 1985). Experiments with *A. drummondii elegans* found a similar response, with low temperature (15/10) producing inflorescences while high temperature (25/20) produced buds which ceased developing before anthers produced polyads. Low temperature (15/10) produced flowering of *A. drummondii elegans, A. glaucoptera, A. buxifolia, A. acinacea* and *A. myrtifolia* plants with initiated buds, producing a flowering response within 3 to 4 months. Few flowers were produced in the higher temperature (25/20), from *A. glaucoptera* and *A. myrtifolia,* with a shorter period to flowering than in the low temperature treatment.

Some species, such as *A. retinodes* and *A. meisneri,* flower during summer indicating the need to investigate whether other species have different levels of sensitivity to temperature for flowering. Research would establish a protocol for a range of potted acacias with different critical temperature requirements.

The continued development of inflorescences at high temperatures and humidity after successful meiosis has been exploited by the European cut flower industry to produce a strong floral display (Accati and Sulis, 1980). A similar effect may be possible with potted plants with floral buds developed, as temperature transfer experiments indicated an initial rapid flowering response to placement at high temperature (25/20). This requires further investigation to improve the period of flowering.

Acacias are woody species which experience a juvenile period during which flowering will not occur. Plant size has been linked to juvenility (Hackett, 1985), and rapid continuous growth, as in the glasshouse, reduces the length of the juvenile period in acacias. The sowing of seed at various intervals identified the period of juvenility before plants would flower. The period was seventeen months for *A. drummondii elegans,* twenty one months for *A. myrtifolia,* and sixteen months for

A. acinacea and *A. glaucoptera*. Some species did not flower at all within the experiments, as their period of juvenility exceeded two years.

Acacia appears not to be photoperiodic in its flowering response. Flowering commenced in *A. drummondii elegans* in environmental growth cabinets after ten months of equal day and night periods. Subsequent experiments on plants (with buds present) of the same species, produced more rapid flowering under the same conditions.

The use of high night temperature in an attemp to reduce plant height of acacias was not effective. This treatment is effective in some herbaceous species (Moe *et al* 1991b, 1992) It is possible that woody plants are less responsive to differential temperatures than herbaceous species.

Investigation of 15 acacia species using Pac, alone or in combination with other treatments, reduced vegetative growth in 12 species. Pac reduced the length of shoots interactively with temperature and time, and internode length with time in mature plants of *A. notabilis*. Pac reduced vegetative growth, as measured by height and width, for extended periods of twelve to eighteen months, when applied to three to thirteen month old plants of *A. glaucoptera, A. imbricata, A. acinacea, A. podalyrifolia, A. cometes, A. vestita, A. notabilis, A. craspedocarpa, A. polybotrya, A. baileyana and A. baileyana purpurea* . Some species, *A. crassuloides, A. decora* and *A. semilunata,* did not respond to Pac at the rates tested. Pac at a high rate (20 mgai) resulted in necrosis and loss of the lower phyllodes of *A. verniciflua.*

In initial experiments with mature plants, Pac interacted with 20/8 temperature to increase total inflorescence number in *A. notabilis*. With younger plants, flowering was not significantly affected in many species, but was reduced in *A. acinacea, A. drummondii elegans*, and in *A. vestita*. When flowering was not affected by Pac, but plant size was reduced, the floral cover (ratio of inflorescences to branches) was enough to produce an attractive flowering plant.

The use of Paclobutrazol (Pac) as a chemical growth retardant for Australian pot plant species has produced promising results for *Pimelea ferruginea* (King *et al*, 1992), *P. ciliata* (Slater, 1994) and *Swainsona formosa* (Sturt's Desert Pea) (Hamid and Williams, 1994). Pac was found to reduce endogenous gibberellic acid in grafted *Eucalyptus nitens,* stimulating flowering (Moncur and Hasan, 1994), increasing the quantity of flowers and reducing the period to flowering in *Eucalyptus nitens* (Moncur *et al*, 1994).

Endogenous levels of cytokinin control cell division and lateral bud development. External applications of cytokinin should increase cellular cytokinin concentrations, promoting bud and shoot development, and increasing inflorescence numbers. The effect of cytokinin, 6, benzyladenine, application to apples increased the number of laterals (Wertheim and Estabrooks, 1994), and increased the number of florets per capitulum of *Leucospermum,* (Napier *et al*, 1986). Bap increased the rate of floral development of *Boronia megastigma*, reducing the period of time to anthesis (Day, 1992).

The cytokinin Bap was applied to 9 acacia species, but was not consistently effective in increasing branching or flowering. Bap produced an effect long after application, in *A. glaucoptera,* with increase in branch numbers eighteen months after treatment. Plants treated with Bap-Pac at six months of age and retained in the glasshouse for twelve months after treatment produced very large numbers of inflorescences. In *A. imbricata* treated at eight months of age, Bap-Pac reduced the number of shoots at twelve months, but the effect was overcome by eighteen months. Bap application in the very slow growing *A. craspedocarpa* also resulted in a reduction in vegetative shoot number which was overcome by eighteen months.

Floral ratio was used as a measure of floral display. The floral ratio of *A. imbricata* treated with Bap-Pac was slightly less than for the control, but considering the 3-4 fold reduction in height of treated plants, this meant that the floral appearance of the potted plant was good. Bap also produced a high floral ratio in *A. decora, A. drummondii elegans*, *A. imbricata, A.*

notabilis, and *A. vestita* treated at four months of age, while Bap-Pac treatment resulted in a high floral ratio for *A. decora,* *A. drummondii elegans,* *A. glaucoptera,* *A. imbricata,* and *A. notabilis* compared to control plants. There was no effect on some species. *A. semilunata* did not flower within the period of the project, and *A. baileyana purpurea,* produced few flowering plants.

A great deal of between plant variability resulted from the use of seedling material. The advantage of seed was the relative ease of propagation (Jusaitis and Sorensen, 1994). Vegetative propagation of *A. baileyana* identified superior clones for rooting, but a possible physiological barrier to rooting of cuttings of *A. vestita* (Glocke and Sedgley, 1995). Tissue culture has been successfully applied to endangered *Acacia* species (Taji and Williams, 1991). Reduction of variabilty and the period of juvenility by selection of early flowering clones, use of mature plants for mother stock of cuttings of selected species, and different flowering times requires investigation for extension of the flowering period of a particular species. These methods have already been applied to selection of dwarf, polyploid *Anigozanthos* hybrids for use as potted plants, with a shorter period to flowering and no need for the use of growth retardants (Worrall, 1995).

Grafting of acacias, while not common in Australia, is practised in Europe. Investigation of grafting of selected high floral ratio clones may provide a more consistent pot plant product.

The flowering pot plant species of most interest were *A. glaucoptera* and *A. imbricata,* with *A. acinacea* also showing promise. Successful growth regulation was achieved, and a successful protocol developed for a small flowering pot plant of *A. acinacea* using prune-Pac treatment. For a larger flowering plant, *A. drummondii elegans* was successful when treated with either Bap or Bap-Pac. Low rates of Pac achieved long term reduction in size, and *A. imbricata* was the most successful species tested in this regard.

Protocols have been developed which include time of sowing, time of treatment, and time of transfer from the glasshouse to result in a flowering plant at the time at which that species normally flowers for a site. These protocols were developed using facilities available to southern Australian nurseries in controlled temperature glasshouses and existing ambient conditions. Under glasshouse conditions plants attain the desired shape and size, then ambient winter conditions are used to promote flowering. The results presented in Chapter 6 show that it would be possible to alter the time of flowering by imposing low temperatures during the warmer months.

Investigation of the optimum time of seeding for the minimum time to flowering, also incorporating temperature control of flowering, would allow more rapid development of a floral product. Protocols could be developed for potted flowering plants for a particular occasion, such as Christmas, which is traditionally a period of demand for "Mimosa" in Europe. Consumer demand for other shades of yellow and gold needs further investigation, with an extended range of species examined for response to treatment, and aimed at various international markets. Tolerance of selected species to low night temperature has implication for European production.

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Appendix 1. Species collected but not included in experiments

The following species were investigated, but there was insufficient material to include them in the experiments.

A. baueri from Queensland and NSW grows 0.5-1 m tall and 1-1.5 m wide, with terete phyllodes in whorls. The globular bright yellow inflorescences appear from September to November (Elliot and Jones, 1982).

A. guinettii from WA grows 1-2.5 m tall and 2-3 m wide, with bipinnate leaves (Elliot and Jones, 1982).

A. iteaphylla grows in SA to a height of 3-5 m and width of 3-6 m, with long, narrow blue-green phyllodes, and soft pink vegetative flush growth. The profuse, small pale yellow globular inflorescences are produced in slender racemes, which as buds are encased in pink brown bracts. Flowering occurs from March to September (Elliot and Jones, 1982).

A. rotundifolia is a SA wattle growing 1-2.5 m tall and 2-3 m wide with oval-orbicular phyllodes ending in a fine point. The profuse bright yellow inflorescences appear from July to December (Elliot and Jones, 1982).

A. purpureapetala grows in Queensland to 0.1-0.5 m tall by 0.3-0.5 m wide, with pale green, lanceolate, slightly curved phyllodes. The small globular, mauve or purple flower heads, one per axil, flower from May to October (Elliot and Jones, 1982). It has a vulnerable plant classification 2V (Briggs and Leigh, 1988).

A. rhetinocarpa grows in SA to 0.5-1.5 m tall and 1-2 m wide, with triangular phyllodes with a curved upper edge and fine point. The globular, small, profuse, pale yellow inflorescences one per axil, flower from August to October (Elliot and Jones, 1982).

Treatment for seeds of less common or rare species

Care was taken in the preparation and germination of seeds which were only available in small quantities.

A. rhetinocarpa was obtained from the Adelaide Botanic Gardens, *A. guinettii* from the Adelaide SGAP group, ten year old seed of *A. purpureapetala*, a pink flowered acacia, and *A. baueri ssp baueri*, were obtained from the Mt. Annan Botanical Garden in Sydney.

Successful germination was achieved after applying surface sterilization to seed.

Surface sterilization consisted of;

-immersing in 70% alcohol for 2 minutes

-immersing in bleach (1% w/v chlorine) for 5 minutes

-3 washes in nanopure water.

The hard seed coat was then carefully scored with a scalpel. Seed were placed in sterile petri dishes and germinated at 23°C under dark, sterile conditions.

Appendix 2. Papers and published material

Sedgley, M. & Parletta, M. (1993). Australian acacias have huge potential as cut flowers. *Australian Horticulture, 9*(2), 24-26.

NOTE:

This publication is included in the print copy
of the thesis held in the University of Adelaide Library.

Parletta, M. & Sedgley, M. (1994). Acacias as potted plants. In *The Third National Workshop for Australian Native Flowers. (Poster Abstract).* Conference conducted in Gatton, Queensland.

Parletta, M. & Sedgley, M. (1995). Acacias as potted plants. *Acta Horticulturae, 397*, 139-145.

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