Rice flower information kit

Reprint – information current in 2001

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This publication has been reprinted as a digital book without any changes to the content published in 2001. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research:

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- Contacts—many of the contact details may have changed and there could be several new contacts available. The industry organisation may be able to assist you to find the information or services you require.
- Organisation names—most government agencies referred to in this publication have had name changes. Contact the Business Information Centre on 13 25 23 or the industry organisation to find out the current name and contact details for these agencies.
- Additional information—many other sources of information are now available for each crop. Contact an agronomist, Business Information Centre on 13 25 23 or the industry organisation for other suggested reading.

Even with these limitations we believe this information kit provides important and valuable information for intending and existing growers.

This publication was last revised in 2001. The information is not current and the accuracy of the information cannot be guaranteed by the State of Queensland.

Queensland Government

Information Series QI00082

Rice flower
production guidelines for growers

Peter Beal[1]

Cynthia Carson

Lois Turnbull[2]

Leif Forsberg

Queensland Horticulture Institute

[1] Retired, now Research Fellow, QHI
[2] Formerly DPI, now florist and flower grower

Department of Primary Industries,

Queensland

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The Department of Primary Industries, Queensland has taken all reasonable steps to ensure that the information contained in this publication is accurate at the time of publication. Readers should make appropriate inquiries to determine whether new information is available on particular subject matter.

Inquiries should be addressed to:
Manager, Publishing Services
Department of Primary Industries, Queensland
GPO Box 46
Brisbane Q 4001

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Sandra Lacey (formerly of DPI) conducted early research into developing rice flower as a commercial cut flower crop. The Australian Flora Foundation supported this work between 1987 and 1990.

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1 Introduction

Rice flower, *Ozothamnus diosmifolius*, is a recently emerged fresh cut flower crop in Australia. It was cut exclusively from natural stands up to the 1980s but is now cultivated in all Australian states and the Northern Territory. In fresh and dried form it is in great demand on Australian and overseas markets and has considerable potential for further product development.

Flowering stems have an attractive display of white or pink flower buds contrasting with mid-green leaves. The fresh stems are used mainly as filler or feature-filler in floral arrangements.

Rice flower, an upright perennial woody shrub that flowers in spring, occurs naturally in coastal and subcoastal regions of the eastern mainland states of Australia from latitude 25° to 37°S (Figure 1). It has colour forms ranging from white or cream to shades of pink.

Two previous publications in the planned three-volume series on rice flower have described market opportunities (Lewis *et al.* 1997) and the integration of production and marketing (Carson and Lewis 1997). Production guidelines for rice flower growers are now described in this final book. DPI researchers have largely developed these guidelines from project work conducted between 1987 and 1997.

The history of the rice flower industry

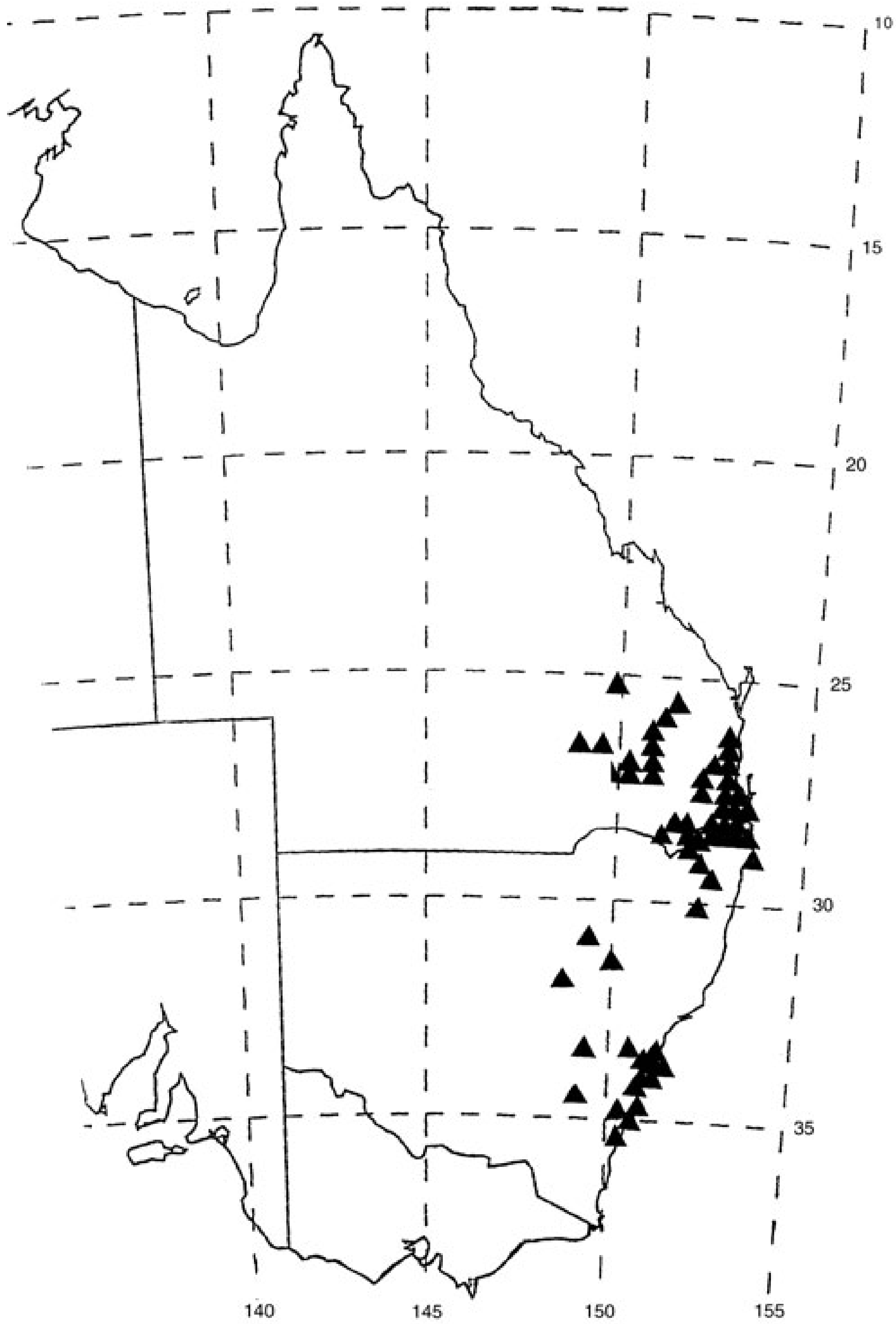
Rice flower was a bush-harvested commodity, primarily for the domestic market, up until the late 1980s. The recent development of rice flower as a cultivated fresh cut flower export crop has been based on private and publicly funded research and development. Innovative growers such as Graham and Esther Cook of Helidon have invested heavily in the research and development of cultivated rice flower. Sandra Lacey, formerly from DPI, conducted the first government-supported work, assisted by growers and the Australian Flora Foundation. The DPI has continued this work in conjunction with RIRDC and also in a three-way project involving RIRDC and Agriculture Victoria.

In 1991, 60 000 stems of the new plantation-grown rice flower were exported from Australia, predominantly to Japan. Production was essentially from Queensland and involved a few growers and a limited 4–6 week production season.

By 1994 exports had increased to 300 000 stems (exporters' estimates) supplied by 38 growers (Karingal Consultants 1997) during a 6–8 week season between September and October. Industry development was supported by cultural and germplasm research. The industry had three commercial fine-leafed cultivars, with Plant Breeder's Rights (PBR) status, in use or being developed. Industry expansion was however still constrained by the lack of a large pool of suitable varieties.

During the 1997–1999 seasons annual exports, still predominantly to Japan, were around 600 000 stems or more. There were around 100 growers located in the eastern states, South Australia and Western Australia. The production season was 14 weeks or longer between July and November. The industry was no longer severely constrained by the lack of cultivars. Around 30 cultivars were in use by industry, with about 15 of these in wider use, and many only used by one grower.

Figure 1: Natural distribution of rice flower (*O. diosmifolius*) in Queensland and New South Wales
Source: Qld and NSW herbaria



2 Botanical description

The common name 'rice flower' given to *O. diosmifolius* (Syn. *Helichrysum diosmifolium*), Family Asteraceae, is derived from the shape of the small flower heads that make up the inflorescence (Plate 1). These flower heads (or capitula) at bud stage resemble grains of rice. The plant is also known as 'sago flower' or 'ball everlasting', because of the shape and long life of the flowers.

The plant[1]

Plants are generally erect, multi-stemmed woody shrubs, growing to 1.5 to 2.5 m in height. Leaves are pungent smelling, linear and 10–30 mm long, and vary in width from 1.0 to 2.0 mm (fine-leafed forms) to 2.5–3.5 mm (broad-leafed forms). Both forms are found between latitudes 25°and 37°S in Queensland and New South Wales. The fine-leafed forms are common inland, while broad-leafed forms are found on the coast and hinterland.

The flowering stem (with the inflorescence) of rice flower (Plates 2 and 3) is generally branched, each branch terminating in a corymb (Plate 4) measuring from 1.0 to 7.5 cm or more in diameter. Each corymb is comprised of capitula (Plate 1), numbering from only a few to more than a hundred. The number, size, shape and colour of the capitula and the arrangement of corymbs on a stem vary between varieties. Flower colour is due to the pigmentation of the papery capitula bracts. In pink forms, pigmentation tends to fade as the flower ages. The floral display in rice flower is strongly influenced by seasonal factors and geographic location.

The breeding system for *O. diosmifolius* involves out-crossing, which is common in Asteraceae. The flower structure and sequence of floret development are common in plants that are cross-pollinated. Florets in a capitulum lengthen in turn over several days, exposing their anthers and stigmas. The time of day of anther maturation and pollen release in a floret is different from that of stigma exposure. This increases the chances of out-crossing, where the pollen source is from another floret on another plant.

Forms of rice flower[2]

There are three general categories of rice flower, the fine-leafed form (Plate 2a), the mid-leafed form and the broad-leafed form (Plate 2b). Broad-leafed forms and fine-leafed forms of rice flower are distributed south from 25° latitude in Queensland (Eidsvold–Wide Bay).

The fine-leafed form has an inland and occasionally coastal distribution, with a southern limit around the western slopes of the Liverpool Ranges and Coonabarabran at 32° latitude. Branching is generally at acute angles, giving the plant an upright appearance. Leaves are 1.0 to 2.0 mm wide, grey-green to mid-green, and mint-scented and aromatic.

[1] For definitions of technical terms used see the glossary.
[2] Dr Chris Puttock, formerly of the National Herbarium, Canberra, is gratefully acknowledged for information on the distribution of rice flower.

The broad-leafed form has a coastal and subcoastal highlands distribution, with a more southerly limit around Goulburn–Tathra at 37° latitude. It branches profusely at wider angles, commonly 40° to 80°, giving a rounded look to the shrub. Leaves are 2.5 to 3.5 mm wide, dark green and pungent in scent.

The mid-leafed form represents an intermediate type (an intergrade) and is common around the lower slopes of the Blackbutt and Liverpool Ranges, where the broad-leafed and fine-leafed forms meet.

Fine-leafed cultivars dominate the industry, although all forms are being cultivated for cut flowers. The wide branch angles (Plate 2b) and high oil content of the broad-leafed forms in particular create problems for both product handling and consumer acceptance. Mid-leaf cultivars are of increasing interest to cut flower growers because of their survival and performance in different environments and more acceptable stem architecture.

3

Cultivars

Rice flower varies widely in morphology and in production characteristics such as flowering season, yield of flowering stems, postharvest life, disease susceptibility and plant longevity in cultivation. Early commercial plantings consisted of a range of highly variable seedling-grown lines. Further development within the industry has involved general use of cutting-grown plants, propagated from superior selections.

The emerging industry

In 1990–91 the emerging industry, characterised by plantation production, had a limited harvest season of only a few weeks and no reputable cultivars. Stems from broad-leafed selections were commonly unacceptable because of leaf blackening.

First commercial cultivars

By the mid-1990s, the industry had a 6–8 weeks production season supported by three clonal (and PBR registered) varieties of well documented performance. These clones 'Cook's Tall Pink' and 'Cook's Snow White' were in common use from 1992, and subsequently, along with 'Redlands Sandra', became the main commercial cultivars. The characteristics (see Table 1) and performance in south-east Queensland of these cultivars are well documented. Each may have a production season of 7–14 days, depending on the uniformity of flowering and maturation. This is influenced by location, growing conditions and harvest method. The three fine-leafed cultivars together provide a production season of 3–6 weeks at south-east Queensland locations.

Table 1: First commercial rice flower cultivars released and selected characteristics

Cultivar	PBR no.	Flower colour at harvest maturity	Production season in SE Qld
Cook's Tall Pink	387	pink	early to mid-September
Redlands Sandra	793	white	mid- to late September
Cook's Snow White	386	white	late September

Current cultivar situation

The industry continued to expand through the late 1990s, attaining a production season of around 14 weeks (based on Australia-wide production). This expansion has been supported by the development of at least 30 cultivars by active growers, nurseries and researchers. Industry expansion is not now as constrained by lack of useful varieties. Many of these cultivars are used by only one grower, but at least 15 have been made available to the industry as a whole.

The Cook's cultivars and 'Redlands Sandra' have become less prominent with the advent of new cultivars such as 'Pretty Pink', 'True White', 'Jim's Pink', 'Benfers Pink', 'Windles White Bouquet', 'Coles Pink' and 'Jacobs Pink'. The main cultivars in use are still fine-leafed types. Mid-leafed types seem better suited than fine-leafed cultivars to southern coastal NSW and Victorian conditions, although comparative performance is not fully documented. Broad-leafed cultivars, although late flowering (October–December in south-east Queensland), are in only minor commercial use.

More cultivars needed

A large pool of commercially useful cultivars is required to sustain plantation productivity and to support industry expansion. Growers seeking to identify rice flower varieties or selections of likely commercial importance should look for characteristics such as plant survival, vigour and growth, marketable stem yield, extension of the production season, clean flower colour, stem quality (see Chapter 6 on standards) and floral display. The production performance of individual clones is commonly site-specific, and growers need to devote time to identifying cultivars that suit their particular location or production requirements. To properly evaluate any new varieties, plantings should include a reference cultivar of known type and performance.

Developing plants from the wild

The growth and performance of single plants or populations in the wild are not necessarily good indicators of the subsequent performance of the same material when brought into cultivation. Wild plants are often seen as wiry understorey shrubs, ravaged by pests and diseases, and growing in arid and infertile conditions. Single-plant selections, from (seedling) populations of interest, should be propagated vegetatively. Pilot plantings of at least 10–20 plants per selection, in conjunction with plantings of a known cultivar, are suggested. At least two flowering seasons are required to identify and evaluate superior new selections. Wider testing over additional years is necessary to identify cultivars suited to a particular location that justify commercial development.

Seedling varieties

The use of seedlings of rice flower for commercial cut flower production is not desirable. Germination is generally low, propagation slow, and most importantly seedlings are seldom true to the parent-type, producing cut flowers of variable quality. Blocks of seedling rice flower are difficult to harvest, as the maturity dates vary from plant to plant. Growers have found themselves walking the whole block only to harvest a few bunches. This is not cost effective, either in the field or in the packing shed.

4 Flowering

The flowering season of rice flower is influenced by variety as well as by growing location and plant age. In the wild in eastern Australia, rice flower may be found in flower from September to January. In south-east Queensland, the fine-leafed forms flower early (September–October) and the broad-leafed forms later (October–December). From such material there appears to be potential for at least four months of commercial production, particularly if successfully grown over a diverse range of locations.

Environmental factors

Environmental factors influencing initiation of flowering may include short days and low temperatures, although the factors involved have not been conclusively identified. Commercial harvests in the main rice flower cultivars are from early September to early October in south-east Queensland and 3–5 weeks later (from early October to early November) in Victorian plantings (1996 data: Beal *et al.* 1999).

At DPI's Centre for Amenity and Environmental Horticulture (28°S) the cultivar 'Redlands Sandra' initiates flower buds in late June to early July.

Flower development continues until a harvestable flower stem is produced around mid-September. It is not known whether differences from year to year in the timing of flowering of a cultivar grown at the same location are due to a variation in floral initiation or to the rate of inflorescence development, or a combination of both factors.

Developmental stages

The development stages of flowering (Plates 5a–5e) include an initial 'pea' stage when the corymb, enclosed in apical leaves, is of pea size and corymb colour first becomes apparent (Plate 5a). This is around early August in south-east Queensland. The corymb expands (Plate 5b) to its maximum size over the next 4–6 weeks, during which the capitula also increase in size, and become ready for harvest (Plate 5c). Further development of the capitula involves parting of the bracts, extension of the florets, fertilisation, browning or discolouration of the florets (Plate 5d), seed development, reflexing of bracts, and seed release (Plate 5e). The seed release stage occurs around 6–8 weeks after harvest maturity.

5 Harvesting

Length of the harvest season at any one location will be influenced by the mix of cultivars grown (Table 1), the uniformity of flowering of each cultivar and the harvest method adopted. Time of flowering in the first year of production of a cultivar (one-year-old plants), may be 1–2 weeks later than for subsequent crops from the same plants. In a single cultivar, delays in onset of harvest attributable to the influence of location have ranged from 2 to 3 weeks between Stanthorpe and Cleveland (similar latitude, but altitude and temperature differences) to 3 to 5 weeks between south-east Queensland and Victoria (latitude and temperature differences). The length of the harvest season of commercial plantings varies with the locality. For example, the season for 'Cook's Tall Pink' was found to be 5 days in south-east Queensland (Helidon) and 15 days in the coastal highlands of NSW (Robertson), whereas for 'Cook's Snow White' it was 4 and 26 days respectively.

Methods of harvesting

The crop may be harvested selectively, by picking individual stems as they mature, or in a single cut, harvesting the entire crop at optimum overall maturity. Selective harvesting using secateurs, although labour intensive, is most appropriate when flower maturity is variable. Less stress is placed on the plant, cleaner cuts are made and more foliage is retained, enhancing the plant's ability to re-shoot.

Once-over harvesting is suitable for crops of uniform maturity. This process is normally mechanised (such as, a chainsaw with a pruning attachment). It is cost efficient, but may lead to significant splintering and tearing of stems, creating potential sites for entry of pathogens. Harvesting aims to produce stems of marketable length (from 40 to 110 cm), while incorporating pruning for height control and the retention of some basal leafy branches to assist plant recovery. Stems should be harvested at 30–60 cm above ground level; one or two leafy branches being retained near-ground level to ensure continued photosynthesis and carbohydrate supply for plant regrowth. (A pruning height of around 0.5 m is normal under Queensland conditions in the first year, with successively higher pruning heights in subsequent years.) Hard pruning, particularly as plants reach their second and third years, can lead to greater plant stress, poor or slow regrowth and even plant death. Cutting into the previous year's wood should be avoided.

Harvest maturity

Changes in maturity are illustrated in the figure within Table 2 and Plate 5. Rice flower is marketed in the closed bud stage, when capitula are full size (normally match-head size), but less than 10% of capitula on the fully expanded corymb are open (Plate 5c). Depending on the variety, this harvest window lasts from one to ten days in Queensland (averaging 2–3 days). During the flowering season, the crop has to be constantly monitored so that stems can be picked at the correct stage of maturity. Varieties with a harvest window of only one or two days are difficult to manage commercially.

A useful indicator for the onset of harvest is when the corymbs are fully expanded and 50% of capitula are plump and all are unbroken (see example graph Figure 2). Stems harvested at this stage do not readily wilt. Some selections can be harvested at an earlier stage (for example with 30% of buds full size) without wilting. With the use of postharvest preserving solutions there is the potential to pick at an earlier stage of maturity, extending the harvest period by up to a month in the case of some cultivars.

A useful index of cessation of harvest is when 10% of the buds have broken (see example graph Figure 2), with florets emerging through the parted bracts. Beyond this point product quality deteriorates. Over-mature rice flower should never be marketed.

When the capitula open, the styles extend and quickly dry off, capping each floret (seen as minute projections on the right hand capitula of Plate 6) with unsightly brown fuzz (Plate 5d). When the florets ripen the bracts reflex and open like a miniature daisy, revealing the seed heads (Plate 5e). The seed heads shatter and fall with the bracts (see far right, Plate 7). European and Japanese importers have long and unfavourable memories of this type of product exported in the late 1980s.

Pink-flowered rice flower tends to fade as the flower head matures. The extent of fading depends on the variety. The fading of pink pigmentation in capitula of different maturities is illustrated with a DPI selection in Plate 1.

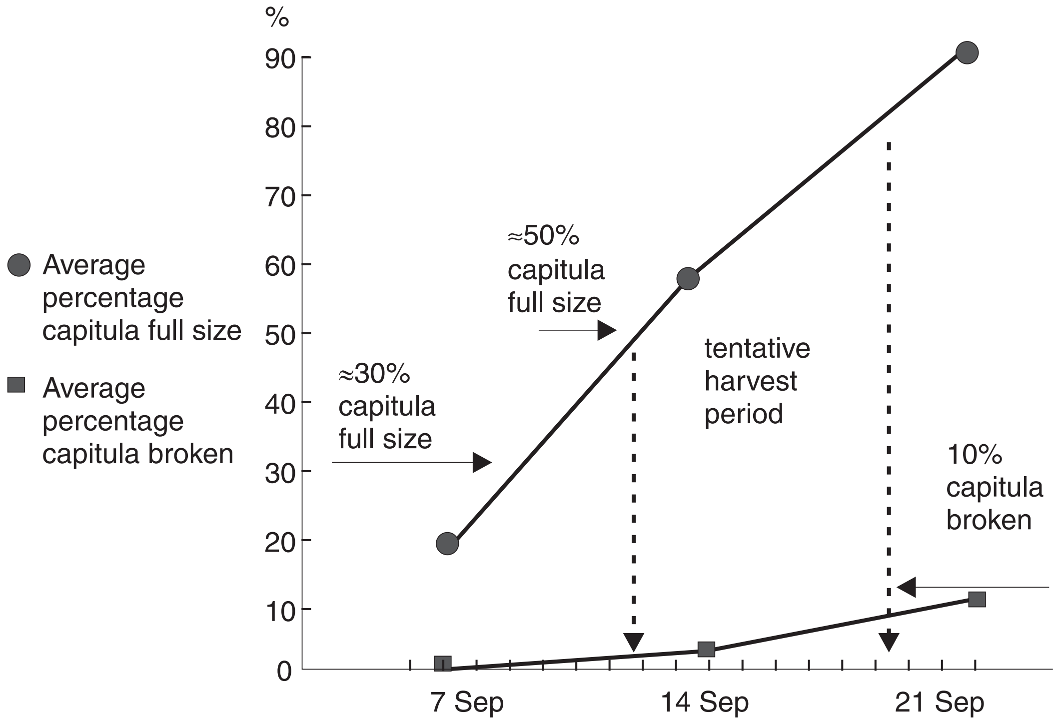


Figure 2: Changes in maturity indices (percentage of capitula full size and percentage of capitula broken) in samples of rice flower 'Cook's Tall Pink' at Helidon in 1994 (Beal unpublished)

6

Postharvest standards

A maturity and objective quality standard has been developed for export rice flower and has been submitted for consideration in draft form to Standards Australia. The standard covers flower, foliage and stem quality, harvest maturity, uniformity of grading, accuracy in labelling and postharvest cooling. The draft standard (see Table 2) provides a basis for Australian growers to meet customer requirements for quality and consistency. This standard should be used in conjunction with the general standard contained in the document *Australian standards for fresh cut flowers: as adopted by the Flower Export Council of Australia* (FECA 1995). Modified guidelines for meeting the general standard are also found in *Rice flower—Integrating production and marketing* (Carson and Lewis 1997).

Table 2: Postharvest industry standard for rice flower (modified draft)

Rice flower—*Ozothamnus diosmifolius* syn. *Helichrysum diosmifolium*

Preface

This industry standard is based on an earlier standard for rice flower adopted by the Flower Export Council of Australia. It has been submitted to Standards Australia for consideration as the Australian standard.

1. Scope

This Standard sets out a specification for rice flower. The Standard does not apply to dried or preserved rice flower, nor does it include information on market-specific matters.

2. Definitions

Capitulum:	A small flower head, approximately match-head size in rice flower
Capitula:	Plural of capitulum
Bracts:	Visible protective structures making up the outermost covering of the capitula of rice flower
Corymb:	A terminal flower head made up of a collection of capitula
Floret:	A small single flower protruding from opened bracts, clearly visible with a hand lens
Flowering stem:	In commercial harvests of rice flower, an array of corymbs
Peduncles:	Stalks supporting the flower head

3. Consistency/Quality

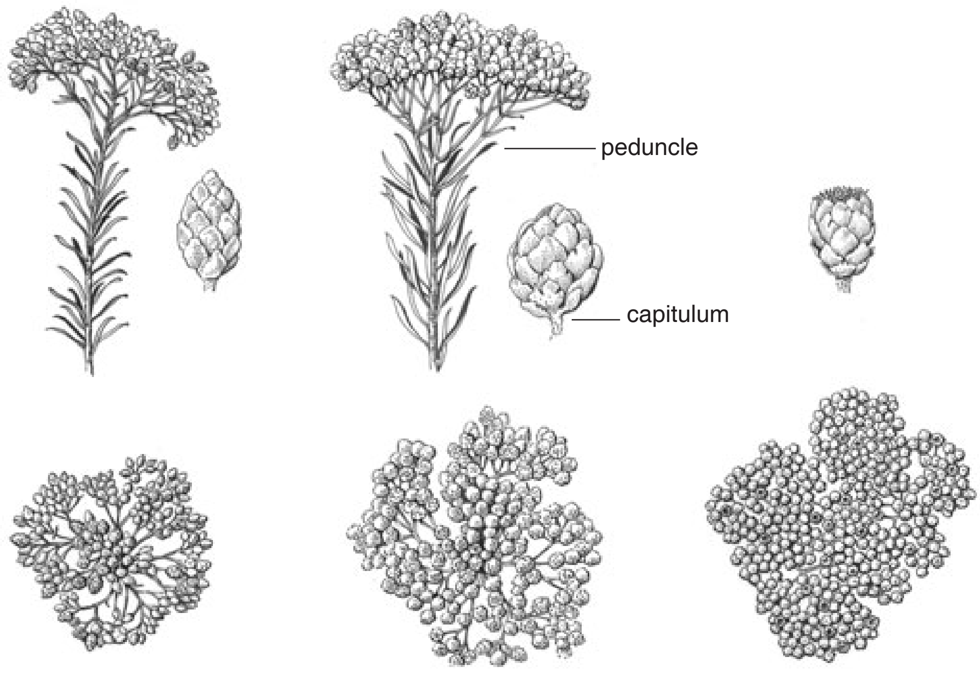
3.1 Maturity and quality for harvesting

a) Less than 10 per cent (2 per cent for top quality product) of capitula in the centre of the most advanced corymbs show bract separation and floret extension.

b) Stalks (peduncles) supporting the corymb do not wilt causing capitula to droop after harvest. This is a symptom of picking too early.

c) Flowers shall be harvested no earlier than at the stage of corymb and capitula maturity illustrated in line drawings of Stage (b) mature, and earlier than that illustrated in drawings of Stage (c) over-mature. Note: postharvest treatments that minimise wilting may advance the earliest harvesting stage.

Corymbs and capitula at three stages: immature (wilted), mature and over-mature



Immature (capitula peduncles wilted) (a)	Mature (b)	Over-mature (c)

3.2 General

The stem shall have the following general characteristics after careful harvesting at the appropriate stage (see Clause 3.1):

a) Capitula are of a clean, distinct colour, such as white, cream, light pink, mid pink or dark pink.

b) Foliage at the top of the stems should be fresh, clean and green.

c) The stem shall be strong, reasonably straight and derived from current season's wood. Strong, low side-branches growing at an angle greater than 45 degrees should be removed.

d) The stem shall meet the requirements detailed in the general standard for Australian export cut flowers (FECA 1995; Carson and Lewis 1997)

4. Export Grade Classification and Appearance

4.1 Criteria for bunches

Each bunch of rice flower for export shall meet the criteria below:

a) give a balanced appearance of high flowering density, produced by a combination of stem number, stem length and size, and number and distribution of capitula;

b) be true to type for described hybrids/cultivars;

c) have uniform foliage colour;

d) be of uniform weight compared to others in the same order or shipment;

e) have a consistent stem diameter ±10 per cent.

4.2 Criteria for rice flower stems in cartons

Each carton of rice flower for export shall meet the criteria below:

a) be cooled to approximately 2°C to 5°C, with forced air cooling, preferably within three hours of cutting in the field;

b) meet the requirements detailed in the general standards for Australian export cut flowers. (FECA 1995; or abridged in Carson and Lewis 1997)

Two issues from the standard have emerged as common problems in the market place. One is that of rice flower maturity. In particular, over-mature rice flower should never be marketed. **Incorrectly harvested rice flower has the capacity to completely kill market interest.** The stems are ready for harvest at the plump bud stage when the capitula are mature yet unbroken, with a fully expanded corymb (see Chapter 5). Depending on the variety, this harvest window lasts from 1 to 10 days in Queensland (averaging 3 to 5 days). Near harvest time the crop needs close monitoring; it is not unknown for less vigilant growers to miss the harvest period on some cultivars. Cultivars with a one or two day harvest period are difficult to manage and should be selected against.

Leaf blackening can also be a problem. All cultivars are prone to leaf blackening in some circumstances. Rough handling of mid-leafed and broad-leafed forms can exacerbate the problem, with tissue damage occurring at the affected sites. To minimise leaf blackening, rice flower should be handled with care and placed in a cool store as soon as possible after harvesting. Forced air cooling is highly desirable for the rapid removal of heat from the centre of cartons. This system involves directing cooled air through the vents in cartons. Laboratory trials have demonstrated that the removal of field heat immediately after harvesting, and holding rice flower at around 2ºC prevent foliage blackening Commercially, good results have been obtained with dry storage and forced-air-cooling at 2ºC in cartons, within two to three hours of harvest.

Some elements of the rice flower standard relate directly to the choice of cultivars. Some desirable and undesirable varietal characteristics that directly affect product quality are listed in Table 3.

In other instances, site or crop management factors affect flower quality. It is not possible to grow quality rice flower cheaply in an unsuitable location, irrespective of how good the cultivar may be. Some of the management areas that have an impact on implementing the rice flower standard and the general standard for Australian export cut flowers (to which rice flower must also conform) are listed in Table 4. Crop husbandry is the most important factor influencing product quality once an appropriate initial choice of site and cultivar has been made.

Table 3: Desirable and undesirable varietal characteristics

Plant part	Good varieties	Poor varieties
Stems	• distinct, clean flower colour • strong stems • straight stems • no 'bypassing' on stems	• pinks fade, giving a washed-out appearance; whites and creams look 'dirty' • whip-like stems • whole plant tends to branch at angles greater than 45°; these branches curve upwards • vegetative shoots produced below the flower head extend beyond the top of the flower head
Flowers, buds	• high levels of flowering, many buds, well distributed • buds mature evenly on stem	• flowering on cut stems looks sparse; there are relatively few buds and/or a poor distribution of buds; inadequate branch numbers per stem • terminal corymb matures well in advance of other corymbs on the same stem
Foliage	• clean green foliage	• leaf blackening; leaf yellowing due to sensitivity to nutritional deficiencies, water stress and salinity

Table 4: Crop management factors that affect quality

Objectives	Management factors
From the rice flower standard:	
• clean green, uniform foliage colour, strong stems of consistent diameter, high levels of flowering	• quality planting material, crop nutrition, root zone management, overall plant health including pest and disease control
• fresh foliage	• irrigation, postharvest handling
• straight stems	• cultivar, planting density, pruning, canopy support, wind protection and nutrition
• stems derived from new season's wood	• harvesting technique, postharvest pruning
From the general standard for Australian export cut flowers:	
• cultivars true to type	• use of a reputable supplier for planting stock, blocks of named varieties, grading technique
• a product substantially free of live pests or diseases	• preharvest pest, disease and weed control, postharvest dipping/fumigation, grading
• a product unaffected by residues of foreign substances	• weed control, field and shed hygiene, no over-spraying (residues)
• no more than 5% of stems affected by bruises or blemishes, vegetation defects, damage by parasites, or flower drop	• preharvest pest and disease control, mechanical handling of plants in the field, stage of picking, harvesting and product handling methods, grading and formal quality controls

7 Yield and productivity

Commercial plantings might expect to yield an average of 10 stems per plant in the first year of growth and 20 stems per plant in each of years 2 and 3. Yields per hectare tend to decrease or plateau after year 2, as the ability of older, woodier plants to recover from harvest cutting and other stresses declines.

Yields of 30 stems per plant in the first year of growth and 110 stems in the second year have been obtained in research trials. Higher than average yields per plant have been associated with the use of selected genotypes, high-quality planting material, well-drained soils and adequate nutrition and water, resulting in vigorous plant growth. The same factors are also associated with low plant mortality and continued crop productivity over several flowering seasons.

Plantation yields

Yield per unit area is highly dependent upon planting density and plant survival. Plant losses of 10–20% per year are not uncommon in commercial plantings. Early losses greatly reduce expected returns. The following examples assume an average yield per plant of 10, 20 and 20 stems in years 1, 2 and 3 respectively.

At a plant density of 3300 plants per hectare (0.75 m x 4 m spacing), with zero plant losses, approximately 33 000 stems per hectare could be harvested in year 1 and 66 000 in each of years 2 and 3. At a higher planting density of 5330 plants per hectare (0.75 m x 2.5 m spacing), stem numbers of 53 000 in year 1, and 107 000 in years 2 and 3 might be expected.

However, if 10% plant losses occur prior to harvesting in year 2 and 20% in year 3, by the third year plant numbers will have declined to approximately 2400 in the low-density planting and 3800 in the high-density planting. Historically such losses in this fragile crop are not unusual in coastal areas with high rainfall and sub-optimal drainage. As a consequence, by year 3, respective yields could be as low as 48 000 and 76 000 stems per hectare.

Maintenance of plant health and survival is critical to the continuing production of economic crop yields, though high plant density can partly compensate for some plant mortality. In trials at the Centre for Amenity and Environmental Horticulture at Cleveland in south-east Queensland, significant yield gains were obtained by reducing the intra-row spacing from 1.0 m to 0.75 m and 0.5 m. In addition, close plant spacing within rows can influence stem length, increasing the number of long stems per hectare, but narrowing their width. This has the potential to increase crop profitability because of the higher returns from long stems in export markets (see Chapter 14).

8 Propagation and planting material

Rice flower can be readily propagated by stem cuttings or from seed. Some cultivars are much easier to propagate than others. Most commercial rice flower is derived from vegetative cuttings of tested cultivars, which enables genetic uniformity within planting blocks.

Clonal propagation

In clonal propagation, the health and vigour of the source plants for cuttings are of prime importance, irrespective of variety. Ideally, well cared for stock plants should be maintained specifically for propagation purposes. Young, healthy, actively growing material gives the best results. Following excision from the stock plant, cuttings should be kept moist and cool and inserted into a propagation mix as soon as practicable. Year-round propagation is possible, as cuttings can form roots (strike) from both vegetative terminal stem sections and flowering stem sections taken immediately below the inflorescence. Average cutting strike time is five to eight weeks, and strike rates above 80% can be expected from varieties that are easy to propagate.

Efficient clonal propagation:

- vigorous, healthy mother stock
- well drained propagation medium
- use of 2000 ppm IBA is generally beneficial
- underbed heating (15°–20°C) in winter and air cooling (mist < 28°C, fog < 35°C) in summer
- 80% relative humidity in the rooting stage

Contaminants can be removed from the surface of the plant tissue by dipping in disinfectants, including sodium hypochlorite. The effectiveness of this method in improving cutting survival and propagation success is a function of the length of time they are immersed in solution and the concentration of the chemical. If material is left immersed for too short an interval harmful organisms may not be destroyed; for too long a period plant tissue may die. A compromise needs to be developed for the particular type of tissue, through practical testing. Treatments of 1000 ppm chlorine[3] for three to five minutes may be satisfactory for rice flower, although broad-leafed varieties may blacken with such a dosage.

A well-drained propagation medium with uniform aeration and moisture holding characteristics is essential. Media such as perlite and peat (9:1), perlite and coarse sand (4:1), or a proprietal free-draining root cube are effective.

Use of rooting hormones is recommended, particularly for material that is difficult to propagate. IBA (indole-butyric acid) at a concentration of 2000 ppm, either in powder or solution form (for example Rootex) may be used.

Temperature and relative humidity should be maintained relatively constant throughout the propagation period, since rooting propensity declines as leaves are lost from the cutting. Exposure of cutting material to sudden increases in temperature may cause leaf blackening and leaf drop. Leaf drop may also result from sudden changes in air moisture content in either direction or *Botrytis*.

Where high minimum relative humidity (80%)

[3] 1000ppm (0.1%) active solution is 84 mL per 10L water when using 120g/L active chlorine stock solution

can be constantly maintained, such as in a fogging unit, higher air temperatures can be tolerated (for example, to 35°C), than in an intermittent misting system (28°C). In warm climates, some form of temperature control is recommended for propagation under mist during the summer months. This may involve the use of shadecloth over the propagation house, or increased ventilation. Underbed heating (15°–20°C) is advantageous for winter propagation.

Production of tube stock

Rooted cuttings should be potted into a free-draining mix and fertilised. A dilute foliar fertiliser can be used on unstruck cuttings and young tube stock to enhance growth. Newly planted tube stock needs a hardening-off period. This may involve holding the plants in a shaded, well-watered area or returning them to the propagation house for seven to ten days after potting on. Holding them for a further seven to ten days under reduced watering is recommended before they are exposed to full sunlight.

Rice flower plants are very prone to root damage. They may become root-bound if held too long in a pot. Native tubes are preferred for growing on.

Commercial propagators

A list of the suppliers of planting material for commercial cultivars of rice flower is contained in Chapter 17. Suppliers should be notified of requirements well in advance, and arrangements made for tube stock to arrive close to the intended planting time. Avoid purchasing plants that have been held for more than eight weeks after potting on into tubes.

Young plants are prone to stress at high temperatures. Tube stock should be transported under cool conditions. Maintain good communication with your supplier and accept only plants in excellent health. Problems with young plants tend to magnify rather than dissipate over time.

Propagation by seed

Rice flower produces large numbers of seeds, but only a few germinate readily. Seed can be easily collected from the flower heads 6–8 weeks after harvest maturity. Seed stores well at room temperature for three months or more. Germination levels of 0.2–0.8% within 4–9 weeks have been recorded in sand or sand-peat media. Higher total germination levels (>1% and up to 5%) have been obtained with some varieties over periods of six to twelve months. As a general rule seed propagation is not recommended for commercial wildflower growers (see Chapter 3).

9 Site Selection

Although rice flower is native to the eastern seaboard of Australia, if it is given an appropriate site it will grow in a wide range of environments from the south-west of Western Australia to eastern Australia, central Queensland, South Australia and Victoria. Achieving top performance is however more difficult, and it may be necessary to experiment with different varieties to determine the best commercial forms for a particular locality.

Climate

The current fine-leafed south-east Queensland cultivars do not appear to be well suited to colder conditions in southern Australia and perform best in climatic zones similar to those of their natural range. However, some fine-leafed cultivars do grow well as far south as Victoria and South Australia (see Appendix).

Mature growth appears tolerant of temperature extremes from –5° to 44°C. Frosts can however affect soft new growth and cause losses in young plants; locations with extreme frosts should be avoided. High summer temperature and rainfall are problems for spring plantings during the crop establishment phase.

Soils

Commercial rice flower is best grown in sandy loam soils with low clay content (low water-holding capacity). Deep well-drained sands are well suited to the growth of rice flower, however nematodes can proliferate in over-wet sandy soils. Soils with higher clay content require mounding to improve drainage in the root zone, however mounding may be of advantage in all soils (Plate 8). Many clay soils are conducive to waterlogging and to the development of root disease, two major causes of plant loss. Plants appear tolerant of both low and high pH soils; however a pH range from 5.5 to 6.5 should optimise the availability of essential nutrients, particularly iron.

Although generally derived from soils of low fertility, rice flower is now cultivated on a wide range of soils of varying fertility (Beal *et al.* 1999) and performs well in highly fertile soils. Unlike some Australian natives, it does not appear to suffer from phosphorus toxicity in soils of high phosphorus content. Land that has previously been cropped with phosphate fertilisers can be brought into rice flower production.

Water

Irrigation is essential. Do **not** use dryland sites for commercial plantings. Young plants need particular care until an extensive root system is established. Older plants can often survive drought, but stem growth and flower development may be severely affected, thus reducing the yield. The availability of supplementary water is important for critical growth stages (such as flowering, development of the vegetative framework, and stem growth and extension). Planting sites need access to bore water, chlorinated town supply, dam water or river water. The estimated water requirement for rice flower is in the order of 35 mm per week during peak demand periods in summer. To cope with peak periods, 5 hectares of rice flower would need a bore of high flow rate (6.9 litres per second). For medium output bores, extended pumping times, either directly onto successive sectors of the crop or into a 1.6 megalitre (1 600 000 litre) dam, could provide a week's supply of water.

Site Selection:

- use well drained soils
- ensure adequate supplies of good quality water
- test for and reduce nematode population before planting
- provide protection against winds.

Some varieties of rice flower have been shown to be tolerant of saline water to 3.7 mS/cm (3700 mS/cm), applied on a sandy soil with drip irrigation. The long-term success of irrigation with water of such poor quality is dependent upon constant leaching to avoid the build-up of salts. If possible, choose a site with high-quality water. This is especially important when establishing young plants using overhead irrigation.

Wind

In cultivation rice flower can rapidly establish vigorous top-growth on poorly anchored root systems. Stems are brittle and prone to splitting at the base. When the thick canopy is buffeted by wind, roots are dislodged and/or the stems may split. This damage places the plant at risk from fungal pathogens entering through root and stem wounds, and may lead to plant death. On exposed sites, top-heavy plants may be blown from the ground. Older plants growing at acute angles away from the direction of prevailing winds are difficult to manage and curved stems are unmarketable.

If possible, find a site with reduced exposure to strong winds. Consider seasonal winds that may not be evident during your on-site evaluation. On windy sites, windbreak protection or crop support (such as trellising with flower mesh) may be required. Establish artificial or living windbreaks in advance of planting to protect the crop.

Root-knot nematode

Rice flower is particularly prone to nematode infection, being susceptible to at least four species of *Meloidogyne* root-knot nematode. In irrigated cultivation, even low levels of infection can quickly build into a major disease problem in a highly susceptible and perennial crop such as rice flower. Irrigated sandy soils with a low level of organic matter are particularly likely to harbour nematodes. Severe plant losses (up to 100%) have been found to be related to cumulative plant stresses associated with nematode infection. Planning for nematode management should begin with the choice of site, as root-knot nematodes are not easily controlled using postplant nematicides.

Prior to planting, all planting sites should be checked for root-knot nematode. Low levels of the nematode may not be detected using standard laboratory soil-nematode counts; a bioassay using actively growing tomato seedlings may be a more effective test. (Details of this test appear in the DPI Note 'Testing Your Own Rice Flower Planting Sites for Nematodes'—see Carson 1997.)

The presence of **any** galls on the roots of the tomato seedlings means that the use of the site should be reviewed. The detection of nematode populations prior to planting allows growers to choose another, nematode-free site for rice flower, select a less susceptible crop, or examine options for preplant nematode control. In warm climates, another alternative is to crop rice flower, a perennial, as an annual or two-year crop and to use crop rotation.

10

Culture

In cultivation rice flower performs well in highly fertile soils. Adequate water supplies are needed to establish new plantings and to obtain adequate productivity. Cultivation, spraying, weed control, pruning and fertilising are all part of the crop management cycle.

Irrigation

Rice flower crops are best irrigated using T-Tape (an inexpensive choice), button drippers or micro-jets. Overhead irrigation uses more water and may predispose plants to foliar fungal diseases.

No information is available on the optimum irrigation management of rice flower, which is cultivated in both arid (<1000 mm/year) and high rainfall (>2000 mm/year) areas. To some extent rice flower watering has largely been a trial and error process. During establishment frequent low-volume irrigation is required, while less frequent higher-volume watering may be used on the mature crop. Watering requirements are likely to be higher in summer than in winter, depending on the incident rainfall and temperatures.

What **is** known is that rice flower has a fairly high water requirement for high early yields. Adequate water supplies are needed to establish new plantings and to obtain good flowering stem length, foliage colour, inflorescence quality and postharvest life. In warm climates, maintenance of high soil moisture regimes in August and September after floral initiation (in June and July at Cleveland in south-east Queensland), may result in vegetative flushing (known as bypassing) (see Plate 26) accompanying inflorescence development, reducing the quality of the flowering stems. In these circumstances it is recommended that watering be cut back to a maintenance level to sustain the plant, without promoting growth flushes. As with fertiliser requirements, research into water management of rice flower is needed to ensure maximum production over the wide range of soil types and climates under which it is currently cultivated.

Some soils, particularly water-repellent sands, can be hard to wet, leaving a moist surface layer and dry root zone. Growers should periodically check that the root zone is moist, using a finger as a probe. Tensiometers and other moisture monitoring devices placed in the soil are valuable tools for determining irrigation frequencies and volumes.

Nutrition

The fertiliser requirements of rice flower are not well known. Each soil environment is different and fertilising decisions need to be made on the basis of a soil test. The normal ranges for both soil tests and leaf tissue tests for rice flower have yet to be established.

Strongly acidic soils should preferably be limed to pH 6.0–6.5 before planting. A fertiliser strategy of 'a little and often' seems to work well. Evenly spaced year-round applications totalling approximately 130 grams of mixed fertiliser per plant per annum appear effective. The N:K (nitrogen:potassium) ratio should be around 6:5. Small quantities (around 15 grams per plant) of organic fertiliser are acceptable, but larger quantities (for example 60 grams) are toxic. Moving into winter, plant requirements for nitrogen diminish and overall fertiliser levels can be reduced.

In some varieties iron deficiency symptoms may occur. Iron deficiency is best diagnosed from leaf yellowing, which responds to foliar sprays of ferrous sulphate (2 g/L). Some varieties suffer from iron deficiency symptoms even in the presence of high soil iron and an acceptable pH, and should be avoided. Some growers have used proprietary mixes of chelated trace elements with success. The addition of 2 g/L low biuret urea will assist absorption of iron into the leaf. In low-iron soils, rice flower may benefit from incorporating iron oxide, such as Micromate, Ironite and GU49 (all granular) or Bayferrox (black powder), at 100–150 grams per square metre before planting.

Planting

In mild subtropical climates planting of tube stock, or of established plants in 15 cm diameter pots, can be successful throughout the year. To minimise problems arising in field plantings from root congestion, the use of healthy, young, non-pot-bound stock is essential. Plants with root congestion should not be accepted. Slashing with a sharp knife can sometimes treat minor root congestion.

The potential problems caused by wind should be considered early, at the site selection (see Chapter 9) and plant establishment stages. At windy sites larger, leafy rice flower plants taken from pots have blown from the ground shortly after planting out. Generally tube stock are preferred. Peat-based tubes have been successful in Queensland.

Losses of young plants may occur following frosts. In areas prone to frosts, planting in late summer and autumn should be avoided. At the other end of the temperature range, do not plant when day temperatures are likely to exceed 30°C.

Weed control

Weeds are a problem for growers. They compete with the main crop, harbour pests and diseases, exacerbate frost damage and can contaminate the harvest. Weed mat, organic mulch (such as straw) or chemical treatments (herbicides) may be used to control weeds.

Weed mat can be used as a single strip with planting holes, or by laying two strips, one each side of the planted row. The edges of the weed mat need to be secured with rocks or soil, particularly on windy sites. Inter-row land can be either planted with a cover crop (such as clover) and mowed, or left bare, weeds being controlled by cultivation or by herbicides.

Weed mat can be damaged by slashers and can degrade over time. Some growers favour mulches with coarse straws (such as sorghum), which don't break down readily. All mulches can harbour vermin such as mice. A clear area should be left around the base of the trunk to prevent moisture build-up against the stem. Bare clodded earth or grassed mounds work well in arid areas, where weed growth is less likely to be a major problem.

Commonly used herbicides are glyphosate or triquat. Rice flower is extremely sensitive to foliage contact with both these chemicals, which therefore need to be applied carefully using a hooded sprayer.

Planting density

Planting densities for rice flower range from 2500 to 10 000 plants per hectare. Distances between plants within a row have varied from 0.5 m to 1.0 m, with 2–5 m centres between rows, depending on the land area, the cultivation equipment used and the width of the machinery used in the lane-way between mounds.

In trials at Cleveland; the number of stems greater than 50 centimetres in length produced per unit area was significantly increased by reducing intra-row spacings from 1.0 m (2500 plants per hectare) to 0.75 m or 0.5 m (3333 or 5000 plants per hectare) (Turnbull 1994, see also Chapter 7). Higher-density planting also allows some compensation for plant losses that may occur; a useful strategy to ensure that crop productivity is maintained, for example in nematode-infested sites.

Crop management

Some growers carry out canopy management, by tip pruning young plants shortly after planting. This shapes the plant, promoting the development of laterals. At Redlands Research Station tip pruning in March, following January planting, slightly delayed harvest time, but did not significantly alter the number of stems harvested (Turnbull 1994).

A trimming of the bushes is normally done at the end of the season, after flower harvest. This pruning should ensure that adequate foliage remains to support plant regrowth. Avoid cutting into the previous year's wood. Low-lying branches and those with odd angles should be removed. The aim of this pruning is to encourage the development of large numbers of upright stems.

11

Pests

A wide range of pests, including insects, spiders, molluscs, rodents and grazing animals, affect rice flower (Table 5). Some of these cause plant injury; others simply live on the plants but present a quarantine risk, particularly in countries such as Japan, which prohibits the entry of plants carrying insects (or pathogens) with unknown or restricted occurrence in Japan. For practical purposes, growers should aim to have no live or dead insects in export consignments.

Longicorn borer

Longicorn borer is by far the most injurious insect pest affecting rice flower. Plant mortality from this pest can exceed 20%. Two species have been identified in rice flower: *Acalolepta ovina* in Queensland and *A. argentata* (Crofton weed crown borer) in New South Wales; however other species could also be responsible for damage. Plants suffering from water or nutrient stress and located in or near bushland are particularly vulnerable. Evidence of the pest can be difficult to detect. The larvae (Plate 12) of the longicorn beetle burrow deeply within the wood (Plate 13). Sawdust at the base of the plant can frequently be tracked to 3–4 mm holes in the lower stem. The holes are produced by adults (Plate 14) that have previously emerged and not by larvae entering the wood, as is often assumed.

Adults cause further minor damage, nibbling the bark of stems and twigs. Often re-infestation occurs from adjacent areas. Wrapping the stems with termite mesh (which is expensive) or heavy-duty insect screen may afford some protection. Minimising plant stresses will help plants survive attack from this borer. Grow cultivars that are vigorous in your locality, control other pests and diseases, and provide plants with adequate water and fertiliser.

An experimental chemical control of adults has been developed, which can reduce the pest population to acceptable levels. However pressure to have this chemical registered for use in perennial flower crops will need to come from flower industry organisations.

Preharvest pest control

Pest monitoring and strategic spraying are preferable to routine pesticide application. During the vegetative growth of the crop, fortnightly inspections are normally adequate. Weekly inspections for tip-eating insects (aphids, caterpillars, mealybugs, scale insects and thrips) are recommended from four months prior to harvest (following floral initiation), through to the harvest. Spraying before harvest will reduce grading costs and the risk of a breach of quarantine. To minimise the risk of developing resistance in insects, avoid over-spraying and do not use postharvest dipping insecticides in the field. Best results will be obtained with correctly calibrated and well-maintained spray equipment.

Supracide (methidathion) will kill a broad range of insects, including predators of some pests. It is registered in most Australian states and territories for the control of aphids, caterpillars, leaf hoppers, mealybugs, scale insects and thrips. Mavrik Aquaflow (tau-fluvalinate) is useful for the control of heliothis caterpillars. Confidor (imidocloprid)[4] controls

[4] Minimise use to avoid insect resistance developing.

Table 5: Pests of rice flower

Pest	Plant part(s) affected	Symptoms and comments
Aphids: Small sap-sucking soft-bodied insects, generally flightless	flowers and foliage	distortion of new leaves and flower buds; severe infestation will reduce plant vigour
Army worms: Caterpillars of a moth, which hide around plant bases during the day to emerge and feed at night	leaves and growth tips	rare; defoliates young plants, but if controlled quickly plants will recover
Boring caterpillars (various species): Larvae of a range of different moths, which bore into the tips of shoots (or stems)	stems, vegetative tips, flower heads	head-boring caterpillars sometimes produce a web that binds flower buds together
Grazing animals	whole plant	control with fencing
Hares, rabbits and mice	stems	damage includes ring-barking and defoliation at rodent feeding height and chewed irrigation lines (mice); stem guards, scare guns (for hares and rabbits) and removal of refuge areas may assist in control
Heliothis caterpillars: A major agricultural pest; caterpillars actively seek and feed on the fruiting parts of plants	individual capitula	pin-prick-like holes on developing flower buds; may destroy the crop if left untreated (Plate 9)
Leaf hoppers: Small (~3 mm) insects with tent-shaped folded wings and the ability to jump or move rapidly sideways when disturbed	stems	a white downy-looking stippling on the stem surface (Plate 10)
Longicorn borers: Beetle larvae that bore into wood	lower stems, stem bases	sawdust at the base of the plant indicates that borer is present, a serious problem which can cause high plant losses
Mealybugs: Essentially scale insects covered by a mealy-looking wax secretion	stem bases, stems	white 'cotton wool' blobs on stems; render flowering stems unsaleable; ant activity at the plant base may indicate mealybug infestation just below the surface, which if severe can cause plant death
Rutherglen and other lygaeid bugs: 4–5 mm sized bugs similar to leaf hoppers with a more flatted body shape, which tend to feed on plant extremities and developing seeds	corymb	can alight on flower heads in large numbers, particularly late in the season; a potential quarantine risk
Scale insects (various): Small sedentary sap-sucking insects with a protective covering	green tissue	often accompanied by sooty (black) mould
Snails	newly rooted cuttings	plant losses occur in young field plantings; weed control destroys snail breeding habitats
Spiders: Eight-legged arachnids	parts above ground	not injurious to the plants, but a quarantine risk

continued ...

Pest	Plant part(s) affected	Symptoms and comments
Spittle bugs: Bugs which as juveniles are protected by a self-created froth (Plate 11)	stems, leaf bases	white blobs of 'spittle' on foliage; not injurious to the plant, but renders stems unsaleable if present during the harvest period; a potential quarantine risk in some circumstances; life cycle is normally over before harvest
Thrips: Small sap-sucking insects with fringed wings	flowers and foliage	bronzing or browning of bracts; can cause distortion of new leaves and flower buds

aphids, mealybugs, some scale insects and thrips Dimethoate (Rogor, Dimethoate and others) is **not** recommended on rice flower, as it can cause plant damage. Mention of specific insecticides is intended as a guide only and is not an endorsement of a particular company's product. Growers must check that a particular product is currently registered in their state for the use they intend to put it to, and follow all label directions, including safety directions and warnings.

Snails are normally troublesome only on very young plants and are more of a problem in the cooler climates of southern Australia. Control can be achieved with either snail grit (a sharp barrier to discourage snails) or metaldehyde snail baits.

Postharvest treatments

See Chapter 13, 'Postharvest handling'.

Pest control:

- monitor pests
- adopt a strategic spray program
- use correctly calibrated and well maintained spray equipment.

12

Diseases and disorders

Rice flower, like most other crops in cultivation, is susceptible to a number of diseases and disorders that threaten its long-term survival and productivity as a cut flower crop. As this crop is grown more widely, the importance of particular diseases or problems is becoming clearer.

Particularly important problems that afflict rice flower include wood-rot diseases and root-destroying diseases such as root-knot nematodes and phytophthora root (and collar) rot. In cultivation, rice flower is generally much more fragile than most other woody plants. Measures to prevent plant damage, which predisposes plants to the entry of wood-rot organisms, are very important.

The diseases and disorders commonly affecting rice flower are summarised in Table 6. Postharvest diseases are covered in the Chapter 13 'Postharvest handling'.

Disease control:

- select lines adapted to your location
- use only healthy, vigorous planting stock, preferably from accredited nurseries
- whenever possible select lines with a demonstrated tolerance to disease
- control root-knot nematode and pests such as longicorn borer. Serious damage caused to plants by these organisms permits the entry of pathogens
- plant in well drained soils
- avoid damage or stress to plants
- provide wind protection.

Phytophthora root and collar rot

Cause

Phytophthora cryptogea causes root and collar rot. Other species of *Phytophthora*, although occurring on some other species of *Ozothamnus* or *Helichrysum*, rarely occur on rice flower.

Symptoms

Affected plants exhibit a dark rotting of roots (Plate 15), which sometimes extends into stem bases. Symptoms are easily visible only when roots are washed and carefully examined and bark is cut away from stems. Above-ground symptoms are usually visible only after the disease is well advanced; they include; dried out foliage, yellowing, leaf drop, death of sections of foliage (Plate 16) and eventually death of the plant.

Source of infection and spread

Phytophthora is a soil-inhabiting fungus that requires water for spore production, spread and infection. Soils with poor internal drainage and prone to periodic waterlogging favour disease development. Infected nursery plants (grown in nurseries with poor standards of hygiene) will spread the disease when they are transported to new areas.

Occurrence and importance

Phytophthora root and collar rot is a common disease in many areas where rice flower has been grown (Plate 17). The disease has been frequently recorded in Queensland, NSW, Victoria and South Australia, but probably also occurs elsewhere. Although widespread, it does not occur in all areas where rice flower is grown.

Table 6: Diseases and disorders affecting rice flower

Disease/disorder	Cause	Importance	Comments
Phytophthora root and collar rot	*Phytophthora cryptogea*	common	Widespread, but not found in all plantings
Wood rots	various fungi including a basidiomycete, a *Phialophora* sp. and *Macrophomina phaseolina*	very common	found in most if not all plantings, particularly as plants age
Root-knot nematodes	*Meloidogyne* spp.	common and serious	limit production
Splitting, flower head and stem breakage	wind or other mechanical damage, such as from grazing animals or machinery	common	See Chapter 9 (wind) and Chapter 11 (grazing animals)
Root congestion or binding	plants held too long in containers before planting out	common	a lessening problem as grower awareness increases
White blister	*Albugo tragopogonis*	becoming more common	some new lines appear highly susceptible
Shoot tip death or dieback	undetermined	becoming more common	

Control measures

Purchase planting stock from reputable suppliers, preferably nurseries accredited by NIASA (Nursery Industry Accreditation Scheme, Australia). Propagate only from healthy, vigorous stock plants, taking cuttings at least 30 cm above ground level, away from contamination from soil splashed onto plants. Do not store potted plants on the ground or for long periods before planting; they may become infected by *Phytophthora* in surface water from infected plants (other commercial species, garden plants or wild species). Also, long periods of storage in too small a pot allows the development of congested root systems.

Plant only in soils with good internal drainage. Internal drainage is not dependent on slope: heavy clay soils with poor internal drainage can occur on steep slopes. Planting on raised beds, and the use of efficient drainage systems to quickly remove excess surface water, are also recommended, particularly in areas with high rainfall. Effective internal and external soil drainage is essential when growing any crop susceptible to *Phytophthora*.

Experiments have shown that there is a great variation in susceptibility to *Phytophthora cryptogea*. Select and grow lines with demonstrated resistance or tolerance, as well as the ability to cope with local conditions. Trial new selections first before planting them in large numbers. Selections such as 'Redlands Sandra', though susceptible to *Phytophthora*, grow well in south-east Queensland but have performed poorly in trials near Melbourne.

Several fungicides are available for *Phytophthora* control in flower and ornamental crops, applied as either a foliar spray or a soil drench. No specific work with these has been reported on rice flower, although some growers have used phosphonates with apparent success. Fungicides will give short-term protection but cannot eradicate infections; they must be applied before significant damage has occurred, and must be re-applied for continuing protection. Long-term reliance on fungicides is not recommended.

Wood rots

Cause

Various fungi cause wood rots in rice flower. They include an unidentified basidiomycete, *Macrophomina phaseolina*, and a species of *Phialophora*. Other fungi are also implicated.

Symptoms

Two types of rot commonly occur: a white or pale wood rot and a darker wood rot. White rot is caused by a basidiomycete. This disease has been common, particularly in older, mature plants. Symptoms are a pale, almost white, dry wood rot inside stems or crowns near ground level (Plate 18). The rot is often covered with a distinct creamy fungal growth.

Pale brown to almost black discolouration is seen in *Phialophora* or *Macrophomina* infections. These fungi may infect plants via the roots, and often advance quite high up in stems, either on one side of or up the centre of stems. *Macrophomina* infections appear very dark when fresh but are paler when older (Plate 19). Small black dot-like reproductive fungal structures (micro-sclerotia) are sometimes visible.

The white rot fungus and *Phialophora* develop very slowly within plants, whereas *Macrophomina* may advance rapidly at high temperatures. In either case, as severe internal damage develops, foliage dies back and plants are readily blown over.

Source of infection and spread

Wood-rot fungi occur in most soils where rice flower has been grown. One exception is *Phialophora*, which as yet has been found associated with rice flower at only one site. Most of these fungi are probably opportunistic invaders, entering through cracked stems or broken roots. Stressed, low-vigour or damaged plants are susceptible to infection. *Phialophora* has been associated with plants damaged by root-knot nematodes, although not in every instance. Many wood-rot fungi probably persist on plant remains in the soil. *Macrophomina* is known to infect more than 300 plant species worldwide.

Occurrence and importance

Wood rots are very common diseases in rice flower, particularly in older plantings and in association with root congestion. The plant's fragile nature and susceptibility to damage are the primary reasons, injury leading to slowly or rapidly developing rots and eventual decline.

Control measures

Buy healthy, vigorous planting stock from reputable suppliers. Use young rooted cuttings approximately four to six weeks old. Do not hold plants for long periods before planting out, as root congestion will quickly develop. Free-foraging roots will anchor effectively in the soil and plants will be less prone to wind damage or root death.

- Select and grow lines adapted to and surviving well at your location, avoiding those known to develop severe wood-rot problems.
- Use disease-free planting stock.
- Control other damaging diseases such as root-knot nematodes. A combination of nematode damage and wood rot will lead to more rapid decline.
- Plant in well-drained soil (see control measures for *Phytophthora* above).
- Avoid damaging or stressing plants in any way. Supplementary irrigation is needed to establish new plantings and in times of drought. Drought stress may predispose plants to diseases such as macrophomina rot.
- Provide adequate protection from damaging winds. Protection may have to be much more substantial than for most other crops. Prune plants so that they develop a sturdy framework that resists wind damage.

Root-knot nematodes

Cause

Being a perennial crop, rice flower is particularly prone to nematode problems, and is susceptible to at least four species of *Meloidogyne*: *M. javanica, M. incognita* and *M. arenaria* in warmer climates, and *M. hapla* in cooler districts.

Symptoms

Affected plants generally, grow poorly; they may become yellow and stunted, and leaves may drop or wilt. When infection is severe plants may fail to respond to irrigation and fertiliser. Often there are no obvious aboveground symptoms until the plant is stressed. As secondary rot organisms follow nematode damage, plants may exhibit symptoms of dieback. Below ground, infected roots develop distinct swellings or galls that look like knots in the roots (Plate 20). Severe galling and root rot develop following infection by most root-knot nematode species (Plate 21), except for M. *hapla*, which produces much smaller galls (Plate 22). Plant death frequently results from a combination of nematode damage and attack by secondary organisms.

Source of infection and spread

Root-knot nematodes may spread in running water, with infested soil, on farm machinery and less commonly (although very effectively) with infected planting stock. They can build up and spread quickly in irrigated free-draining sands. Once introduced, nematodes increase in numbers on susceptible host plants. They have a very wide host range that includes many weed species.

Occurrence and importance

Root-knot nematodes are common soil inhabitants. They are a major factor limiting rice flower production, and can cause complete loss of commercial plantings.

Nematode populations build up in areas regularly cropped with susceptible plants, particularly in very sandy soils. No useful resistance to root-knot nematodes has been found in any of the rice flower lines so far tested. Nematode problems may be exacerbated in very sandy soils combined with over-wet conditions.

Nematode control:

- before planting, test for root-knot nematodes
- avoid infested sites, or fumigate before planting
- increase levels of soil organic matter
- practise crop rotation with plants that are not hosts to root-knot nematodes.

Preplant testing

It is essential to test for the presence of root-knot nematodes well before planting, as nematodes are not easily controlled once plants have become infected.

Check for swelling and galls on the roots of nematode-susceptible crops, weeds or native plants up to 12 months before planting rice flower. Take action to reduce populations if root-knot nematodes are present (see Control using cultural practices next page). Time must be allowed for practices such as fallowing or rotating rice flower with a nematode resistant crop, which slowly reduces nematode populations.

Test soil samples for the presence of root-knot nematodes at least two months before the expected planting date. Soil samples can be tested by a disease diagnosis laboratory or by using the tomato plant bioassay technique (see Carson 1997). Professional testing and advice as well as do-it-yourself testing is recommended. Both approaches have advantages and disadvantages: laboratory tests are fast, but may not detect nematodes if populations are very low; tomato bioassaying is slower, taking about four weeks, but can detect very small nematode populations.

Preplant treatments

Where nematodes occur, some form of soil treatment before planting must be carried out to reduce populations. Some cultural practices, such as the addition of organic soil improvers, will help do this. However, reducing nematode numbers may not be sufficient: even very small populations may multiply rapidly and reach damaging numbers on the roots of rice flower, which is very susceptible to root-knot nematode.

Fumigation with methyl bromide gas is an effective means of eliminating root-knot nematodes in affected ground. However, methyl bromide is highly toxic and must be applied by a licensed operator. Whole-block treatment is preferable to strip treatment, but is prohibitively expensive ($8 000/ha). Australia is a signatory to the Montreal Protocol on substances, including methyl bromide, that deplete the ozone layer. Under this agreement, methyl bromide use is likely to be completely phased out by 2005, hence it is becoming a less viable option.

Soil solarisation can be effective in reducing soil nematode levels. Wetted soil is covered with clear plastic, trapping the sun's heat to disinfest soil. To be effective, the soil temperature must be raised to at least 40°C, preferably 45°C or above, to the depth of the root zone. For a satisfactory treatment, clear skies and air temperatures above 35°C are required for at least two or three hot periods of several days' duration. To achieve this, solarisation periods of four weeks are normally needed, though the treatment is sometimes completed sooner. The technique is not suited to all climates and seasons.

Mobile steam sterilisation techniques are being developed and could be used in the future. Research continues into alternative methods of fumigation.

Clean planting material

Check the root systems of incoming tube stock for visual symptoms of root-knot nematodes. However these will not always be evident, so choose suppliers with a reputation for healthy plants. Root-knot nematodes are not commonly a problem in nurseries with good standards of hygiene, but potting mix ingredients such as sand may become infected, particularly if contaminated by soil. Ask the nursery operator about the composition of the media used and the measures taken to prevent the spread of diseases through the mix and by contact with ground water.

Control using cultural practices

Some cultural practices will reduce numbers of root-knot nematodes in soil. None of these practices are highly effective, but combining several of them will decrease (though not completely eliminate) nematode populations.

- Avoid continuous cropping with nematode-susceptible crops, including rice flower. Use crop rotation with nematode-resistant crops such as sorghum x sudan grass hybrid cultivar 'Jumbo' in summer, or a cereal such as oats cultivars 'Algerian', 'Amby II' or 'Culgoa II' in winter. (For details of many other possible nematode-resistant crops see Stirling *et al* 1996).
- Cultivate and rest land between crops, and control weeds. Mechanical damage by cultivation, the heating and drying of exposed soil, and a lack of host weeds will all help to reduce nematode populations. A 4–6 month fallow period can reduce nematode numbers by over 95% in moist warm soils in Queensland.
- Remove and burn infected plant roots as quickly as possible. Large numbers of nematodes build up rapidly on plants and many are initially contained within roots. Their prompt removal will substantially reduce overall populations.
- Some organic soil improvers can affect nematode populations. In trials with vegetable crops, application of 20 to 25 cubic metres of chicken manure per hectare reduced damage by nematodes. Some rice flower growers have used pre-plant applications of chicken manure, and molasses applied through trickle irrigation, with apparent benefits. However, the use of these amendments cannot be recommended without further evidence of their effectiveness.

Postplant nematicide treatment

Nematicides are dangerous chemicals that should be applied strictly in accordance with label directions. Read the label carefully and check registration status in your state before use. Use chemicals such as fenamiphos (Nemacur)[5], applied immediately after planting and repeated at the recommended interval. They have a protective function only, and will not be effective if applied to plants that are already infected.

Soil microorganisms that de-activate fenamiphos build up with repeated applications of the chemical, making it ineffective after as few as two applications. Chemical protection will be more effective if other measures (previously outlined) are also used to reduce nematode populations.

[5] Mention of a specific nematicide is meant as a guide only and not an endorsement of a particular company's product. You must check that a particular product is registered in your state for the use you intend to put it to, and follow all label directions, including safety directions and warnings.

Some additional strategies

Rice flower is very intolerant of root-knot nematodes and even very low numbers can cause severe damage, especially after the first year. Planting rice flower is not recommended if root-knot nematodes have been detected before planting. However, experience may show that the use of several control measures, including preplant fumigation, a postplant nematicide and other cultural practices may allow the crop to be grown successfully.

Another suggested strategy for affected sites is to crop high-density plantings of rice flower for one or two years, removing plants before major yield reductions occur. This method has not been proven, but could be effective in warmer (high growth rate) climates when the previous crop was relatively nematode resistant. See Chapter 15 for a cash flow budget for a high-density planting scenario.

Summary

Detection of nematodes:

- Assume that root-knot nematodes may be present in the soil.
- Examine the roots of susceptible plants (rice flower, other crops, weeds and native plants) for symptoms.
- Test the soil for presence of root-knot nematodes, using laboratory soil tests or tomato plant bioassay.

Once nematodes are detected, take measures to reduce their populations:

- Use environmentally friendly measures such as fallowing, organic soil amendments, crop rotation with nematode-resistant grasses, and crop hygiene practices.
- Wherever possible, avoid using environmentally damaging fumigants such as methyl bromide.

Retest:

- Following the use of non-chemical methods to reduce nematode populations, re-test by tomato plant bioassay before planting.

Plant:

- Only if the tests are negative and no root-knot symptoms are observed:
- Use disease-free stock from reputable nurseries.

Miscellaneous foliage disorders

Rice flower is subject to a number of foliage disorders causing shoot, leaf and stem dieback or death, or abnormal growth. The cause of many of these disorders has yet to be determined.

Shoot dieback disorders

A number of disorders, mainly affecting new growth, have been troublesome in some growing areas.

White blister is a disease caused by the fungus *Albugo tragopogonis*. This is potentially an important disease. Although not many occurrences have been identified in rice flower, the disease has caused severe damage in nursery and field plants. Some new selections appear highly susceptible.

The cause of other dieback disorders has not been determined, although sucking insect pests, nutritional disorders or pathogenic fungi may be involved. A number of fungi have been found, sometimes consistently, associated with some of these disorders. They include *Alternaria*, *Colletotrichum* and *Exserohilum* species. Pathogenicity has not been demonstrated with any of these fungi and they may simply be saprophytes secondary to some other cause of damage.

The symptoms of white blister are shoot and stem dieback with small white blister-like fungal structures within dead areas. Control measures include treatment with a broad-spectrum protective fungicide.

Typical symptoms of other types of stem dieback may include the browning and rapid death of young shoots and stems, or a pale discolouration or bleaching of tip growth (sometimes referred to as 'brown tip' and 'white tip' by growers see Plates 23 and 24 respectively) and apical dieback. Any control measures will depend on the correct diagnosis of the underlying cause of the problem.

Wind or other mechanical damage

Mechanical damage to plants is frequently caused by strong winds (Plate 25). It commonly occurs in association with wood rots and root congestion. Rice flower is generally a fragile plant, producing brittle and easily damaged woody stems. Other factors contributing to damage may include waterlogging, drought stress, insect attack, and root infection by nematodes and *Phytophthora*.

Obvious symptoms are cracked or broken branches, usually near ground level; frequently, when stems are split obvious rotting and fungal growth are evident. Root damage may also occur. Dark and obviously rotted roots commonly occur where root systems are congested, (see also symptoms described above for wood rots and other diseases).

Plant damage in association with other diseases, particularly wood rots, is common. Damage is likely to be the primary problem, followed by slowly developing fungal wood-rot diseases.

To prevent plant damage:

- Avoid where possible exposure to strong winds, waterlogging and drought stress. Use windbreaks and/or plant support structures and irrigate strategically. Pay attention to soil drainage (see control measures previously outlined for *Phytophthora*).
- Plant only vigorous and healthy stock obtained from reputable suppliers.
- Plant out only material that has spent minimal time in containers.
- Apply the control measures previously outlined for *Phytophthora*, wood rots and root-knot nematodes.

Some selections of rice flower vary in wood strength under cultivation. The selection of types with stronger wood may be a future option.

Other disorders

Bypassing and growpast are common names for a commercial fault in otherwise acceptable flowering stems. Typically, immature shoots occur beside or beyond mature corymbs as a result of uneven plant growth. These can be either vegetative or flowering (see Plates 26 and 27).

Fasciation involves a flattening and distortion of the terminal part of both vegetative and flowering stems (Plate 28). Its cause is uncertain, although viral infection, insect damage or non-specified physiological factors are suggested as being involved. It is only common in some varieties, which are normally discarded.

Saline soil conditions can cause symptoms ranging from whole plant yellowing (chlorosis) to generalised death (necrosis) of foliage. Typically sustained irrigation with water of will 4–5 mS/cm (4000–5000 μS/cm) will induce such symptoms in rice flower crops (see Plates 29 and 30).

Root congestion (binding)

Cause

Root congestion results when plants are held too long in containers before planting out.

Symptoms

Roots are gnarled and twisted, in severe cases forming a tightly packed mass (Plate 31). These roots do not grow or spread out properly. Wood or root rot is commonly associated with the restricted root development. Congestion is not usually obvious when planting out, but may be severe after only one season.

Occurrence and importance

Root congestion was a common feature of rice flower plantings in the past. However, with more awareness of the phenomenon and earlier planting out of tubestock, it is now less frequently seen.

Preventive measures

Plant only good quality nursery stock that has had minimal time in containers (Plate 32). Check the age of planting stock before purchasing and planting. Stock four to eight weeks old is ideal, depending on what time of the year it is produced. One trial showed that six-week-old root systems in tubestock were satisfactory, although some congestion developed as plants matured in the field. However, plants held for an additional four weeks (by potting on) before planting out eventually developed severe root congestion in the field.

Clearly, tubestock should not be held over to the extent that root congestion becomes a problem. When root congestion exists physically pruning the roots just before field planting can help, provided the congestion is not too severe. Treatment of tubes or pots with copper compounds is not recommended, as it may lead to severe root compaction.

Summary—important disease control measures

- Nursery Stock: Plant out healthy and vigorous planting stock grown in nurseries with high standards of hygiene.
- Root System Development: Ensure a healthy, well-anchored and non-congested root system in the field by planting out only young tubestock that has spent minimal time in containers.
- Minimisation of *Phytophthora* Problems, Root Damage: Select growing sites with internally well-drained soil and additional systems to efficiently remove surface water (such as raised beds and drains).
- Root-knot Nematode Prevention: Avoid root-knot nematode damage by always testing for nematodes and, if they are present, using a combination of methods to reduce populations before planting.
- Preventing Damage: Take measures to avoid plant damage or stress. Protect plantings from strong winds, use supplementary irrigation to prevent drought stress, and prune to develop a sturdy stem framework.
- Selection of Lines: Select suitable lines with good local survival records and disease tolerance. Trial new selections in your area before planting large numbers.

13 Postharvest handling

Understanding the postharvest problems[6] of rice flower is of paramount importance to obtain a product that has a good postharvest appearance and is of reliable quality. Rice flower has a number of postharvest problems including leaf drop, leaf blackening, flower wilt and flower shatter.

The harvest time for each rice flower cultivar is very short and critically important. Optimum harvest maturity is when 40–50% of capitula are full size and less than 10% are broken. Rice flower must be picked when the flowers are at the plump bud stage (see Chapter 5 and Chapter 6). When the bracts are fully open they shatter very easily and cannot survive harvesting and marketing. Overmature rice flower is a major problem in the market place, particularly at the end of the season (see Maturity and quality for harvesting Chapter 6 Table 2 3.1). On the other hand if the stems are picked too young the immature capitula stalks wilt. Water uptake can be improved and wilting delayed by adding 50 ppm chlorine to the vase solution.

Leaf abscission and blackening are the main postharvest problems. Leaf abscission occurs on both fine-leafed and broad-leafed forms, but is more obvious on the latter due to their larger leaf size. Silver thiosulphate (STS) can reduce leaf abscission on both forms. Leaf blackening may occur when the harvested crop is exposed to increases in ambient temperatures (for example >25°C). It can also result from transport and storage problems and has been reported in Australian-grown rice flower in both the United States and Japanese markets.

The end of useful vase life of rice flower[7], is characterised by any of the following symptoms—flower wilt; discolouration (usually yellowing, browning or blackening) of a major proportion of either capitula, peduncles or leaves; shattering of capitula or leaf fall[8]. A vase life of between six and eight days should be routinely achieved at the destination point for export rice flower. Vase life can vary between cultivars and between growing locations. The market requirement is for a vase life of seven to ten days or longer. Stem length and stem diameter do not appear to be factors in maintaining quality, and a similar range of variation is experienced with both short and long-stemmed bunches and with thick and thin stems.

Cultivars and production location

Good postharvest life begins with the selection of rice flower cultivars with good vase life and an extended harvest period, that are well suited to the conditions under which they will be grown. The substantial variation in useful cut flower quality characteristics, such as stem architecture, corymb colour, vase life and period of harvest maturity, has been well documented for rice flower by Beal *et al.* (1995) and Beal *et al.* (1999).

In a study conducted at the Institute for Horticultural Development (IHD), Knoxfield (Victoria), a range of rice flower clones was obtained from various locations to compare their vase life following simulated transport. The cultivars and selections with a vase life of more than seven days after simulated transport were 'Redlands Sandra', 'Cook's Snow White' and 'Redlands 95.3', all from Queensland, and the pink mid-leaf form from Victoria (Table 7). Interestingly, 'Redlands Sandra' obtained from Monbulk, Victoria had a poor vase life compared with cultivated 'Redlands Sandra' obtained from its natural climatic zone in south-east Queensland. This subtropical cultivar was struggling under temperate zone cultivation and its impaired vigour affected its vase life performance.

Pretransport pulses

Experiments conducted at IHD on a pink mid-leafed form of rice flower looked at the effect on vase life of a range of pulsing solutions administered prior to simulated transport. None of the solutions tested were any more effective than water for immature stems. Enhanced vase life, compared with re-hydrating stems in water alone, was obtained from mature stems in three solutions: 50 mg/L chlorine (80 mg/L sodium dichloroisocyanurate, DICA), 2 g/L citric acid (pH 2.5), and 0.01% Agral plus 250 mg/L aluminium sulphate. These solutions increased the mean postharvest life of this cultivar from 10.8 days to between 12.9 and 13.1 days.

Although some cultivars of rice flower seem to respond to pulses of STS (an inhibitor of ethylene action), the role of ethylene in the postharvest life of rice flower needs further investigation. In a study by IHD Knoxfield, a pink mid-leafed form responded significantly to a 0.1 mM STS[9] (silver thiosulphate complex) pulse. The total postharvest life increased from 10.8 days with water to 15.2 days after the STS pulse. The stems that had the STS pulse were more uniform in their total postharvest life than the stems rehydrated in water alone. However, recent work by Macnish *et al.* (2000) indicated no significant effect of the gaseous, ethylene-binding inhibitor 1-MCP (1-methycyclopropene) on rice flower, either with or without exposure to an external source of ethylene.

Pretransport treatments

In warmer climates where rice flower is vigorous and well adapted, the accepted practice for fine-leafed forms is to cool the stems quickly to 2°C without rehydrating them. It is recommended that stems maintained out of water be cooled within two hours of harvest. At temperatures greater than 28°C, processing should be as soon as possible—preferably less than one hour—after harvest. The stems should

Table 7: Postharvest life of rice flower clones

Species	Clone	Growing location	Transport time (days)	Vase life (days) after transport
Ozothamnus. diosmifolius	CG3	Redlands, Qld	3	6.4
O. diosmifolius	Cook's Tall Pink	Redlands, Qld	3	6.4
O. diosmifolius	Cook's Snow White	Gatton, Qld	5	8.5
O. diosmifolius	Redlands Sandra	Redlands, Qld	3	8.5
O. diosmifolius	Redlands Sandra	Monbulk, Vic.	4	3.2
O. diosmifolius	54.4	Redlands, Qld	3	4.2
O. diosmifolius	67	Redlands, Qld	3	4
O. diosmifolius	95.3	Redlands, Qld	3	7.0
O. diosmifolius	mid-leaf, pink	Wangaratta, Vic.	3	7.8

then be held at around 2°C if possible throughout the marketing chain.

Precooling stems improves vase life, although in one experiment there was a slight reduction in the vase life of fine-leafed forms in south-east Queensland when stems were precooled while standing in buckets of water (Johnston *et al.* 1992). In other circumstances, particularly at higher temperatures, growers have gained major improvements in vase life quality by placing stems into water either in the field after harvest or soon after in the packing shed. In a trial conducted by Agriculture Victoria on 'Redlands Sandra' from Monbulk, Victoria (on stems with an inherently low vase life), stems that were rehydrated with water at 0°C or 20°C rather than stored dry at 0°C had a significantly better postharvest life. No significant difference was seen between stems rehydrated overnight in the cold compared with those rehydrated at room temperature.

Posttransport solutions and treatments

In earlier studies conducted at the Centre for Amenity and Environmental Horticulture in south-east Queensland a vase life exceeding 10 days was obtained with vase solutions containing 2% sucrose and 50 ppm chlorine and 50 ppm chlorine alone (Beal *et al.* 1995). Higher sucrose levels (5%) increased browning of the peduncles and reduced vase life. Flower development ceased in the absence of sucrose, but continued in its presence. This may make the addition of sucrose to the vase solution more suitable for immature flower heads than mature ones, which might shatter.

In a IHD Knoxfield experiment using 'Cook's Snow White' from Gatton in Queensland, two vase solutions, one with: 1% sucrose and 50 mg/L chlorine (80 mg/L sodium dichloroisocyanurate, DICA), and the other with Chrysal (one 11 g sachet/L), significantly improved the total postharvest life of rice flower, compared with water alone. With these vase solutions the mean postharvest life of this cultivar was increased from 8.5 days to between 10.7 and 12.0 days. Stems treated with Chrysal were more uniform in their total postharvest life than stems in water or in the other vase solution. Such an improvement in consistency contributes to overall stem quality.

In the same study, no differences were found when stems were re-cut in air or underwater or not re-cut, following transport, although stems cut underwater took up more water.

Stems that were rehydrated overnight in a cool room at 0°C after transport, were found to have a significantly improved postharvest life. The mean postharvest life of the stems that were cooled after simulated transport was 14.6 days, compared with 11.6 days for those that were rehydrated at 20°C.

Stem and leaf blackening

Blackening in rice flower is a common problem, believed to be of physiological origin and similar in nature to that observed in some protea species (Plate 33). The problem can be severe in some seasons and in certain cultivars. It is known to be more of a problem when there is unseasonal rain during harvest, and is more common in higher rainfall areas, than in drier zones. The cut stems appear to have less sensitivity to blackening in drought years, when rice flower plants tend to be wiry and less succulent.

The apparent relationship between blackening, high temperatures and the changing water status of rice flower plants in the field and cut stems needs further research. Growers should be aware of the increased risk of blackening associated with high field and postharvest temperatures, delays in cooling stems and inefficient protection from heat along the marketing chain.

Severe blackening symptoms were induced in both a fine-leafed and a broad-leafed form of rice flower after holding vegetative stems for one or two days at 35°C (Beal *et al.* 1995). In contrast only moderate leaf blackening developed after three or four days at 26°C. Leaf blackening was virtually non-existent at 2°C. The effect of heat appears cumulative, with longer exposures to moderate temperatures also generating blackening. This supports the findings of previous studies into the effect of increasing temperature on rice flower (Johnston *et al.* 1992). Cut rice flower stems benefit from rapid cooling immediately after harvest and being held at around 2°C throughout the market chain (see also Chapter 6 Postharvest

Standards).

In a study of leaf and stem blackening prior to simulated transport, blackening in a pink mid-leafed form of rice flower was found to occur after the stems were subjected to rough handling, but not after normal handling, nor after the retention of excessive water within the packaging. During the bunching and binding of the stems, the rough handling (excessive finger pressure and tight banding) was observed to increase the aroma of the essential oils in the air, in comparison with normal handling. These oils are usually found in the leaves (and occasionally in the soft stem tissues) and are released following bruising or crushing of the plant tissue. After the three-day period of simulated transport the area that had been roughly handled was blackened, unsightly and unsuitable for sale. Leaf blackening has also been reported following other incidents of damage resulting in crushing or bruising.

Insects

Insects may often be clearly visible on the stems during the grading process, though this is not always the case. Sometimes they may only become apparent days later with larvae emerging from the inflorescence, grazing on the flowers, covering the heads with webbing and depositing frass. Moth or butterfly caterpillars are commonly encountered postharvest pests.

These pests can be controlled with approved insecticidal dips for cut flowers. Deltamethrin (for example Cislin) at 250 mL/100L is commonly used in Queensland and Western Australia. Dips must be properly maintained and replenished. Alternatively flowers can be fumigated. The aerosols Pestigas (pyrethrins plus piperonyl butoxide) and Insectigas (dichlorvos) can be used either alone or in combination, but these gases are not effective on all insects and are less able to penetrate the flower head than a true fumigant. The phosphine formulation ECO_2FUME (a fumigant) plus Pestigas (which acts to mobilise as well as kill insects) is registered for use on flowers. Rice flower exposed to ECO_2FUME plus Pestigas for16 hours remained in good condition.

Where insecticides are mentioned, they are meant as a guide only and are not an endorsement of a particular company's product. You must check that a particular product is registered for the use to be made of the product, including registration in your state of Australia and follow all label directions, including safety directions and warnings.

Postharvest disease problems

The fungi *Botrytis* and *Alternaria* are the two main organisms commonly associated with postharvest disease in cut rice flower. However, the role of these fungi as a primary cause of breakdown or as a secondary agent to other forms of damage has not been determined. The symptoms of postharvest disease include blackening of the leaves and flower heads and wilting of the peduncles. Stems can show no symptoms in the packing shed but deteriorate during transit, resulting in a soft and soggy black product on arrival. In Queensland, bunches are commonly dipped in the fungicide iprodione (active ingredient) plus a wetting agent prior to packing into boxes; however iprodione is not approved for this use in other states.

Where a fungicide is mentioned, it is intended as a guide only. You must check that a particular product is currently registered for the use to be made of the product, including registration in your state of Australia and follow all label directions, including safety directions and warnings.

Although dipping can be used as an insurance against postharvest diseases, other control measures are essential. These include in-field control of foliar diseases, preferably with a fungicide different from the one used in the dipping solution. Good hygiene in the packing shed is also important. Flower buckets and the solutions in them, along with cutting tools, bench tops, the shed floor, cold rooms and storage areas, should be kept clean and free of plant debris.

Pest and disease control

Most export markets require stems to be free from insect pests and diseases. This is best achieved through growers providing good in-field pest and disease monitoring and control. Dipping provides a secondary defence against the development of postharvest disease. Fumigation and postharvest dipping treatments are normally effective in killing only low-level infestations of insects.

For quarantine purposes some postharvest insect control measures are essential on all rice flower destined for export. The Japanese market has a zero tolerance for live insects not already present in Japan and the United States has a low tolerance for insects. Re-infestation of consignments with insects can be a problem, which some growers have overcome by sealing the vents in the cartons with gauze. It is worth noting that, if treatments in Australia prove ineffective, exported rice flower will not tolerate quarantine fumigation with methyl bromide, a common practice in Japan.

Postharvest processes

The harvesting, grading, packing and cooling of fresh rice flower should be conducted according to the standards outlined in Chapter 6. Poor quality and badly packaged stems can easily yield negative returns after commission, government charges and freight have been deducted. This necessitates a rigorous adherence to quality standards on the plantation and in the export packing shed prior to departure. Many exporters have their own product quality audits to provide feedback to growers.

The following points about getting rice flower successfully to market need to be noted:

- The packing density of each carton needs to be correct. Too few stems per carton means that stems shift excessively during handling, while too many stems results in crushing and increases the potential for overheating.
- Cartons must be strong enough not to collapse during transport.
- Rough handling at any stage of transit (plantation to export packing shed to freight forwarder to importer to overseas distribution chain) can cause mechanical damage and blackened leaves.
- Overheating due to lack of cool storage facilities at airports and receiving depots, to non-refrigerated vehicles and to poor distribution infrastructure at some overseas destinations is common. If possible, choose a route for your flowers that will keep them cool.
- Delays in placing stems in cool storage, along with delays caused by inadequate documentation and changes to flight schedules and route travelled, all affect the quality of rice flower at the destination market. Choose a reliable exporter and freight forwarder and take care to get the documentation right.
- Take measures to control pests and diseases (originating at the plantation or from re-infestation) otherwise consignments can be condemned or subjected to expensive and deleterious fumigation treatments.
- Poor quality product at packing is likely to deteriorate into product of extremely poor quality further down the distribution chain.

The on-farm postharvest chain is summarised in Figure 3 and illustrated in Plate 34.

Summary

To obtain a good postharvest life from rice flower, the following points should be considered:

- The preharvest considerations are paramount.
  - selection of cultivars and forms with a good vase life is essential;
  - selection of forms suited to the growing area is important. Vase life will be maximised in healthy, well-cultivated plants.
- Harvesting at the correct stage of maturity is important to maximise vase life.
  - optimum harvest maturity is when 40–50% of capitula are full size and less than 10% are broken;
  - additional information is provided in Chapter 5 (Harvesting) and Chapter 6 (Postharvest standards).
- Stems should be handled with care as they can be bruised; this is particularly the case with mid-leaf forms.
- In warm areas, the stems should be cooled to remove the field heat.
- Leaf blackening is a common postharvest problem. STS can be used to control leaf blackening in the mid-leaf form. The additional

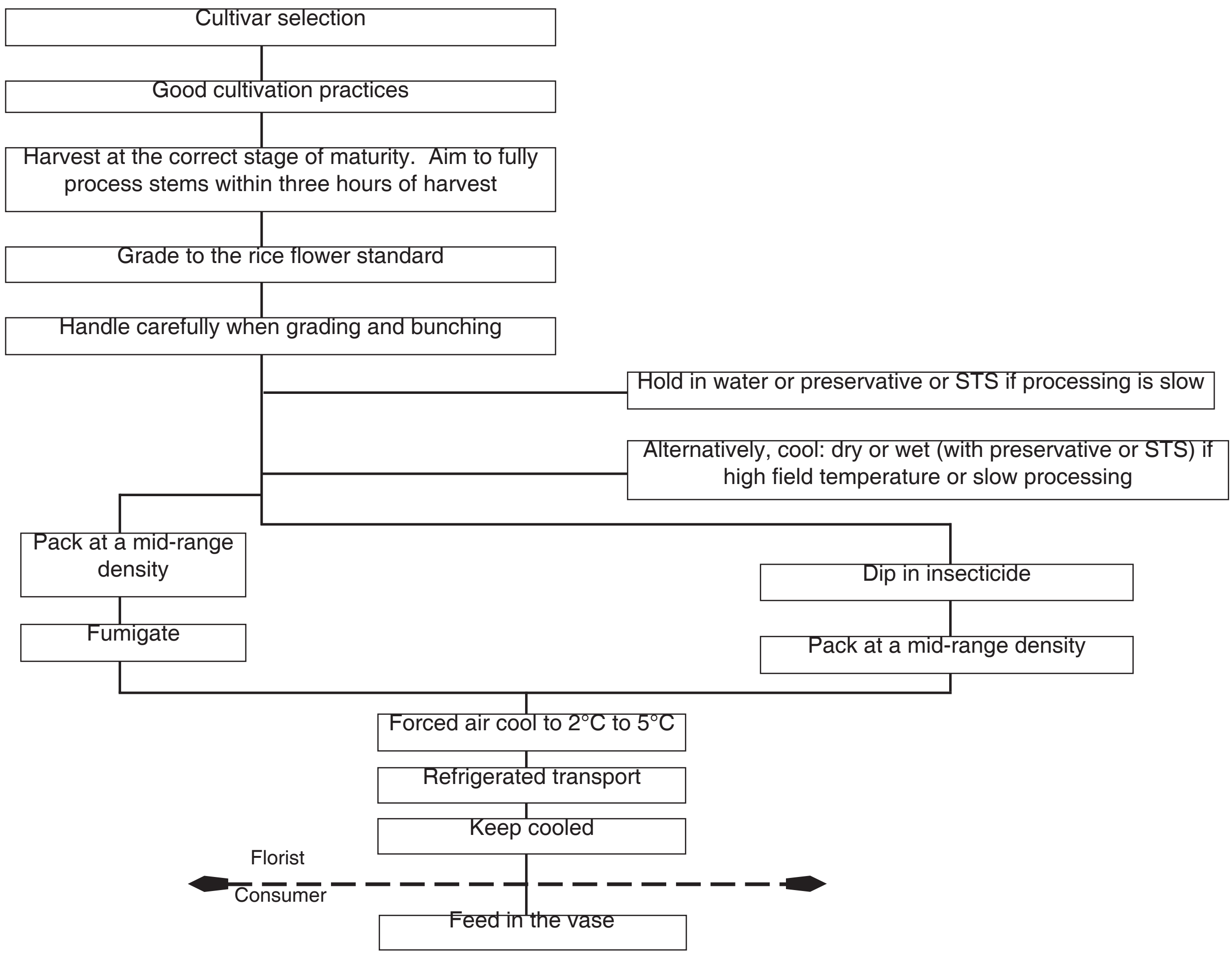
cost is approximately 6c/100 stems for chemicals, plus the cost of labour, buckets and space.

- For stems not rapidly cooled, the vase life of the flowers can be maximised by rehydrating the stems in water before storage and transport. Rehydration with 50 mg/L chlorine or 2 g/L citric acid (pH 2.5) or 0.01% Agral plus 250 mg/L aluminium sulphate is even better.

  Additional cost of rehydration with chemicals is approximately 1–2c/1000 stems for compounds, plus the cost of labour, equipment and facilities.
- Stems should be dipped in an insecticide or fumigated to prevent hatching of insects on the flowers.
- If unable to use forced air cooling, try to increase the speed of cooling by precooling after harvest but before packing, leaving cartons open in the cool room or packing in the cool room. Pretreatment with STS and/or water and preservative is more important when forced air cooling is unavailable. Consider holding stems in water or preservative solution prior to transport.
- If the stems can be cooled during and after transport vase life will be improved.
- At the consumer or florist level, if the flowers are supplied with a solution containing 1% sucrose and 50 mg/L chlorine or a flower preservative such as Chrysal, vase life can be improved

Implementation of these guidelines will help ensure that rice flower has a good postharvest appearance and a reliable quality during an extended vase life.

Figure 3: Rice flower—steps to achieving good postharvest quality



14 Marketing

Fresh rice flower competes in a fickle and fashion-conscious world market with plentiful supplies of other flowers. It the grower's job to ensure that rice flower is attractively presented, performs well for the customer and is seen as being value for money.

A small domestic market exists for rice flower as a filler, but the greatest potential for volume sales and high profits is in the export arena. The Australian domestic market is characterised by small volumes, low risks and low returns for growers. The export market can accept large volumes of good quality rice flower and can provide the growers with good returns for it. However, inferior product can easily result in a low or even a negative return. In 1999 the average return to grower, over all export markets, was between A$0.40 and A$0.70 per stem, an average to below average figure. Average prices in that year, a difficult one for coastal Queensland growers, reflected the effects of unsuitable weather on rice flower quality. In 2000, the quality of Queensland rice flower was greatly improved and the exchange rate favoured Australian exporters; however, the average return to grower remained similar due to a flat market in Japan and increasing freight rates due to high oil prices.

Export markets

The major export markets are Japan, which generally pays high prices for quality long-stemmed rice flower, and the United States, which provides a lower per-stem return but is a high-volume market for shorter-stemmed flowers. Test marketing has also been done in some Asian markets other than Japan, and to Europe. There is a market for rice flower in Taiwan and Hong Kong, however these markets expect good quality at low prices. There is also interest in the Netherlands and Italy in rice flower, however the European Union tariffs (although being progressively reduced) and high freight costs, mean that supply is most likely to come from Israel or the African continent. Overall, export demand is expected to remain firm for quality rice flower harvested at the correct stage of maturity. Relatively high export prices for fresh rice flower, coupled with a lack of preserving know-how, has delayed the development of potential markets for a preserved product. In the United States a large proportion of the crop is sold to preservers.

In addition to the United States, rice flower is grown in Japan, New Zealand and Israel as well as in Australia.

More information on specific market requirements and uses for rice flower, and on the costs, risks and mechanics of exporting, is contained in *Rice flower—Integrating production and marketing* (Carson and Lewis 1997). For details of potential export markets for rice flower and a broad view of international competition and the place of rice flower in the world market, refer to *Riceflower as an export industry—Market opportunities* (Lewis *et al.* 1997).

To position themselves at the top end of the international market, flower growers need to know their product and their market. Exporters are able to provide the latest information about requirements for specific markets in terms of stem lengths, bunch sizes and colour-mix requirements. Growers will find it worthwhile to cultivate a good business relationship with their exporter(s). Good export agents provide growers with not only information on price received but also valuable feedback on other aspects of their product.

Lack of continuity of supply, poor quality, leaf blackening, over-mature flower heads, short shelf life and cultural preferences relating to colour, flower form, use and seasonal availability all have an impact on market acceptance. Growers need to pay special attention to the effects of the entire cool chain on quality right up to the time their product reaches the final consumer. Any break in refrigerated storage and/or refrigerated transport diminishes product quality and reduces returns.

To maintain acceptable prices per stem in overseas markets, quality control is vital, and needs to be implemented through all the phases of growing, harvesting, packaging, transport and marketing. A major quality issue in wetter seasons can be leaf blackening. It is more common in coastal areas and in some varieties. Another factor is that many growers are still not harvesting at the correct stage of maturity. The market is particularly intolerant of shattering in over-mature flowers, a phenomenon commonly resulting in a cascade of bracts, seeds or even capitula from the bunch (see Plate xxx).

For all export markets:

- Harvest at the correct stage of maturity.
- Grade to an Australian standard.
- Pack boxes correctly (not tightly packed, but not too loose).
- Use forced air cooling on the farm.

- Maintain the cool chain.

Japan

Fresh rice flower is air freighted to Japan (Osaka or Tokyo) as bunches in lengths from 50 cm in 10 centimetre increments through to 110 cm. Extra-long stems may be sent loose. Japan is a high-priced market, the best prices being paid for well graded, long-stemmed, quality rice flower harvested at the correct stage of maturity. Growers who provide consistent presentation and good quality can generally expect to be rewarded with good prices.

Stems are normally kept refrigerated until their departure from Australia. In Japan, however, they are sometimes subjected to high ambient temperatures during customs and quarantine clearance and periodically through the marketing chain. Japanese flower handlers do not use forced air cooling and this can lead to problems, particularly in August and September when air temperatures can be high. Most rice flower is distributed to one of more than 200 auctions. From the auctions it moves through the wholesaler, via the internal freight network, to the retailer and final customer. Direct selling of flowers is gradually increasing in importance in Japan, but the distribution of larger volumes still requires the use of the auction system.

Although it is unusual for flowers sent to auction to be left unsold, prices received are sometimes very low. For rice flower the range can be from 10 Yen ($A0.18[10]) per (short) stem to more than 300–400 Yen ($A5.37–7.17) per (long) stem. Net returns to grower after insurance, commissions, freight and Australian quarantine inspection fees are deducted are around half the auction price. Longer stems generally bring higher unit prices than short stems of equivalent quality. Prices received at auction can vary dramatically between auction houses and between shipments; growers therefore need to use average return data collected over time on considerable volumes to obtain return figures for budget forecasting purposes. Spot prices can be dramatically misleading.

Japanese buyers value the small delicate buds of rice flower and the colour and texture it adds to

[10] Based on a highly favourable exchange rate for Australian exporters (depreciating $) as at 20 October 2000 of 55.8181 Yen (¥) to A$1.00. However, an appreciating Australian dollar can be 90 ¥ to A$1.00, which would translate to an auction price of A$0.11 for a 10 ¥ stem and A$3.33 for a 300 ¥ stem.

arrangements. Most rice flower is sold by florists, who use it in arrangements for gift giving, for weddings and for foyer displays in hotels and business premises. It is used as a main flower in arrangements in Japan, unlike other markets where it is seen as merely a filler flower.

The United States

Australian-grown rice flower is exported to the United States, in the form of weighed bunches of stems 40, 50, and 60 cm in length. These bunches normally weigh about 400 g, but there is also a market for lighter bunches. An indicative price for growers in this market would be from A$3.00–$3.50 for a 250–300 g bunch with 50–60 cm stem lengths and at least five stems per bunch.

Rice flower is perceived as a filler flower in the United States market, where florists, supermarkets and mass market outlets are the major outlets for flowers. The United States market is price-sensitive and highly competitive. Demand has been increasing for non-traditional cut flowers, a trend that should help boost the demand for Australian cut flowers, including rice flower.

The United States has a rice flower industry in California of a size similar to or perhaps even larger than that in Australia. Rice flower is harvested in the Northern Hemisphere spring (mid-March to mid-May), predominantly for use as a preserved filler flower in the domestic market. The distribution chain is different from that in Japan: there are no auctions in the United States and virtually all rice flower is sold to order on a fixed-price basis. The product is forced air cooled on arrival and kept cool, usually through to the retail level. Australian rice flower most frequently lands on the west coast—in Los Angeles or San Francisco. Although available in the Northern Hemisphere autumn, Australian-grown rice flower faces strong price competition from similar high quality filler, foliage or even mass-produced glasshouse-grown traditional flowers.

Buyers compare Australian-grown rice flower with Californian product available from March to May. During its season, Californian-grown rice flower is fresher and available in larger bunches, hence Australian rice flower can be perceived as being of lesser value-for-money Due to the long transit time to the United States, Australian growers need to be particularly vigilant in supplying rice flower that is free from dehydration and foliage blackening. The United States market expects value for money and looks for individual stems with many corymbs consistent with the length of the stems. The high cost of producing and delivering Australian-grown preserved rice flower to the United States would preclude its entry into this market.

There is little margin for error in this market. Buyers are intolerant of poor quality product, poor service and flowers that fail to meet specifications. Because Japan has an auction system most flowers can be sold there¾at some price—but in the United States poor quality rice flower will remain unsold, resulting in a claim on the exporter and cancelled orders.

The Australian market

On the east coast of Australia, consumers first became familiar with bush-harvested rice flower, which is regarded as a cheap product. This originally tended to set the price per bunch for **all** rice flower; however, consumers now accept the higher quality cultivated rice flower as a legitimate cut flower product line.

In Sydney and Brisbane, the average return to grower is between A$2.00 and A$3.50 for large bunches (generally of ten-stems or approximately 500 g). Native flower wholesalers with a specialist clientele are able to offer the best returns to growers, wholesaling cultivated rice flower at A$3.00 to A$5.00 per bunch. The Australian market accepts 50 to 60 cm stem lengths for ordinary sales and stems of 100 cm for special purposes such as hotel foyer arrangements. Longer-stemmed rice flower in general may attract an extra $0.50 cents per bunch, and there is a premium for early season, long-stemmed pinks.

Growers need to grow a number of rice flower cultivars or allied flowers, such as *Cassinia* (Chapter 16), to extend the harvest period. As rice flower itself has a relatively short season, growers need also to have other flower crops in order to maintain a market presence for the rest of the year and to develop a

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Costs and returns

One way of assessing the value of Australian native flower production is to construct a cash flow budget, and to examine the difference between variable or operating costs (expenditure) and gross return (income) over time (cumulative net return). Variable or operating costs include growing, harvesting and domestic freight costs. The calculation does not consider fixed or overhead costs such as rates, capital items, interest repayments, electricity, insurance and living costs. Nor does it include time spent in management activities and administrative overheads such as telephone, facsimile, stationery, postage, licensing costs, accountants' fees or the cost of water. These costs must be taken into account when calculating a whole farm budget.

The following budgets are intended as a guide only. The budget framework—rather than the figures provided—may be useful for developing appropriate cash flow budgets for individual circumstances. All data included in these budgets are based on information provided to the authors. Input costs and income received are subject to change without notice. No responsibility is taken for accuracy of the data. They should be confirmed and modified where necessary by the user before any decisions based on them are made.

The changing value of the Australian dollar has a significant impact on export market returns. Growers generally receive a higher return when the Australian dollar is lower relative to overseas currencies[11]. Since the same fixed overheads are associated with lower value or poor quality products, an appreciating Australian dollar reduces grower returns for lower value products more than for high value products.

On both the domestic and export markets, product prices are subject to market volatility, as are input costs. Talk to an accountant and engage the services of a qualified horticultural consultant familiar with the Australian native flower industry to maximise financial returns from the business.

General Assumptions

The budgets are based on a one hectare monoculture. However an Australian native flower farm will often have smaller units of a single crop, such as rice flower, at different ages. The introduction of rice flower onto a farm needs to be considered in the context of other flower and foliage crops and unrelated farm activities. These other activities may have a significant impact on cash flow and/or the availability of labour and other resources.

Production labour costs are included in these budgets. Extensive use of the owner–operator's own labour can reduce these cash costs and significantly improve the net returns achieved. Owner–operator labour is not costed for management or marketing activities. All operations with a machinery component include costs for fuel and oil, but not for repairs and maintenance. It is common practice for growers to replace young plants lost during establishment with new plants. The budgets do not make provision for this; however the practice can improve overall net returns for rice flower.

[11] The value of the Australian dollar varies with different currencies; for example a low US dollar value does not necessarily mean a low value with the Euro.

In these budgets the costs of export have been subtracted from the gross price in order to arrive at the net price. The off-farm overheads associated with exporting include insurance; AQIS fees; freight and distribution costs overseas, which are independent of the sale price of the product; and auction, importer and exporter commissions, which are usually a percentage of the sale price. It should be noted that in export markets the fixed overheads must be paid irrespective of the return achieved at auction. Instead of receiving a cheque growers could receive an invoice.

These budgets do not include provision for GST (input credits can be recovered by eligible businesses) or inflationary factors.

Opportunities and Risks

Rice flower is a profitable crop when both yield per unit area and return per stem are high. Cash flow budgets are strongly sensitive to price movements and to yield reductions caused by high plant mortality. If plant deaths are high (for example 20% in year 1, and another 30% of the original planting in each of years 2 and 3—not an unlikely scenario) the crop is unprofitable, even when export returns per stem are high (for example A$0.80[12]). Similarly, if export returns are low (for example averaging A$0.20 per stem) substantial net losses will be incurred, even when plant mortality is at the relatively low level (for rice flower) of 10% of the original planting per annum.

More details are provided as part of a sensitivity analysis in *Rice flower—Integrating production and marketing* (Carson and Lewis 1997).

Success in the rice flower business requires high prices—achieved through quality, innovation and service—along with low plant mortality, high yields, and an efficient cost structure. Table 8—see below shows a cost structure and cash flow budget for an average grower. Compared with these figures, good growers may be able to achieve major cost reductions, or superior yields or quality, and thus better returns.

[12] ~~In this section dollar amounts refer to A~~ustralian dollars.

[13] Includes workers compensation and superannuation.

Specific Assumptions

The budgets are for a one hectare Autumn planting of rice flower in south-east Queensland with 10% plant mortality each year for the first three years and 20% losses in each of the fourth and fifth years (where applicable).

In Table 11, years 3 and 4 are new plantings and have the same mortality rate as years 1 and 2 (10% per annum). Net export returns are set at a mid-range point of A$0.50 per stem and domestic sales at A$0.20 per stem.

It is assumed that 75 % of harvested stems are sold to the export market and 25% to the domestic market. Freight to market costs are taken to include refrigerated transport from south-east Queensland to Sydney.

Medium density planting strategy

The first budget (Table 8) is for a standard medium density planting with an average mortality rate and medium market returns per stem. The rice flower is planted in single rows 3.3 metres apart centre to centre, with an intra-row spacing of 0.75 metres; creating a density of 4000 plants per hectare.

In this example, productivity is well down by year 5 and life of the plantation should not extend beyond four years. **Income fluctuations could be reduced with a continuously rotated planting over a four year period.** A staged planting, with 1000 plants being removed and replaced every year (preferably on new ground), could achieve average net returns of A$7 224 per hectare per year.

With the budget outlined in Table 8, the average variable cost of production per stem was A$0.32. With this cost structure, domestic market sales at $0.20 per stem are actually incurring a loss, although many farmers do not cost their own labour. Most growers will sell 'seconds' to the domestic market; however for improved profits every possible stem needs to be of export quality.

Table 8: Cash flow budget for one hectare of rice flower—medium density planting (4000 plants)

Income ($)	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Yield (stems/plant)	10	25	30	35	35
Yield (stems/hectare)	36 000	81 000	87 480	81 648	65 318
Gross return (75% @ $0.50/stem export and 25% @ $0.20/stem domestic)	$15 300	$34 425	$37 179	$34 700	$27 760
Expenditure ($)					
Establishment costs					
Rooted cuttings (4000 @ $2.00/plant, including transport)	8 000				
Irrigation materials (in-paddock delivery and fittings, timer)	3 000				
Weedmat or plastic	4 000				
Soil preparation	800				
Basal fertiliser	300				
Contingencies	1 000				
Post-planting costs					
Fertiliser	100	400	440	440	440
Irrigation (electricity and pump maintenance)	300	500	550	550	550
Chemicals	400	440	500	500	500
Harvesting, processing, packing and packaging— @ $0.18/stem (including labour costs)	6 480	14 580	15 746	14 697	11 757
Freight to market (@ $0.02/stem)	720	1 620	1 750	1 633	1 306
Fuel	140	160	170	170	170
Contingencies	1 000	1 000	1 000	1 000	1 000
Labour @ $14.00/ hour[13] (all operations excluding harvest, on-farm postharvest handling and marketing activities)	4 396	1 596	1 316	1 316	1 316
Total expenditure	**30 636**	**20 296**	**21 472**	**20 306**	**17 040**
Net return	**–$15 336**	**$14 129**	**$15 707**	**$14 395**	**$10 721**
Cumulative net return	**–$15 336**	**–$1 207**	**$14 500**	**$28 895**	**$39 615**

Table 9: Labour for land preparation, planting, for crop care and maintenance (hours)

Operation	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Soil preparation (deep ripping, discing (twice), cultivation and bedding-up)	50				
Planting @ 50 plants/hour (4000 plants/ hectare)	80				
Laying irrigation lines	20				
Mulching	50				
Fertilising and spraying	24	24	24	24	24
Weed control	60	60	40	40	40
Tipping (year 1) and pruning (other years)	20	20	20	20	20
Additional crop observation/monitoring	10	10	10	10	10
Total	**314**	**114**	**94**	**94**	**94**

Experienced growers should be able to carry out the above tasks in fewer hours. As indicated, labour

[14] ~~However it may make stems less florifer~~ous, which can reduce the return per stem.

[15] Assumes that an office (administration area with a telephone and facsimile) is located in the nearby farm residence.

Labour

A breakdown of the number of hours, by activity, costed into this budget (excluding harvest and postharvest labour) is given in Table 9. Labour costs are a significant component of expenditure. Any measures that improve labour efficiency and reduce the costs of production and processing without compromising stem yields and quality, will improve the average net return achieved.

for planting is a significant component of first year labour costs. A planting rate of 120 plants per hour—considerably faster than shown in the table—can be attained by efficient and well-organised growers. The labour costs involved in harvesting and fully processing flower stems are also substantial.

Table 10 summarises the average number of stems that need to be handled per hour to achieve a harvesting, processing and packing target of approximately A$0.15 per stem, after deducting A$0.03 for cartons, banding and internal packaging (as assumed in Table 8).

Table 10: Approximate post production labour target rates for rice flower (labour costed at A$14.00 per hour)

Activity	Average number of stems/hour	Cost ($/stem)
Harvesting	245	0.057
Processing (including dipping, grading, bunching and precooling)	180	0.078
Packing	730	0.019

High density planting strategy

Rice flower can remain commercially productive for three to four years; however many growers are now replacing plants after two years (the scenario presented in Table 11). The following production strategy has yet to be experimentally verified. In the example, rice flower is planted at twice the regular density (for example, double row mounds with centres 5 metres apart and an intrarow spacing of 0.5 metre or 4–6 rows singly planted at 600 mm then an access laneway). Trial results suggest that high densities do not depress first and second year yields[14]. The plants are cropped for two years, then removed and the land is cover-cropped with forage sorghum in Summer before the rice flower replanting program in Autumn.

This strategy requires a higher initial investment, but provides a faster rate of return. Returns at year 4 are similar (given the variables associated with rice flower production) to those from the standard density planting (Table 8). **A strategy of continuous replanting will remove the peaks and troughs from the income flows in the model.** In some locations early summer planting of some selections will yield a 20 stem crop within 12 months. This substantially improves returns.

[16] Connected to water and electricity (assuming a nearby residence).
[17] A cool room may be hired for the first season.
[18] Higher figure allows for dam construction. The cost of delivering water for irrigation is subject to major variation from site to site.

Table 11: Cash flow budget for one hectare of rice flower—high density planting (8000 plants)

Income ($)	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Yield (stems/plant)	10	25	10	25
Yield (stems/hectare)	72 000	162 000	72 000	162 000
Gross return (75% @ $0.50/stem export and 25% @ $0.20/stem domestic)	30 600	68 850	30 600	68 850
Expenditure ($)				
Establishment costs				
Rooted cuttings (8000 @ $2.00/plant, including transport)	16 000		16 000	
Irrigation materials (in-paddock delivery and fittings, timer)	3 000		3 000	
Weedmat or plastic	4 000		4 000	
Soil preparation	800		800	
Basal fertiliser	450	25	450	
Removal of plants		500		
Cover crop		460		
Contingencies	1 000		1 000	
Post-planting costs				
Fertiliser	500	800	500	800
Irrigation (electricity and pump maintenance)	600	500	600	500
Chemicals	500	500	500	500
Harvesting, processing, packing and packaging—@ $0.18/stem (including labour costs)	12 960	29 160	12 960	29 160
Freight to market (@ $0.02/stem)	1 440	3 240	1 440	3 240
Fuel	170	170	170	170
Contingencies	1 000	1 400	1 000	1 200
Labour @ $14.00/ hour (all operations excluding harvest, on-farm postharvest handling, marketing activities and cover cropping)	6 076	1 876	6 076	1 876
Total expenditure	**48 496**	**38 631**	**48 496**	**37 446**
Net return	**–$17 896**	**$30 219**	**–$17 896**	**$31 404**
Cumulative net return	**–$17 896**	**$12 323**	**–$5 573**	**$25 831**

Costs of establishment

The capital investment required, even after excluding the cost of land, can be high for native cut flower production. The capital outlay required (excluding land) will vary depending on the resources already available on a property. For a grower starting from nothing, $85 000 to $150 000 in capital investment would be needed for equipment on a five hectare plantation. This would include a packing shed, a cold room, fencing, windbreaks, irrigation (pumps, filter, main lines to paddock), a fertiliser injection system, machinery (tractor, slasher, sprayer, vehicle) and sundries. Table 12 gives a breakdown of items that might be required. Farmers often have sheds and equipment that could be used for rice flower production. The use of existing resources would enable major cost savings to be made. Buying reliable second-hand equipment and hiring equipment can also cut expenses.

Savings can be achieved if growers have particular skills (such as those of a builder or plumber) and are not costing their own labour. Small growers would benefit from the use of contractors to undertake the initial land preparation, thus avoiding the need

Table 12: Capital equipment for rice flower production—five hectare plantation

Buildings[15]	**Cost ($)**
Packing shed[16]	15 000 – 20 000
Forced air cooling and cold room[17]	10 000
Irrigation—pump(s), filter, main irrigation lines	15 000 – 25 000[18]
Fertiliser injector	1 500
Windbreaks	1 000
Fencing	1 000
Fittings for shed[19]	4 000
Total for buildings	**47 500 – 62 500**
Machinery	
Tractor (25–35 hP)	9 000 – 20 000
Cultivation equipment, hoe, bedformer	2 000
Trailer[20]	1 000
Spray unit	7 000
Slasher	2 700
Strapping and bunch tying machine[21]	0 – 10 500
Delivery vehicle	15 000
Total for machinery	**36 700 – 58 200**
Minor capital[22]	**2 000**
Sundries Example: area to maintain new planting stock[23]	1 000
Total capital costs	**$87 200 – 123 700**

to purchase a large tractor and heavy cultivation equipment.

A cool store is an essential item; however for the first season, newer growers may prefer to hire rather than buy their own. Successful exporting of rice flower can only be achieved by using correct postharvest treatments, on-farm cool storage and moving the product in cooled transport.

Many growers start small, and items such as a trailer can be downscaled to a wheelbarrow. Direct planting without cultivation may also reduce costs. However do not cut corners as planting on poorly prepared ground or not on raised beds can have disastrous consequences.

[19] Bunching and grading benches, packing and boxing benches, a dipping tank, a lockable chemical store and a fertiliser storage area.
[20] To move flowers from the field to the packing shed.
[21] Bunch tying and box strapping can be done manually on a small enterprise.
[22] Such as a hedge cutter; scales for weighing chemicals and for weighing bunches; gloves, secateurs, bunch cutters and buckets; and safety equipment for handling chemicals.
[23] While not all growers have a designated area, at the very least such an area is good insurance and becomes essential if delays occur in planting out new stock. This can easily happen if the ground is not ready due to soil moisture levels that are too high or too low, inadequate soil preparation or prolonged poor weather, or if labour is not available, or if plants need rehabilitation.
The facility will need shade and wind protection, benches to keep stock away from contaminated ground water, a well-drained, sealed floor area (such as blue metal screenings or concrete) and access to good quality, uncontaminated water for irrigation.

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Alternatives to fresh rice flower

Foliage and flowers of rice flower are amenable to procedures that allow stems to be marketed not only as fresh product but also in dried (Plate 35) and dyed form (Plate 36). Cut stems can be treated with glycerol to help ensure that foliage remains supple and will not dry to the point of brittleness.

Drying and dyeing

The normal practice is to use a solution of 10–30% glycerol in water, either soaking the whole stem (the immersion method) or allowing the bases of stems to stand in the solution and actively draw it in (the uptake method). The stems are then allowed to dry.

Preliminary investigations (D. Joyce and N. Moncada, personal communication) compared uptake treatments of 20% glycerol in water, glycerol plus Sandocryl red textile dye and glycerol plus Ponceau red food dye (Plate 36). The last combination produced an attractive product (Plate 36, far right). The potential for a range of dried and dyed rice flower products is to be investigated in further trials. Introductory articles on preserving, drying and dyeing are Farmnotes by Dubois and Joyce (1994a, 1994b & 1994c) and a review by Joyce (1998).

Close relatives of rice flower

Asteraceae species other than rice flower may have the potential to complement and enhance rice flower production because of different flower colours, a different flowering season and unique adaptation (Turnbull and Beal 1998, Beal *et al.* 1999). Growers, nursery operators and researchers have identified species with these useful attributes. Examples include *Cassinia leptocephala* (Plate 37), *C. compacta*, *C. aureonitens* (Plate 38), *Ozothamnus obcordatus*, *O. diotophyllus* (Plate 39, right) and *O. diosmifolius* x *O. diotophyllus* hybrids (Plate 39, middle). These are all spring flowering and have yellow corymbs and attractive stems. *C. laevis* (Plate 40) has December–January flowering and cream-white panicles (Carson *et al.* 2000). The full potential of such species may be realised only after

17 Planting material suppliers

The information on cultivars in this section has been supplied by nursery operators and has not been independently verified.

Queensland

Diane Akers
Lass O'Gowrie Gardens
PO Box 639
CHARLEVILLE Q 4470
Ph: (07) 4654 1915; Fax: (07) 4654 1918
E-mail: dianeakers@bigpond.com
Selections from south-west Queensland; white, pink and yellow forms of *Ozothamnus*

Jim Baker
J. & R. Baker's Nursery
2 McLaughlin Street
KINGAROY Q 4610
Ph: (07) 4162 5170.
E-mail: jimbaker@kingaroy.big.net.au
Have 'Jim's Pink' (slightly later than 'Cook's Tall Pink') and other cultivars

David Carson
Wanguri Australian Cut Flowers
PO Box 249
IMBIL Q 4570
Ph: (07) 5484 5811; Fax: (07) 5484 5911.
E-mail: wanguri@telstra.easymail.com.au
A grower who does some propagation and is prepared to supply cuttings for contract propagation; has 'Coles Pink', 'Southern White' (a late mid-leafed form), and other cultivars

Damian Cumming
Ausplant Nursery
Cnr Winton & Hayden Streets
DALBY
Postal address:
PO Box 766
DALBY Q 4405.
Ph: (07) 4662 4934; Fax: (07) 4662 5611.
Have Cook's cultivars, 'Pretty Pink', 'Pearl Pink', 'True White' and 'Alpine White'

George and Sandra Hendrick
Festival Flowers
PO Box 144
ESK Q 4312
Ph: (07) 5424 1270; Fax: (07) 5424 2096
E-mail: festivalflowers@bigpond.com
A grower prepared to supply cuttings for contract propagation; 'Redbank Pink', 'Redbank White', 'Valley White' and 'Tuffi' and 'Coles Pink'

Judy Moffat
Nanju Proteas
Ravensbourne
MS 582
TOOWOOMBA Q 4350
Ph: (07) 4697 8195; Fax: (07) 4697 8195
Contract propagation of rice flower

Chris Petersen
Garoyda Nursery
PO Box 96
BURPENGARY Q 4505
Ph: (07) 3888 1735; Fax: (07) 3888 0247
E-mail: garoyda@ozemail.com.au
John Windle's selections—'Benfer's Pink Bouquet'™ and 'Windle's White Bouquet'™ grown to order

Marie Watson
Tubestocks Queenland Pty. Ltd.
133 Dalmeny Street
ALGESTER
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Phillip Dowling
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[24] NIASA-accredited nursery

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19 Abbreviations

AQIS:	Australian Quarantine Inspection Service
FECA:	Flower Export Council of Australia
IBA:	Indole-butyric acid
IHD:	Institute for Horticultural Development
NIASA:	Nursery Industry Accreditation Scheme, Australia
PBR:	Plant Breeder's Rights, enables the registration of a plant variety to allow a royality to be collected by the plant breeder
RAPD:	Random amplified polymorphic DNA markers, a scientific technique used to identify genetic similarities and differences
RIRDC:	Rural Industries Research and Development Corporation
ppm:	Parts per million
STS:	Silver thiosulphate

20 Glossary

Abscission: A natural separation of two plant parts (such as leaf stalk from stem), which occurs at a defined layer.

Agral: A wetting agent that assists in the distribution of a chemical in or on plant tissue.

Anther: The pollen-producing sac of a flower.

Apical: Concerning the apex or tip (of a plant).

Basidiomycete: Member of a group of fungi related to mushrooms and puffballs.

Bracts: Visible protective structures making up the outermost covering of the capitula of rice flower.

Bioassay: A biological measure of an effect, such as the effect of root-knot nematode on the growth of tomato seedlings.

Biuret: An unwanted contaminant in urea.

Capitula: Plural of capitulum.

Capitulum: A small flower head, approximately match-head size in rice flower.

Chelated: Linked to an organic molecule to improve the availability of an inorganic molecule.

Clonal: Genetically identical. In plants, often the result of non-sexual forms of propagation.

Corymb: A terminal flower head made up of a collection of capitula; in rice flower the clusters of capitula are brought to a common level for presentation purposes by shortening and/or lengthening of individual flower stalks. A specialised form of panicle.

Cultivar: A cultivated variety.

Et al.: Latin abbreviation meaning 'and others'.

Filler (flowers): Smaller flowers used to fill the space around larger or more dominant flowers in an arrangement.

Floret: A small single flower protruding from opened bracts, clearly visible with a hand lens; in rice flower approximately 20 small florets are present in each capitulum.

Flower shatter: Disintegration of the flower involving the falling of individual bracts or the whole capitulum.

Frass: Insect faeces, often accompanied by fine debris.

Fungicide: a chemical compound that kills or inhibits fungi.

Genotype: Genetic constitution.

Germplasm: Genetic material occurring in all cells.

Inflorescence: The group or arrangement in which flowers are borne on a plant.

Micro-sclerotia: Plural of micro-sclerotium (see below).

Micro-sclerotium: A very small and compact mass of fungal threads, capable of surviving unfavourable conditions and regenerating the fungi.

Nematode: A small worm-like animal that is parasitic to plants (such as root-knot nematode) or animals or that is free living in soil or water.

Panicle: A branched inflorescence.

Pathogen: A parasite able to cause disease in a host.

Pathogenicity: The ability of a pathogen to cause disease.

Peduncles: Stalks supporting the flower head.

Phosphonates: A phosphorus-based chemical with the specific ability to control disease caused by *Phytophthora*.

Preserved: (Of flower stems) chemically treated to maintain stem and leaf flexibility.

Pulse: A short duration treatment of flowers (or foliage) in a postharvest solution.

Saprophyte: An organism that uses dead organic material for food.

Stigma: The flower part carrying the pollen-receptive tissue.

Stock plants: Source plants for cuttings and vegetative propagation.

Style: The column supporting the stigma.

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Colour plates

Plate 1. Capitulum maturity sequence for a fading pink variety. The least mature capitulum is on the far left, the oldest on the right

Plate 2. Flowering stems of: (a) a fine-leafed form (above) and (b) a broad-leafed form (below)

Plate 3. Flowering stems of rice flower

Plate 4. A corymb

Plate 5. Flowering stages:

5 (a) Undeveloped corymb—of 'pea' size;

5(b) Expanding corymb—capitula increasing rapidly in size;

5(c) Corymb and capitula of full size—capitula unbroken;

5(d) Corymb mature and of full size—capitula broken;

5(e) Seed release.

Plate 6. Capitulum sequence; youngest (left) to oldest at first break, with florets extended and stigmas visible (right)

Plate 7. Complete capitulum maturity sequence; unbroken (left), all florets matured (middle) and seed release (right)

Plate 8. Rice flower plantation established on mounds with weed mat and irrigation line

Plate 9. Pin hole damage from Heliothis caterpillars in rice flower capitula

Plate 10. Blemish caused by leaf hopper on rice flower stems

Plate 11. Spittle bug on rice flower

Plate 12. Longicorn larvae exposed in basal stem of rice flower

Plate 13. Tunnels from longicorn larvae in woody stems of rice flower

Plate 14. Longicorn beetle

Plate 15. Healthy rice flower root system (left) compared to one severely affected by *Phytophthora cryptogea* (right)

Plate 16. Rice flower plant severely affected by *Phytophthora*

Plate 17. Rice flower planting affected by *Phytophthora cryptogea*

Plate 18. Basal stem of rice flower split to show severe white rot symptoms

Plate 19. *Macrophomina phaseolini* causing wood rot in stems of rice flower

Plate 20. Galling in roots of rice flower caused by root-knot nematodes

Plate 21. Severe galling in roots of rice flower caused by root-knot nematode *Meloidogyne arenaria*

Plate 22. Rice flower roots affected with *Meloidogyne hapla* nematode. This nematode causes less obvious damage compared to some other nematodes (see Plates 20 and 21)

Plate 23. 'Brown tip' on rice flower

Plate 24. White tip' on rice flower

Plate 25. Wind damage in cultivated *Ozothamnus obcordatus*

Plate 26. Vegetative growpast in rice flower

Plate 27. Floral growpast in rice flower

Plate 28. Fasciation in flowering stems of rice flower

Plate 29. Chlorotic foliage of rice flower growing in saline soil conditions

Plate 30. Chlorotic foliage in a less salt-tolerant rice flower selection under saline soil conditions

Plate 32. Rice flower tube stock with a well developed root system

Plate 31. Severe root congestion in rice flower

Plate 33. Foliage deterioration—desiccation (foreground) and blackening (background)—in rice flower intercepted prior to auction in Japan

Plate 34. A postharvest handling sequence

34(a) Rice flower block at harvest time. Juvenile plants in front row;

34(b) Harvesting rice flower with a brush cutter;

34(c) Grading of rice flower stems for length;

34(d) Tying bunches;

34(e) Tied bunches;

34(f) Holding in a preservative solution;

34(g) Dipping rice flower for postharvest pest and disease control;

34(i) Box with flowers showing end vents for forced air cooling;

34(h) Packing bunches into boxes;

34(j) A packed carton.

Plate 35. Air drying rice flower

Plate 36. Rice flower after uptake treatments of 20% glycerol in water (left), glycerol plus Sandocryl red textile dye (middle) and glycerol plus Ponceau red food dye (right)

Plate 37. Flowering plants of cultivated *Cassinia leptocephala*

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Plate 38. Flowering stem of *Cassinia aureonitens* in close up

Plate 39. Flowering stems of *O. diosmifolius* (left), *O. diotophyllus* (right) and a hybrid between the two (middle)

Plate 40. *Cassinia laevis*