Introduction to Floriculture

Bulletin Number 30

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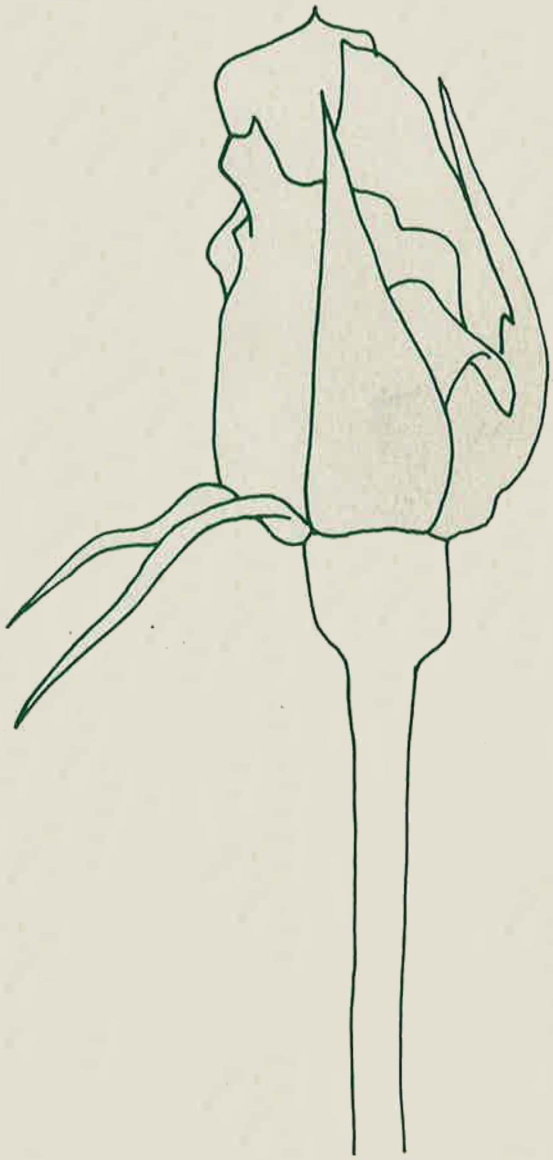

FOREWORD

This bulletin is to provide a basic understanding of the principles and practices of commercial flower production, from which further studies can be undertaken as required.

A complete study of floriculture is beyond the objectives and resources of this course because of the complexity of the flowering process and its control in plants.

These notes are to be supplemented by lectures, slides, demonstrations and field studies.

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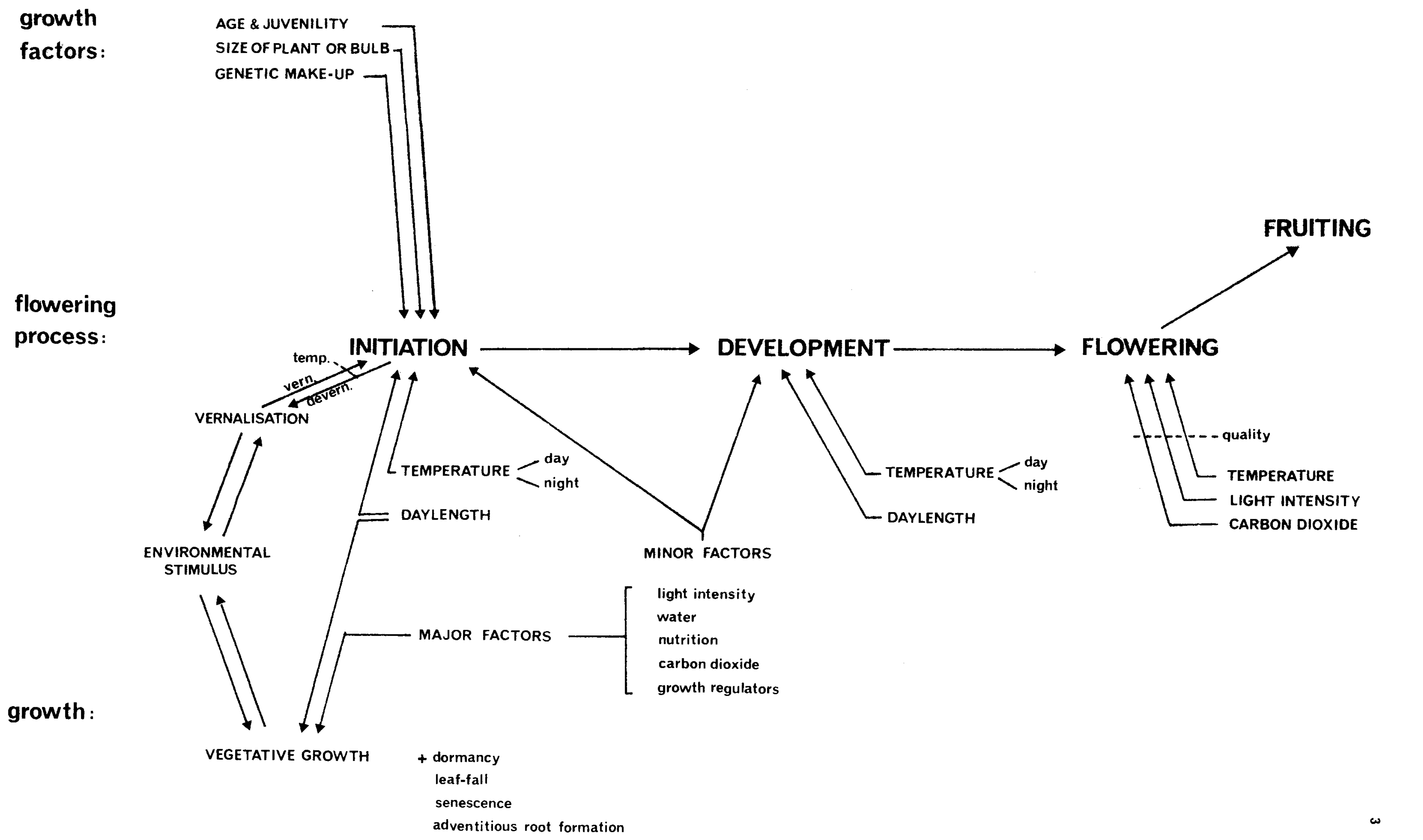


the flowering process

AREAS - FLOWER CROPS IN NEW ZEALAND**

CROP	OUTDOOR (ha)		GLASSHOUSE (m^2)	
	Cut Flowers	Plant Sale	Cut Flowers	Plant Sale
* anemones	9.3	1.6	-	-
* carnation	1.6	0.8	44000	1500
* chrysanthemum	25.0	0.8	8800	750
cyclamen	-	-	2400	8750
dahlia	3.3	2.0	-	470
* freesia	1.2	1.2	7350	280
gerbera	1.6	0.8	280	90
* gladiolus	31.0	13.0	560	-
hyacinth	2.8	2.0	90	-
iceland poppy	2.0	-	-	750
* iris (bulbous)	13.7	4.8	90	-
* lilies	6.0	5.0	180	180
* narcissus	61.0	16.6	-	-
* orchids	-	-	8560	2140
* roses	8.5	-	5020	-
stocks	5.3	-	560	560
violets	3.3	-	-	-
bulbs (unspecified)	18.2	19.4	180	-
	193.8	68.0	78070	15470

* crops covered in notes

** source: New Zealand Dept. Agr. survey 1966-67
Marcussen, K.H. 1969. Commercial production of flowers. N.Z. J. Ag. <u>118</u>: 99-101.

Estimated total value of production: $7m

F.O.B. ($NZ) value of floricultural exports (June year 1975-6) $274730

ANEMONE

Anemone coronaria fam. Ranunculaceae

Anemones are an important winter and spring flowering crop in milder areas. In 1967 the areas grown outdoors were 9.3 ha for flowers and 1.6 ha for tuber sales.

VARIETIES:

Selections from the original single flowered *A. coronaria* comprise the bulk of commercially grown anemones. A. 'De Caen', single flowered and more productive during the winter months, is offered in mixed shades or in separate colours of scarlet, blue and white. The double or semi-double strain, 'St Brigid', is available in a similar colour range, and is preferred for spring flower production.

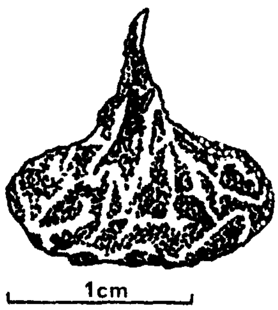
PROPAGATION:

Anemones are best produced from seed as many tuber diseases are transmitted by vegetative increase.

The seed should be mixed with moist sand and kept at 21°C for 10-14 days before being sown in a bed, where emergence occurs about 1 week later. October sowings have given the most satisfactory results.

The seedlings must be kept moist, shaded and well ventilated. Roguing for satisfactory flowers should be carried out at flowering time.

Production of flowers from old tubers is seldom satisfactory because of disease problems, and for flowering purposes, anemones are best treated as annuals. Planting stock normally consist of 1 year old tubers, raised from seed and discarded after 1 flowering season.



ANEMONE TUBER

SOIL:

Perfect drainage is essential - rotting of tubers causes considerable plant losses and can be attributable to poor drainage.

A high organic matter content and a pH of 6.5 - 7.5 is recommended.

Soil sterilisation and 7 year rotations are used to reduce soil-borne disease problems. Weed control is essential as competition from weeds reduces flower production and encourages disease.

PLANTING:

Good air circulation about the plant is essential and it is normally this requisite that determines the planting systems.

Anemones can be planted 15-20 cm apart in the rows, 5 cm deep with the bud facing upwards. Deeper planting often results in reduced flower production. Single rows 80 cm apart or double staggered rows 60 cm apart with an 80 cm path between are preferred to bed plantings.

Ridging for winter production results in improved air circulation, better drainage and warmer soil in winter, but requires some irrigation in summer.

The 20-30 cm high flower stems are self-supporting.

WATERING:

The plants should be kept uniformly moist. The use of automatic watering systems is advocated to avoid moisture on the plant crowns which results in crown rot and plant deterioration.

FERTILISER:

Fertiliser requirements are not heavy if the plants are grown in fertile soils. Adequate nitrogen is essential but too much may depress flower production and make growth more susceptible to disease and physical damage.

FLOWERING:

In common with many other commercially grown "bulbous" flower crops, the natural habitat of anemones is the Mediterranean region. The growth habit of anemones shows adaptation to this climate of high summer temperatures and cool winters.

Anemone coronaria flowers naturally in the cool winter and spring periods. After flowering, the foliage matures and dies down and the tuber goes into summer or high temperature induced dormancy. Root and shoot growth recommences with the onset of cooler autumn temperatures.

Seedlings from October sowings may produce a few flowers by April but reach a peak in September/October.

Planting of tubers in December results in flowering from March/April to September/October in high-health crops. Early flowers produced before March are usually inferior because of the warm conditions.

Tubers planted in summer (January-March) may find difficulty in forming adequate root systems under warm, dry summer conditions unless irrigation is provided.

April plantings can be used to extend the flowering season - flower production commencing in July and continuing until October/November.

Small to medium sized tubers (2-3 cm circumference) planted in December give the best plants and greater flower production. Larger tubers (3-4 cm) planted too early tend to produce too much foliage before flowering, which can be damaged by winds with resulting disease problems. These sizes are preferred for early winter planting and late spring flowering.

As anemones are a winter crop, the best quality flowers are produced when night temperatures are less than 5°C. Higher temperatures speed flower production but both flower size and stem length are reduced. Summer dormancy may be induced if the temperatures are too high.

Because they are a cold temperature crops, anemones are not grown under glass, although a moveable cover to protect the plants from excess winter moisture may improve crop health and result in better flower production.

Depending on crop health and favourable weather conditions, each tuber may produce between 10-15 marketable blooms.

After flowering in winter and spring, the foliage dies off in November/December. The tubers are dug, dried at warm temperatures for 1 week when the tubers shrink to 1/3 of their original size. Tubers left too long before lifting start root growth again and become of little value for flower production, because of root damage at lifting.

Tubers can be stored 2-3 years, if properly dried and kept dry in storage, and still form satisfactory flowers when planted.

Injury to roots or the crown through physical damage, impeded drainage or excess fertiliser may result in short flower stems, small flowers or reduced flower production.

HANDLING OF FLOWERS:

The flowers must be cut at the advanced bud stage (when almost open) - green-cut buds fail to open and develop properly.

Without damaging the leaves, the flowers should be cut early or late in the day when turgid, placed immediately in water, and kept cool.

The risk of virus spread can be minimised by periodic disinfection of the cutting knife.

Anemone stems may elongate in water or transmit so they should not be packed too tight.

Under average room conditions, a vase life of 6-10 days should be obtained.

PESTS AND DISEASES:

aphids, thrips, mites, leafroller.

botrytis, sclerotinia, powdery mildew, rust.

virus - cucumber mosaic, tomato spotted wilt, mosaic.

RECOMMENDED READING:

MARCUSSEN, K.H. (1961): Anemones for pleasure and profit. N.Z. J. Ag., 103(6): 599-607.

MIN. AGR. FISH. FOOD (1971): Anemones. Advisory leaflet 353 7 p.

CARNATION

Dianthus caryophyllus fam. Caryophyllaceae

Carnations are the major glasshouse flower crop grown in New Zealand. The area in 1967 was 44,000 m^2. Very little is now grown outdoors. The main areas of production are: Christchurch, Auckland, Nelson and Levin.

VARIETIES:

The most popular group of perpetual flowering carnations in the world are the 'Sim' varieties. The original red William Sim has sported to almost all colours except dark pink and crimson, and the resulting race are renowned for their quality, production and vigour.

PROPAGATION:

The cutting selection and propagation phases have the greatest influence on the quality and profitability of a carnation crop. Carnations are usually grown as a long term crop (2 yrs +) - high plant health is essential, especially as carnations are susceptible to many viruses and fungal diseases.

Carnations are propagated from terminal stem cuttings. The recommended procedure is to purchase rooted cuttings from a specialist propagator who either obtains and propagates from virus free mother stock via terminal meristem methods, or grows virus tested stock on a mother block system.

meristem → nuclear stock plant → mother stock plant → planting stock (sold to grower)

The nuclear stock plant - mother stock plant - planting stock stages are basically multiplication processes and are the only way high health plants can be sold to growers at reasonable cost. Mother stock is generally not commercially available.

The mother block system involves the growing of mother stock plants solely for cutting production, in isolation and under rigid hygiene conditions. In addition, the plants are routinely tested to ensure freedom from viruses and fungal diseases.

The grower can establish a mother block system from either new planting stock obtained from a specialist propagator or less favoured, from "disease-free" selections of his own flowering stock. This system is aimed primarily at the control of systemic fungal and bacterial diseases. Because of an invariable decrease in hygiene standards, the growers mother block system is not fully effective in the control of virus diseases.

The selection of the actual propagating material is also very important. Under normal environmental conditions, an unstopped carnation plant will produce between 15-18 pairs of leaves before flower-bud initiation. In the axils of the lower leaf pairs, vegetative buds are formed while floral buds are formed in the upper 6-8 leaf axils. Gradations in reproductiveness occur between the top and lower buds. To enable proper development of the plant before flowering, cuttings should be taken from those parts of the plant producing vegetative laterals. Increased internode length is normally an indication that a flower bud has already been initiated and these cuttings should not be propagated.

The preferred cutting length is 15 cm and cuttings should be snapped off the stock plant to avoid disease transmittance. Cuttings are removed from the stock plants as soon as they reach the optimum size to allow development of the next batch of cuttings.

Cuttings treated with hormone powders (0.3% IBA or 0.25% NAA), inserted in a standardised rooting media under mist with bottom heat of 15-20°C, should root in 3-4 weeks.

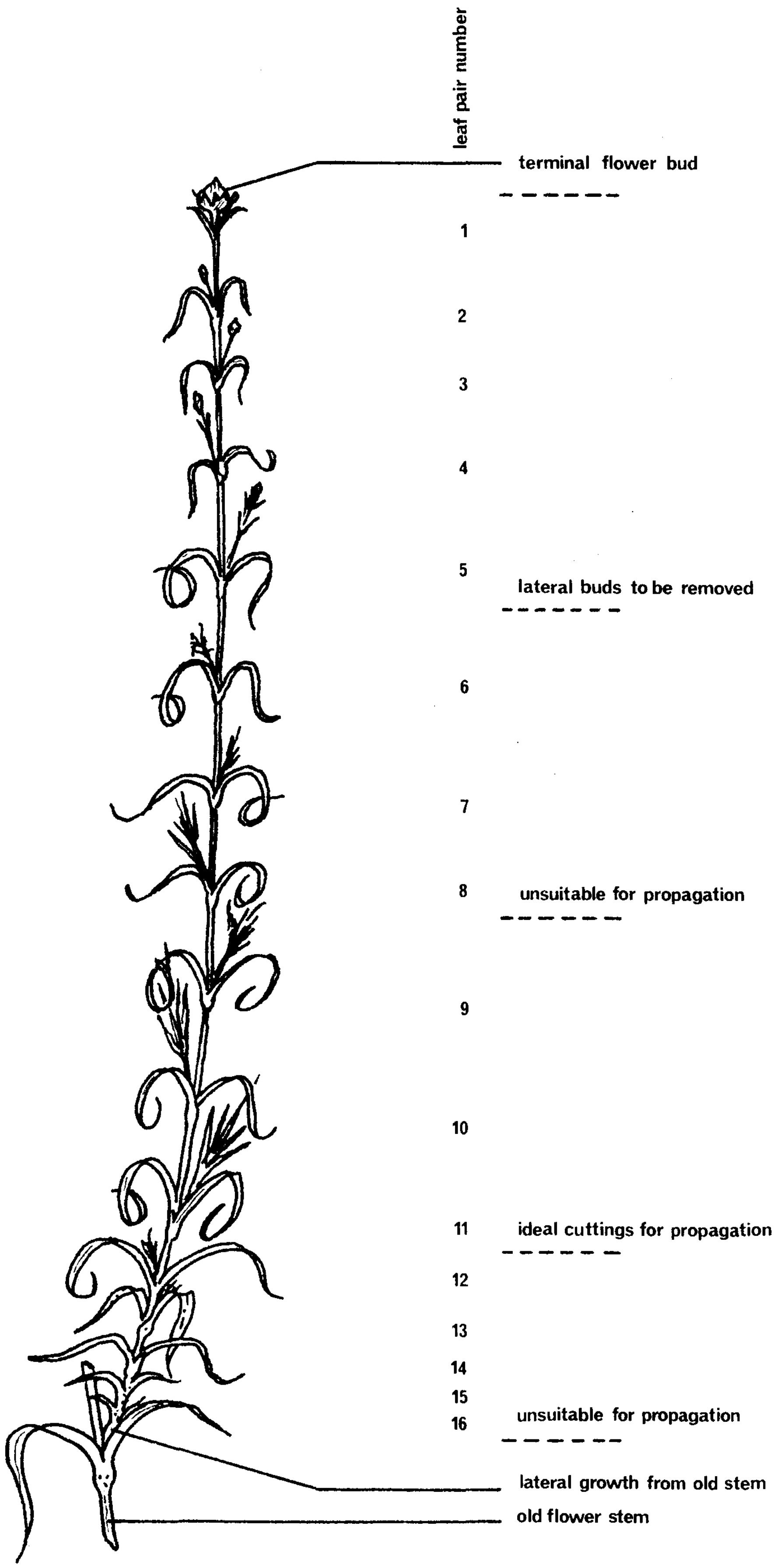
A significant decrease in the ease of cutting strike has been observed during November to February and it is not recommended to propagate during this period.

Cuttings can be stored to allow propagation in more favourable times of the year and crop planning through planting date. Store at 1°C for 2-3 months (unrooted) and 1-2 months (rooted).

SOIL:

Adequate soil preparation is of vital importance as this crop is grown for several years and corrective procedures are hard to apply.

Although relatively tolerant of a wide range of soil types, carnations prefer a well aerated and drained soil, a high organic matter content and a pH of 6.5 - 7.0.


leaf pair number
terminal flower bud
1
2
3
4
5
lateral buds to be removed
6
7
8
unsuitable for propagation
9
10
11
ideal cuttings for propagation
12
13
14
15
16
unsuitable for propagation
lateral growth from old stem
old flower stem

CARNATION

The use of curbed beds and concrete paths allows improved hygiene and most of the glasshouse carnation crops are now grown in this way.

It is essential to sterilise the soil for soil-borne fungal diseases. Steam and chloropicrin are commonly used but methyl bromide residues are toxic to carnations and should not be used.

PLANTING AND TRAINING:

Carnations planted directly into glasshouse beds must be planted as shallowly as possible to encourage rapid root growth - deeper planting may encourage root and stem rots.

There is no set spacing for carnations as this depends on the variety, proposed pinching treatments, and the purpose of the plantings, but is normally 15 x 15 cm or 20 x 20 cm, either staggered or on the square. Staggered planting may help in production operations and allow improved air and spray circulation. Increased planting densities, although resulting in increased production, leads to a quality decrease through competition factors.

Short-term crops can be planted closer (8 x 10 cm) while stock plants are spaced further apart (25 x 25 cm).

After planting, the atmosphere about the plant should be kept damp and cool for 7-14 days until the new root growth begins. About 4-6 weeks after planting, plants should be stopped to encourage lateral bud development.

Carnations are supported by trellises at the end of the glasshouse beds. Horizontal wires run between the trellises and supporting frames and further support is provided by cotton strings across the bed. This grid pattern is repeated at 15-30 cm intervals up the trellis throughout the life of the crop as required. Double wiring may be required at the lowest 2 tiers to support the weight of a 2 year crop.

WATERING:

Carnations require a steady water supply and automated watering systems-sprinkler irrigation with directional nozzles, perforated hoses or trickle systems are recommended. Any of these irrigation systems can be coupled to fertiliser injection systems.

Sufficient water should be applied to wet the soil thoroughly, and depending on the soil-type, a flush watering without fertiliser every 3 weeks in summer and 6 weeks in winter is most beneficial in preventing soluble salt build-up.

Carnations must be grown in conditions of low humidity - too humid an atmosphere is detrimental as it encourages fungal diseases.

FERTILISER:

Carnations are "heavy feeders" - the quantity and quality of blooms is largely dependant on the fertilisation program.

Nitrogen and potassium requirements are relatively high - the low phosphorus requirement is usually adequately supplied in the soil before planting.

The injection of soluble fertilisers - nitrogen, potassium and trace elements (particularly boron for which carnations have a relatively high requirement) into the waterline is an ideal method of fertilisation. The amount of fertiliser is then correlated to the rate of growth, which varies throughout the year.

The choice of fertiliser affects the potential level of soluble salts in the soil. As soluble salts adversely affect bloom quality more so than quantity, these levels should be kept as low as possible, consistent with good fertility.

LIGHT:

Light (photoperiod and intensity) and temperature have a strong influence on growth, flower-bud initiation and development.

Flower initiation is mainly influenced by photoperiod and light intensity, while subsequent development of the flower-bud to anthesis is primarily affected by temperature.

Carnations were originally long-day plants, but breeders aiming for perpetual flowering have since removed most of the obvious response to daylength. However, day-length is still a modifying factor in flowering - the carnation is now termed a <u>facultative</u> long-day plant in that flowering, although not inhibited by short-days, is hastened by long-days.

Carnation plants appear most sensitive to flower inducing conditions when 5-7 leaf pairs have unfolded (18-20 cm long), so factors favourable to vegetative growth are generally conducive to faster flowering.

Flower-bud initiation is promoted by high light intensities, long photoperiods and low temperatures. Conversely, initiation is delayed by low light, short-days and high temperatures.

When other growth factors are not limiting, the use of supplementary light to extend daylength and increase intensity promotes flowering and assists in crop timing. It is also desirable to design glasshouses for maximum light, especially for winter production.

Carnations should be grown in high light intensities at all times - low light, in addition to its effect on initiation, results in weak stems and decreased flower quality.

The number of leaf pairs below the flower bud is a good indication of the time and rate of initiation. Slower initiation means more leaf pairs are formed before floral initiation. (Under the 'normal' conditions of light, and temperature, 15-18 leaf pairs are formed.)

	daylength - hrs			
	8	12	16	20
av. no. leaf pairs	19.3	18.7	16.0	14.6
days, planting to anthesis	175	158	130	115

	light intensity	
	50%	100%
av. no. leaf pairs	20	16
days, planting to initiation	101	86
days, initiation to anthesis	91	66

Production is therefore faster in summer (December-March) - during this period, about ½ of the annual production is harvested although prices are lower than at other times of the year and returns are not as high. Planting of glass-houses during December-January is often practised, resulting in the first crop of flowers being harvested in the higher price periods of April-June. The time to flower depends on the season and planting date but is normally 3-6 months from stopping.

TEMPERATURE:

The carnation is one of the most sensitive plants to temperature. Temperature affects the rate of growth, size and shape of flowers, stems and leaves, flower production rate and cut-flower life.

The development of the flower-bud to anthesis is primarily affected by temperature. Low temperatures retard development but in conjunction with long photoperiods, advance floral initiation.

	temperature °C				
	12	15	18	21	24
no. leaf pairs	15.7	18.1	19.5	19.8	19.8
days, planting to anthesis	182	154	119	112	105

Floral initiation, although promoted by low temperatures, depends on the average daily temperatures - day and night temperatures have no specific effect on initiation. Flower development subsequent to initiation is promoted by high day (24°C) and low night (12°C) temperatures or high constant temperatures (24°C). However, temperatures above 18°C generally result in decreased quality.

For ease of production and temperature control, night temperatures of 12°C and day temperatures of 18°C (12°/18°) are usually recommended.

At 5-10°C production is slower than at 10-15°C; at 15-20°C production is not greatly affected but quality decreases.

Accurate temperature maintenance also reduces calyx splitting and bullheads. Calyx splitting is damage to flowers resulting from the calyx being unable to retain excessive petal development. This is caused primarily by temperature fluctuations although it is influenced by light, nutrition, moisture and heredity. The degree of splitting at a day/night temperature differential of 6°C is greater than at 3°C or at constant temperature.

Bullheads, the result of a sudden large drop in temperature, are caused by development of secondary buds within the terminal flower or flower-bud.

In winter or when light is poor, lowering the temperatures to around $10^{o}/15^{o}C$ helps to strengthen the stem and improve quality. But as the temperature decreases, so too does the production rate.

Continuous air movement provides uniform air temperatures and humidity. The use of fan and pad ventilation or polythene ducted air systems enables humidity and temperature control - important in the provision of uniform growing conditions and in the control of certain fungal diseases.

FLOWERING CONTROL:

The carnation plant at planting consists of a 15 cm rooted cutting, which after stopping produces lateral shoots that extend and develop a terminal flower, at a rate governed by light, temperature and other growth factors. As these flowers are picked, the flowering stems are replaced by 1-2 further laterals arising from buds below the cut flower stem. So after the original stop 4-6 weeks after planting, subsequent stopping and flowering control is normally accomplished by flower harvesting.

Additional stopping treatments depend on shoot development and are related to the time of planting and requirement for flowers.

(a) light stop - encourages earlier flowering especially under unfavourable conditions (leave 4-6 leaf pairs on the lateral).

(b) hard stop - delays flowering. This procedure is used if environmental conditions are conducive to rapid flowering and flowers are not required (leave 2 leaf pairs on the lateral).

Since carnations are timed mainly by planting date, the system of pinching and controlled lighting programs, and flower production rate dependant on a range of environmental factors, the control of flowering, although never exact, does enable scheduling for favourable times of the year and markets.

As the flowering stem develops and flower-buds appear, all secondary or lateral buds should be removed from around the terminal flower-bud while still small. Disbudding of lateral buds down to the 6th to 8th leaf pair ensures subsequent lateral growth after flower harvesting is vegetative and will develop a normal stem before flowering.

HANDLING OF FLOWERS:

The stage of flower development at which carnations should be cut varies between "3/4 open" and with fully expanded centre petals.

Flowers should be cut in the morning when turgid, and placed upright in deep water for 6 hours in a cool store at 4-8°C to remove "field heat". They can be stored dry at -1°C to 0°C for up to 4 weeks, ensuring that before market delivery, the flowers be 'conditioned' by standing in water at 32-38°C. Carnations must never be stored with fruit or vegetables as ethylene gas produced by these items induces 'sleepiness' - a partial flower closure attributed to restricted water uptake.

Preservative solutions should be used in all post-harvest stages to increase vase-life, which is normally 7-10 days.

PESTS AND DISEASES:

aphids, red spider mite, thrips, leafroller.

fusarium (*F. oxysporum* f. *dianthii*), verticillium, rhizoctonia (stem rot), *Alternaria* (leaf spot), botrytis, *Cladisporum*, *Uromyces* (rust), bacterial wilts.

virus - carnation mottle, streak, mosaic.

RECOMMENDED READING:

ABOU DAHAB, A.M. (1967): Effects of light and temperature on growth and flowering of carnation. Meded. Landbouwhogeschool,Wageningen. 67-13: 65 p.

ADVISORY SERVICES DIVISION, MIN. AGR. FISH (N.Z.) (1975): Commercial Flower Production - glasshouse carnations. 14 p.

HOLLEY, W.D. & BAKER, R. (1963): Carnation Production. Wm. C. Brown Co. Inc., U.S.A.. 142 p.

CHRYSANTHEMUM

Chrysanthemum morifolium fam. Compositae

Chrysanthemums can be grown successfully under glass, shade cloth, or in the open, and are a major flower crop in New Zealand.

The areas in 1967 were: 25 ha outdoor (+ shade cloth), 8800 m^2 under glass and 750 m^2 for sale as potted flowering plants.

The main production areas are: Palmerston North, Auckland, Christchurch and Nelson.

VARIETIES:

Of the many thousand cultivars available to the grower, probably less than 50 account for 90% of commercial flower production.

Chrysanthemums can initially be classified according to their form and petal arrangement thus: incurved, reflexed, spider, single, anemone and pompon.

The colour range encompasses all shades of red, orange, yellow, green, mauve and white.

PROPAGATION:

Overseas, and increasingly so in New Zealand, firms specialising in propagation of chrysanthemum cuttings offer plants culture-indexed for virus and systemic fungal and bacterial pathogens. These sources are recommended unless growers have their own propagation program. If growers cannot regularly procure plants from specialist propagators, then at least new stock, to replace potentially diseased stock plants, should be purchased for this propagation program.

Propagation material is obtained from the chrysanthemum stool - the old flowering stem, roots and developed rhizomes which are selected during or after flowering in the previous season.

Some chrysanthemum cultivars, especially those in the "early flowering" group, still have a vernalisation requirement. This can be overcome naturally by overwintering the stools in an unheated glasshouse or cold-frame to ensure the stools are exposed to 5°C for at least 2-3 weeks.

After vernalisation, the stools are planted in beds in a heated glasshouse and grow rapidly. The temperature is maintained at 12-15^{o}C and the cuttings should be ready within 2 months of planting. To minimise virus spread, either snap the cuttings off the stock plant or regularly sterilise the cutting knife.

The flowering responses of certain cultivars are affected by the temperatures at which the stock plants were grown. Cuttings produced at 21^{o}C+ are more prone to premature budding and delayed flowering than cuttings produced at the recommended 12-15^{o}C.

Terminal cuttings, 6-10 cm long may be propagated in any standardised media (peat, sand, perlite, or pumice), with bottom heat of 18°C and under mist. Cuttings should be rooted within 10-14 days. Hormone powders (Seradix 1) result in more even root formation but the time to strike is affected very little.

Batches of cuttings can be obtained every 2-3 weeks, the number and rate of production depends on the cultivar and the time of year. As the stock plants age, they lose 'vigour' and become prone to premature budding and less uniform vegetative growth. For this reason, stock plants are usually discarded after 3 batches of cuttings have been removed.

To enable rapid stock build-up, or for propagation of late-planted cultivars, the initial cuttings can be used to establish stock beds instead of being planted under glass or outdoors for flowering.

The cuttings are planted 15 x 15 cm in prepared glasshouse beds, watered and fertilised regularly and stopped 1 week after planting. Subsequent cutting production is the same as for stool-produced cuttings.

As the season progresses, supplementary lighting of the stock plants to keep them under long-day conditions will prevent premature budding.

The natural season of bloom is specific to each cultivar regardless of the time of propagation, so to enable scheduling of production, and to avoid excessively large plants, cuttings should be propagated 20-25 days before they are required for planting in their permanent position.

Cuttings can be stored for 3-8 weeks at 0-1^{o}C, and with the use of stock beds and extended lighting programs, scheduling for all year round production can be achieved.

SOIL:

Any soil that permits good drainage and aeration is suitable for chrysanthemums - their high water requirement demands a media that will withstand repeated water applications without waterlogging.

Peat and/or organic matter is frequently added to soils, particularly in glasshouse beds to improve soil structure and water-holding capacity.

The soil, both glasshouse and outdoor, should be sterilised to prevent fungal problems and weeds.

A pH of 6.0 - 6.5 is recommended.

PLANTING:

Rooted cuttings can be planted directly into glasshouse beds and under shadecloth, or boxed in flats for outdoor planting.

Planting distances vary according to the season, as more space per plant is required in periods of low light intensity such as winter.

Normal spacings within the 1 m wide beds are 15 x 20 cm (10 x 15 cm if single stem). Similar bed spacings, or 20 x 20 cm staggered planting in double rows, can be used outdoors or under shade cloth. Wooden edging of glasshouse beds is recommended for the protection of the outside rows of plants and the conservation of soil.

Plastic, nylon, or wire nets for bed plantings and side-strings for row plantings provide support to the flowering stems and are raised as the crop grows.

WATERING:

Chrysanthemums have a high water requirement because of their rapid growth and large leaf area, although as the tissues harden towards maturity (flowering), this requirement becomes less.

Constant uniform moisture and humidity should be maintained until the newly planted cutting has become established, after which the humidity is reduced to avoid fungal problems and to prevent moisture condensation on the flowers.

Semi-automatic watering systems apply uniform amounts of water and can be coupled to proportioner equipment for liquid feeding.

FERTILISER:

Chrysanthemums are gross feeders and regular fertilisation through the use of side-dressings, controlled release fertilisers or trickle irrigation/fertilisation is essential.

Base applications of nitrogen, potassium and phosphorus are applied before planting. These pre-planting applications are supplemented throughout the growing season with regular soluble nitrogen and potassium side-dressings at 2-3 week intervals, commencing after plant establishment.

Several researchers have shown that adequate nitrogen fertilisation in the first 7-8 weeks has great bearing on subsequent flower quality, so early fertilisation is stressed.

After this initial period, fertilisation should be reduced and cease by the time the flower buds show colour. High nitrogen applied at this time results in brittle, easily damaged foliage and 'soft' flowers which have a greatly reduced vase-life.

PINCHING SYSTEMS:

Chrysanthemums can be grown as 'single stems' (1 flowering stem per plant) or more commonly, 'pinched' - (3+ flowering stems per plant). If pinched crops are grown, the number of plants required for a given area will be reduced because of the wider planting distances, but an extra 2-3 weeks will be required for each cropping period.

The plant is stopped (normally only once) 1-4 weeks after planting. More rapid and numerous lateral growth is obtained from softwood or rapidly growing plants than from hardwood.

Chrysanthemums can be further classified according to their disbudding treatments, into standards or sprays.

For standards, either single or multiple stemmed, the disbudding process consists of removing all lateral shoots or flower buds leaving the terminal flower bud (1 large bloom per stem).

The spray is a special form of cut flower consisting of a main stem bearing a number of lateral flowering stems with smaller flowers. Therefore the lateral buds are not removed although some disbudding of sprays may be practised in order to improve the arrangement of flowers.

If the disbudding operation is carried out too early, the process will have to be repeated to remove the later developing buds, while disbudding too late results in unsightly scars and possible stem damage.

Normally, new seed-raised cultivars are classified as either standard or spray according to the method that results in the best flower form and arrangement.

FLOWERING:

Flowering in chrysanthemum is a quantitative response to it's environment. The interaction of all main factors - light intensity, daylength, temperature and the infinitely variable varietal differences make general recommendations impossible although the basic responses are usually within certain limits.

To attain a high standard of flower and foliage, and to enable flowering to be timed accurately, the crop is best grown under cover (glasshouse) throughout the year. Shade houses or outdoor crops are generally for natural seasons flowering only.

Although the traditional natural flowering season for chrysanthemums is autumn, the flowering of the newer hybrids extends over a much longer period, and is the basis for a further classification of chrysanthemums - the natural flowering period. These are:

Early	-	December-March
Midseason	-	April
Late	-	May-June

The other reasons for this spread in natural flowering date will be discussed under 'Daylength'.

LIGHT:

Rapid chrysanthemum growth is obtained when the plants are grown in full light intensity.

High light intensity is required to stabilise the vernalisation stimulus. Prolonged exposure to low light intensities, especially in short-days, causes complete devernalisation with the resultant irregular vegetative growth and lack of flower-bud initiation.

Artificial lighting in naturally low light periods (winter) to supplement natural light and increase the light intensity in the first 2 weeks of short-days has resulted in earlier flower-bud initiation and faster development, even when the light intensity was later reduced.

Shading of plants to reduce light intensity prevents possible sunburn damage at flowering, but may result in delayed flower-bud initiation and development and alter flower shape and decrease vase-life by reducing the initiation of petals.

Chrysanthemum cv. "Bright Golden Anne" (10 week cultivar)

light level	SD to anthesis	leaf no./lateral	floret number
100% [a]	65	7.3	282
50	73	8.4	252
25	93	10.5	245
12.5	112	15.9	-

[a] NZ midsummer sunlight levels

A further division of chrysanthemum cultivars can be made on their response to light intensities. The light efficient cultivars (mainly in the 12-14 week response groups), are naturally adapted to lower light intensities since they flower in the later parts of the season. The light inefficient 8-11 week cultivars flower naturally in periods of higher light intensities and poor flowering and reduced flower development result from flowering in low light periods.

The choice of variety is therefore particularly important when planning for year round production, as cultivars that make best use of limited light are best for winter production.

DAYLENGTH:

Chrysanthemums are the classical short-day plant - flowering is controlled by the length of the day, or more correctly, the length of night.

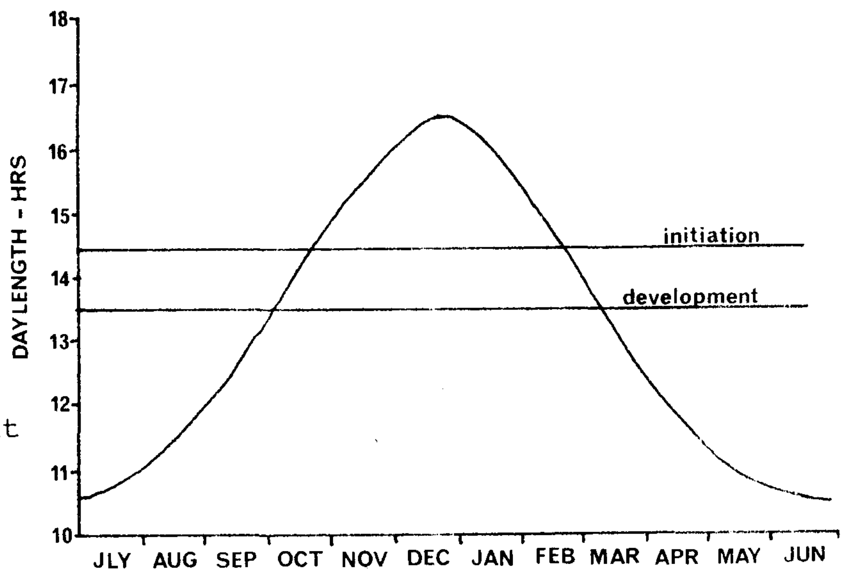
Under long-days, the apex of the stem remains vegetative while short-days promote initiation and differentiation of the flower-bud.

Most varieties require a period of growth (10-25 days) after pinching before they become responsive to daylength for flower-bud initiation.

Two critical photoperiods have been distinguished for chrysanthemum.

In general, to initiate flower buds, the daylength must be less than 14½ hours (> 9½ hours dark), and to develop the initiated flower bud the daylength must be reduced to less than 13½ hours (> 10½ hours dark).

From the daylength curve, it can be seen that although buds will initiate in October, the daylength is too long to allow development while buds initiated in February can develop in the shorter daylengths that follow.



The discovery that flowering in chrysanthemum could be regulated by the length of the light and dark periods in each daily cycle was followed by procedures to modify the natural photoperiod within a protected environment, such as a glasshouse, to reduce or extend the flowering season of chrysanthemums.

Practically, this control of flowering is achieved in one of two ways.

To advance the flowering date of chrysanthemums in naturally occurring long-days, the daylength is reduced to less than 13½ hours by shading the plants with black shade cloth or black polythene. To ensure that the plants are not exposed to consecutive day periods of sufficient length to prevent flower initiation and development, the darkening times should be planned so that the light periods do not exceed 8 hours. The darkening is best carried out at each end of each light period. The covers are moved on and off daily until the flower-buds show colour, when all shading can cease.

Since some chrysanthemum cultivars perceive light intensities as low as 25 lux as a long-day response, the shading has to be extremely effective. Also, the daylength response is perceived by the photoreceptor pigment, phytochrome, in the leaves of the plant therefore shading of the plant apices (overhead shading only) will not promote flowering if light can get in the sides.

Under naturally short-days (mid February-October) the flowering date can be extended by using additional light to ensure that the natural daylength + the time of the extended lighting is greater than 14½ hours and initiation is prevented.

This lighting is found to be effective and usually less expensive when given in the middle of the night to interrupt the dark period and should not be used to extend the natural daylength. This system can be operated by a 24 hr time switch.

To produce the long-day (LD) response, both the duration of the lighting and its intensity must be considered. A shorter period of illumination requires a higher light intensity to ensure initiation is prevented.

Various lighting programs can be used to extend the flowering season.

(a) constant - the lights above the plants are arranged to give a minimum of 60 lux at the darkest point for 3-4 hours from 10 p.m. to 2 a.m.

(b) cyclic - 1-1¼ min/5 min at 100 lux; or 15 min/30 min at 100 lux between 10 p.m. to 2 a.m.

(c) flashlighting - 4 sec/min at 200 lux (10 p.m. to 2 a.m.).

Certain light sources are better than others for use in controlled lighting programs. The conversion of phytochrome red (initiation promotor) to phytochrome far-red (initiation inhibitor) is more effective in high red light (600-680 nm). The normal domestic incandescent lamp and certain fluorescent lamps emit most of their light in this zone of the spectrum and are preferred for their inhibitory effect on flower-bud initiation.

Most chrysanthemum cultivars used in commercial flower production have been classified into response groups. These groups (which range from 6-15 weeks) signify the number of weeks of short-day treatment required from bud initiation (the start of short-days) to flowering under ideal temperature and light conditions.

A 10 week cultivar will flower 10 weeks after the short days commence, i.e. when the extended lighting program is discontinued, or the date after which the natural day-length is short enough to cause initiation.

Experiments have shown that initiation and partial development occurred at the same rate until 24 days of SD treatment in both 9 and 14 week cultivars. However, subsequent development to anthesis was longer for the 14 week cultivar. This difference in flower development rates accounts for the different response groups.

Cultivars in the 6, 7 and 8 week groups are mainly grown as garden or potted plants, while most commercial flower cultivars are in the 9, 10, 11 and 12 week response groups.

The control of photoperiod through extended lighting and less commonly shading and the knowledge of the response groups has enabled all year round chrysanthemum flower production.

If all chrysanthemum cultivars had critical photoperiods of 14½ and 13½ hours then the natural flowering would extend only over a 9 week period (15 week response - 6 weeks) in autumn and early winter.

Through hybridising and selection, plant breeders have obtained cultivars with different critical photoperiod requirements to the extent that some cultivars, although still showing a photoperiod response are controlled mainly by temperature. These cultivars are mainly the early flowering group which flower naturally before the end of March.

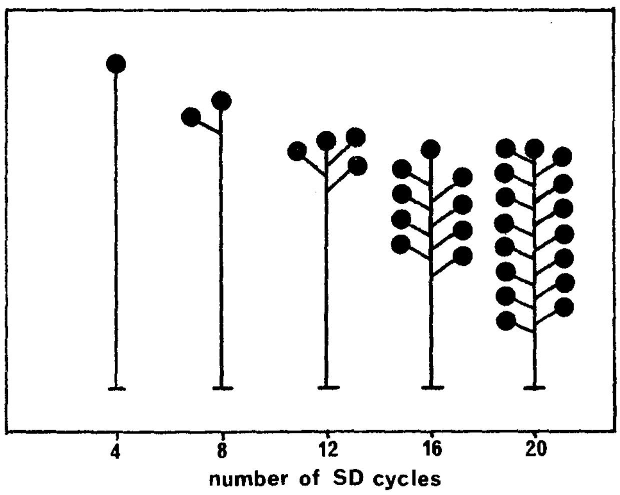
In general, the shorter response groups have longer critical photoperiods, i.e. they flower naturally in the longer daylengths of summer. For example:

	critical photoperiod - hrs	
response group	initiation	development
6	16	$13\frac{3}{4}$
10	$14\frac{1}{2}$	12
15	11	10

This factor of different critical photoperiods and different response groups accounts for the spread of natural flowering from December to June.

The number of short-day cycles that the plant is exposed to affects the type of flower produced.

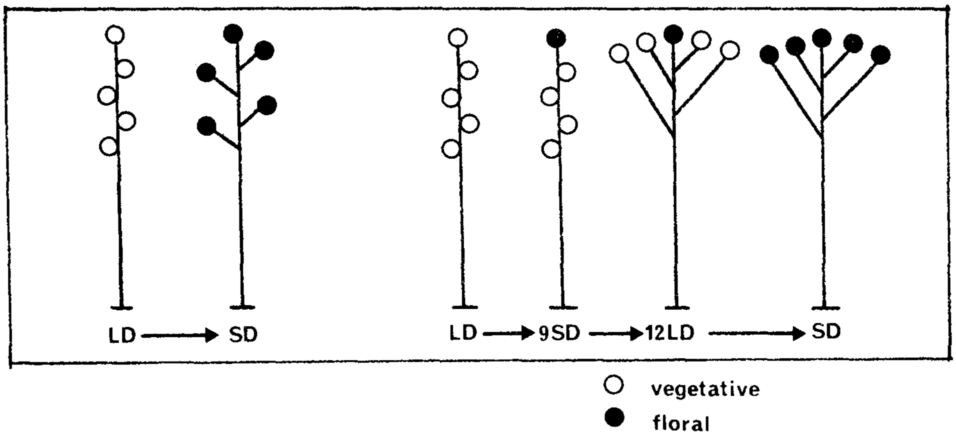
The terminal bud is the first to respond to short-day cycles. Apical dominance is removed by terminal flower initiation and release from dominance proceeds basipetally so that successive short-day cycles cause initiation of the lateral buds.



Crown buds are formed (but may not develop, in which case they are termed break-buds) after a few SD cycles are followed by continued long-days. These buds are normally initiated on natural season flowering crops early in the season after a period of low light such as cloudy weather. The crown bud is surrounded by vegetative buds which can develop at the expense of the flower bud, and in effect, 'pinch' the stem.

Terminal buds, surrounded by lateral flower-buds, are initiated under continued SD cycles. These buds form later in the season, develop under naturally decreasing daylength, and although resulting in a slightly smaller flower, are preferred because they develop consistently.

As opposed to the common off LD-on SD method of controlled chrysanthemum flower production, some growers may use an <u>interrupted lighting</u> program to improve the form of spray varieties. Long-days are followed by 9 SD cycles which ensure the initiation of the terminal buds, then 12 LD cycles to extend lateral stem growth. These lateral apices are then initiated by continued short-days.



TEMPERATURE:

Control of temperature is very important for uniform fast vegetative growth and flowering in most cultivars.

After the discovery of photoperiodic control of flowering in chrysanthemum, later work tended to overlook the importance of temperature in flowering. Recent investigations have shown that in many cultivars, temperature is as important as daylength in determining plant responses particularly in the 'early flowering' group.

Flower initiation and development are very sensitive to temperature - although basically a 'cool' autumn flowering crop, many chrysanthemums will not initiate and develop flower buds even under short day conditions if the night temperature is below 16°C. Day temperatures are less critical and 21-24°C, depending on the cultivar and the time of year, are recommended.

Control of the night temperatures is therefore more important:

constant	varied	flowering over
day: 21°C	night: 5, 10, 16, 21, 27°C	36 days
night: 21°C	day: 5, 10, 16, 21, 27°C	11 days

Variation from the recommended 16^{o}C temperature causes delayed flowering and even flowering failure, while there is minimal vegetative growth at less than 10^{o}C.

After the flower-bud becomes visible, up to the 4-5th week of short days, the temperature may be gradually reduced by 2^{o}C per week to 12^{o}C to enhance flower quality and potential cut-flower life.

Chrysanthemum cultivars have been separated into 3 temperature response groups:

(a) no temperature response (thermozero) - these cultivars flower under a wide temperature regime but temperatures more or less than 16^{o} result in delayed flowering.

(b) low temperature inhibited (thermopositive) - don't flower when the temperature is below 16^{o}C and flowering is delayed above 16^{o}C.

(c) high temperature inhibited (thermonegative) - will not flower above 16^{o}C and flowering is delayed when the temperatures are below 16^{o}C.

As with the selection of cultivars with a shorter response to SD, plant raisers have also concentrated on breeding for a wide temperature tolerance.

The proper selection of cultivar will help to reduce flowering problems during the times of the year when temperatures are difficult to control.

In all-year-round growing of chrysanthemums, cultivars which have a minimal or no vernalisation requirement are being used, whereas those with this requirement are usually eliminated from AYR schedules and flowered during the natural season only.

The temperature also modifies the critical photoperiods required for initiation and development. For example:

response group	temperature	initiation	development
6	10°C	13¾	-
	16	16	13¾
10	10	13¾	13¾
	16	14½	12
15	10	12	12
	16	10	9

It is obvious therefore, that the interactions between daylength, temperature and light intensity exceed the main effects, so, for controlled growing, perfect control of these factors within the recommended limits is essential.

Flower colour is affected by temperature. Under high temperatures or low light intensity, bronze, pink and red cultivars may be lighter in colour. This is not fading and is due to increased carbohydrate loss (high temperature respiration) or decreased carbohydrate supply (low light affecting photosynthesis) to the developing buds - the colour doesn't develop.

Cool temperatures ($< 16^{o}C$) generally increase the colour intensity in most colours except yellow and white where cool temperatures result in "pinking" of the petals.

Continuous air circulation to provide uniform temperatures within a glasshouse environment is essential. Although ridge and side ventilators are adequate, greater temperature control can be achieved by fan and pad ventilation or ducted air systems.

HANDLING OF FLOWERS:

Chrysanthemums should be nearly fully opened when harvested. However, 'bud-cut' standard chrysanthemums have been successfully opened in preservative solutions. The timing of harvesting is critical (florets just expanding) so this method is generally not recommended.

The spray types of bloom (sprays, pompons) are harvested when the terminal bud(s) are fully opened, at a stage when the surrounding lateral flower buds are well developed and coloured.

After the flower stem is snapped off the plant, the lower leaves are stripped off and the stem placed in cool water at $5^{o}C$.

Vase life has been extended by dry storage of blooms at $0-1^{o}C$ for 3 weeks. Before marketing, the stems must be placed in warm water at $27-37^{o}C$ to facilitate rapid water uptake.

Depending on the cultivar and cultural and post-harvest treatments, chrysanthemums should last 10-30 days when cut.

Through the AYR production procedures, flower production can be scheduled for special market periods such as Easter, Mothers Day and Christmas, giving the grower a considerable marketing advantage over most other flower crops.

PESTS AND DISEASES:

nematodes, chrysanthemum gall midge, aphids, thrips, leafroller, whitefly, mites.

verticillium, fusarium, botrytis, rust, white rust, powdery mildew, leaf spot.

virus - stunt, tomato aspermy, chrysanthemum mosaic, cucumber mosaic, leaf mottle.

RECOMMENDED READING:

LANGHANS, R.W. (ed) (1961): Chrysanthemums, a manual of culture, diseases, insects and economics. N.Y. Sta. Flr. Gr. Assn. 179 p.

SALINGER, J.P. (1965): Commercial cultivation of chrysanthemums. N.Z. J. Ag. 110(3): 257-64.

SEARLE, S.A. & MACHIN, B.J. (1962): Chrysanthemums the year round. 2nd ed. Blandford Press, London, 294 p.

FREESIA

Freesia hybrida fam. Iridaceae

Freesias are the main "bulbous" flower crop grown under glass in New Zealand. In 1967, the area of freesias under glass was 7350 m^2; 1.2 ha were grown outdoors for flowers and a further 1.2 ha for plant sales, predominantly as dormant corms.

Their fragrance, vigour, long vase-life and winter flowering period makes freesias desirable as early (winter/spring) cut flowers.

As a short-term crop, freesias are frequently grown in combination with a single cropping tomato system.

VARIETIES:

The parent species, *F. refracta* has, through intenstive hybridising in Europe, given rise to a wide range of cultivars and colours ranging from the traditional white, cream and yellow, to red, pink, orange, mauve and blue.

In recent years, the development of the improved tetraploid freesias with their stronger stems, larger flowers and long stemmed spikes, coupled with plant breeders rights has seen a proliferation of cultivars suitable for commercial flower production being retained through vegetative increase.

PROPAGATION:

In New Zealand, glasshouse freesias are normally raised annually from seed. Seed sown in October/November will produce a few flowers by February, followed by the main flowering period in April-October.

In boxes of moist peat/sand, at 20°C and in darkness the seeds should germinate in 2-3 weeks. Pregermination of seeds in water at 20°C for 24 hrs before sowing, has resulted in improved growth and flowering of seedlings compared with untreated seeds.

Seedlings can also be germinated in prepared beds outdoors if some protection is given.

Flower production from corms is the most common method of production used overseas. Several large bulb producing firms such as Van Staaveren, have many cultivars, each with well-detailed cultural requirements and flowering responses. In these instances, the advantages of uniform planting stock exceed the disadvantages of vegetatively produced corms with respect to disease transmittance.

Corms multiply rapidly and are best lifted annually.

SOIL:

A deep, well drained soil high in organic matter and a pH of 6.5 - 7.0 is required.

The inherent fertility of the soil should not be too high otherwise excessive foliage growth, poor flowering and deformed stems may result.

The soil should be regularly sterilsed for soil-borne fungal diseases and for weeds.

PLANTING:

When the seedlings are 5-6 cm high, they should be transplanted into 15 cm deepflats, or into outdoor or glass-house beds at spacings of 8 x 8 cm before root growth becomes too advanced.

After transplanting, the seedlings should be grown under cool conditions (10-12°C) in diffuse light such as a shade or lathe house. When the flowerbuds show, the flats should be moved under glass and the outdoor beds covered with a mobile glass or polythene structure for flowering.

Corms can be planted 4-5 cm deep, 8 x 8 cm apart from February till May - February plantings flower naturally in June. The quality of later plantings deteriorates unless the environmental conditions required for good flowering are maintained.

Increased planting densities do not consistently affect the flowering date but plants are generally taller and both the number of flowering stems and flowers are reduced.

Support for the flowering spikes must be provided. Two layers of nets and cross strings as used for carnations, at 15 cm intervals, are suitable.

About 2-3 months after flowering, the corms are dug, cleaned and graded - corms>7 cm in circumference are preferred for glasshouse planting since they produce more flowering spikes and more flowers per spike than smaller corms.

WATERING:

Adequate irrigation according to the needs of the crop is commonly applied combined with fertiliser through a trickle system. Wetting the foliage must be avoided as it encourages fungal diseases. Similarly, adequate ventilation during all stages of growth and flowering is essential.

FERTILISER:

Freesias require little fertiliser in moderately fertile soils but a compound fertiliser can be applied when the plants are in a period of rapid growth.

After flower formation, it is beneficial to feed the crop. Urea and potassium nitrate, applied through a dilutor and trickle irrigation system are commonly used. Adequate potassium fertilisation is essential.

High fertiliser levels particularly of nitrogen, cause excessive vegetative growth and poor flowering and should be avoided.

FLOWERING:

In their native habitat of South Africa, freesias sprout in the cool autumn period (February/March). After flowering in winter and early spring (July/August) the corms go into summer dormancy until the following autumn when shoot growth follows the onset of cooler temperatures.

An understanding of the different temperature and daylength requirements has enabled scheduling for all year round flowering of freesias.

Freesias are short-day plants and flower naturally under the short days of late autumn, winter and early spring.

Flower initiation is promoted by SD, the degree of response differing between cultivars. The development of the inflorescence is strongly promoted in the early stages by short-days although this effect becomes less marked in later stages of development.

Short-day cycles also increase the number of lateral stems, and the number of flowers on the spikes and therefore the total number of flowers per plant.

	daylength - hrs		
	8	12	16
days to initiation	31	68	79
days to anthesis	100	170	-
total no. flowers	37	18	-

Low light intensities delay flower initiation and development, decrease the number of lateral stems, slightly increase stem length and reduce the number of flowers per spike. Therefore, if temperatures can be controlled, freesias should be grown in high light conditions.

Despite the profound influence of daylength, temperature is the main factor affecting flowering in freesia.

Freesias require a warm period to "ripen" the corms followed by a cool temperature treatment which precedes flower initiation and development.

Flower initiation is promoted by low temperatures (9-15^{o}C depending on cultivar). The plant must experience these temperatures for at least 4-6 weeks after planting in the autumn or as a pre-cooling treatment before planting. Plants appear most receptive to the flower-inducing conditions of short-days and low temperatures at the 6-8 visible leaf stage so larger and older plants give the most consistent flowering results.

Flower development after initiation is fastest at 15-18^{o}C therefore glasshouse heating is essential in colder areas for good flowering. Depending on light and temperature, flowering starts 9-10 weeks after the end of the low temperature treatment.

Freesia cv "Rijnveld's Golden Yellow"

temperature and flowering

°C	plant height	number of leaves	days to initiation	days to anthesis	no. flowers/ plant
12	52 cm	9	27	114	23
15	66	10	29	103	29
18	73	11	28	96	30
21	91	12	45	122	34
24	90	15	51	148	14

Unlike initiation where day and night temperatures have no specific effect, it is the night temperatures that have the main effect on flower development rates.

High temperatures during flower development may increase the number of flowers but both the number of lateral stems and flower quality are reduced.

Flowering is delayed by high temperatures and long days - the normal summer conditions. To avoid flowering in late spring (the prices are lower) the temperature should be lowered, preferably without any reduction in light intensity and the daylength reduced to 8-10 hrs.

Through proper storage treatments and temperature control the flowering period can be advanced into winter so that the daylength factor is maintained naturally.

Lifted corms should be dried at 20°C, cleaned, graded and stored at 27-30°C for 10-14 weeks depending on the cultivar. During this treatment, relative humidity should be maintained between 60-70% to avoid corm rot problems.

If the corms are stored at less than 20°C, they may become "sleepers" and remain dormant without flowering for 1 year.

The corms can then be planted in glasshouse beds or flats. The temperature should be maintained below 15°C for at least 4-6 weeks to satisfy the corms cool temperature requirement, and to promote initiation. Although higher temperatures after planting result in faster sprouting and growth, flowering is delayed and abnormal inflorescences through incomplete initiation can result.

FREESIA

After the flower-buds become visible, the glasshouse temperature should be raised to 15-18^{o}C to hasten development to anthesis.

Storage temperatures and precooling treatments can be used to regulate flowering date.

For early flowering, the corms are stored at 27-30^{o}C for 10-14 weeks as before. This treatment is followed by 13^{o}C for 4-6 weeks, given as a "precooling" treatment to "dry" bulbs which are then immediately planted. This treatment results in flowering 1-2 weeks earlier than bulbs planted after the 30^{o}C treatment only, but quality and quantity of flowers may be slightly reduced.

To extend the planting and flowering dates, a successional planting pattern can be adopted by retarding corm sprouting.

Corms stored at 13-15^{o}C from lifting (about November/ December) to June form new corms while in storage - known as pupation. These new corms when subjected to the treatments, 30^{o}C (10 wks) and 13^{o}C (4 wks), flower if daylength and temperatures are controlled, but quality may be reduced. By this method, the flowering season is delayed by 6 months.

The preferred method for delayed flowering is to store the corms at 1-2^{o}C for up to 9 months. Flowers of acceptable quality are produced after the normal high and low temperature treatments.

<u>HANDLING OF FLOWERS</u>:

The flower spikes should be harvested when 2-3 florets have opened and the remainder are in the bud stage. By cutting the stems, lateral stems or sideshoots may develop to extend the flowering season.

Flowers store well at 0-1°C for up to 2 wks. The vase life of freesias depends on the number of florets per spike but averages 10-14 days per spike.

<u>PESTS AND DISEASES</u>:

aphids, thrips, mites.

fusarium, botrytis, sclerotinia (bulb rot).

virus

RECOMMENDED READING:

ADVISORY SERVICES DIVISION, MIN. AGR. FISH.(N.Z.) (1969): Commercial flower production - glasshouse freesias. 5 p.

DE LINT, P.J. et al.(1969): Flowering in freesia; temperature and corms. Acta Hort., 14: 125-131.

MANSOUR, B.M.M. (1968): Effects of temperature and light on growth, flowering and corm formation in freesia. Meded. Landbouw. Wageningen 68-8: 76 p.

MARCUSSEN, K.H. (1962): Freesias as a commercial flower crop. N.Z. J. Ag. 105(4): 367-375.

SENNELS, N.J. (1951): The cultivated species of freesia. J.E. Ohlsens Enke, Copenhagen. 64 p.

GLADIOLUS

Gladiolus fam. Iridaceae

Gladioli are one of the main summer flower crops grown in New Zealand.

In 1967, the commercially grown areas were: 30 ha for cut flowers, 13 ha for corm sale, and 600 m^2 was grown under glass. Glasshouse growing has been reduced due to the introduction of different varieties which extend the natural flowering season into spring and autumn.

The main growing areas are Canterbury, Auckland and Nelson.

VARIETIES:

There is a wide range of varieties suitable for cut-flower production.

Gladiolus "Colvillei" and *G.* "Nanus" are smaller flowered hybrids, flowering naturally from October to December in Canterbury.

The larger flowered *G. grandiflorus* is the parent species of a very large number of suitable cut-flower cultivars and is the more common type of gladioli grown. Selected cultivars cover the colour range of red, orange, yellow, green, lavender, purple, blue and white in separate colours, shades and bicolours.

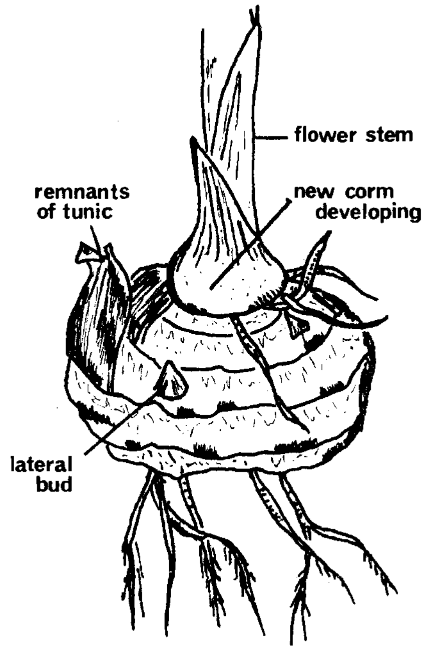
Gladiolus primulinus hybrids produce smaller flowers, more widely spaced on shorter stems than the grandiflorus type.

PROPAGATION:

Commercial propagation of gladiolus is by natural corm increase.

The gladiolus corm is the enlarged basal part of the current season's axis, produced by food storage at the base of the leaves. The new corm starts to develop as soon as the foliage appears and continues to increase in size until it is fully formed after flowering time. The "mother" corm shrinks gradually and is replaced annually.

Lateral buds on the corm may also develop to produce flowering sized corms.



GLADIOLUS CORM

At the base of the maturing corm, a cluster of cormlets are produced, which are later used as planting stock for flowering.

SOIL:

A well-drained soil with a pH of 7.0 - 7.5 and an ample supply of organic matter is most suitable for corm production and good flowering of gladioli. As the corms are dug annually, sandy soils are preferred for ease of corm digging and cleaning.

Corms are replanted annually in new soil on a 3-5 year rotation because of the danger of soil-borne fungal diseases such as fusarium and sclerotinia.

PLANTING:

For both early and late production in the field, raised beds or ridges are sometimes used to ensure warmer soils, better drainage and improved air circulation.

After lifting and drying, corms and cormlets are graded - the larger cormlets are retained for flowering stock and flower within 1-2 years; smaller cormlets require 3-4 years and are frequently discarded.

The cormlets are replanted 5 cm deep, 5 cm apart in rows 25 cm apart until they reach flowering size.

Flowering-sized corms (large flowered - > 10 cm circumference, primulinus - 8-12 cm and small flowered - 6-8 cm) are replanted 10 cm apart in beds of 4-6 rows, 20 cm apart or in single or double rows 60-80 cm apart. Increased planting densities, while increasing the number of spikes produced from a given area, results in fewer florets per spike and can slightly delay flowering.

Planting depth, normally 10 cm, will vary between soil types as the depth should be sufficient to support the flowering stem without tying. Deeper planting, as in sandy soils can delay flowering by 3-6 days and reduce subsequent cormlet formation and development.

The time of planting is varied to give a succession of flower production for both small and large flowered hybrid gladioli.

In Canterbury, early planting from June to August will result in flowering 100-110 days later from late October/November to December depending on light and temperature conditions. From earlier plantings, flowers are produced earlier in northern (and warmer) areas - Nelson (October), Auckland (end of August).

From the normal November-December plantings in Canterbury, flowers are produced in 70-80 days - the "main crop" flowering from January to March/April.

Earlier flowering and large good quality spikes can be obtained by growing gladioli in glasshouses or under cover.

The corms are planted from June and July since the success of plantings in or before May is limited by the low light conditions of winter.

WATER:

Length of stem, and size and spacing of florets on the spike are all determined by moisture supply.

Irrigation is essential for quality crops in most areas. Recent trials with trickle irrigation of Canterbury gladioli have resulted in significantly improved vigour and quality and has enabled closer corm planting without obvious competition effects.

Temporary wilting of the plants causes crooked flower stems.

FERTILISER:

The nitrogen requirement of gladiolus is high during the growth period - vegetative growth and the number of flowers per spike are reduced at low nitrogen levels and flowering may be delayed.

The most beneficial effects of fertilisation have been obtained from 2-3 sidedressings throughout the season rather than from a base fertiliser application.

The effects of phosphorus and potassium are less marked and these fertilisers are normally applied as a base dressing only.

LIGHT:

Gladioli are known for their high light requirement.

Full light is essential although excessively high light intensities without provision for temperature control may depress growth. A slight reduction in light intensity will increase stem length.

Low light intensity is the main cause of flowering failure in gladioli. Initiated flower-buds may abort in low light conditions, with implications for both winter growing and planting distances. Supplementary lighting in low light periods has improved flowering.

The responses of different cultivars vary but improved growth, earlier flowering, taller stems, larger floret size, increased floret number and increased size and number of corms and cormlets produced, have resulted from specific photoperiod treatments. In some cultivars a daylength of 12½ hours has given better results than either shorter or longer daylengths. The specific effect of photoperiod on flower-bud initiation has not yet been determined but it could be related to light intensity.

FLOWERING:

Corms should be left in the ground until the tops yellow or more specifically, until the cormlets turn to a mauve colour. This period varies between 6 weeks after flowering for early flowering crops, to immediately after flowering for late crops.

Later harvesting has resulted in increased spike length and floret number the following season, while earlier flowering can result from earlier lifting.

The corms are dug either manually or mechanically, placed in 10 cm deep trays and cured at 27-32°C for 1-2 weeks or until the corms clean easily.

After curing, the corms are graded and rogued for bulb diseases. Grading is essential as the size of corm affects the flowering - larger corms flower a few days earlier than smaller corms and both the number of florets per spike and the number of spikes per 100 corms increase with corm size.

After the curing treatment, cool temperature treatment of 7-16°C, depending on the cultivar, is maintained until planting.

Fungal diseases such as scab, fusarium and botrytis may appear in storage unless the humidity is controlled at about 50%. Fungicidal dips may help.

Earlier commencement of vegetative growth and flowering can be promoted by transferring the corms from cool storage to 27-32°C for 2 weeks before planting.

Flower initiation in gladiolus occurs as the stem elongates. Experiments have shown the 2-leaf stage, normally reached 4-7 weeks after planting, to be the most sensitive to temperature. Low night temperatures decrease the flowering percentage and reduce number of florets per spike, indicating that the 2-leaf stage may be the flower initiation stage. Initiation is promoted by warm night temperatures and delayed by cool night temperatures. Low day temperatures retard stem elongation therefore delay flowering but do not affect the number of florets per spike.

A second period of low night temperature sensitivity occurs at the 5-6 leaf stage where the young inflorescence is particularly susceptible to low temperature damage.

Stem elongation is primarily controlled by temperatures exceeding 5°C and anthesis normally follows 70-100 days after planting depending on the time of planting and the subsequent growing conditions.

Temperature also affects corm dormancy. Corms will not develop in the second season if the cool period requirement is not satisfied. Therefore high storage temperatures (18-24°C) and low humidity have enabled prolonged storage of up to 1-1½ years with normal spikes still being produced at flowering.

HANDLING OF FLOWERS:

Flower spikes should be cut at a stage of development suitable to the market. When the lower florets are just showing colour, the spikes should be cut for distant markets or for export while for local markets, the lower 2-3 florets should be fully open.

Spikes should be cut by knife, taking care not to wrench the corm in the ground while retaining as many leaves as possible, since leaf removal reduces corm size.

Gladioli spikes must be kept upright after cutting - stem growth is negatively geotropic and stem tips will bend upwards if placed in a horizontal position. Spikes held upright at 5°C and in low humidity for 2 days or held out of water for several hours at high temperature do not bend when later placed in a horizontal position.

Vase-life depends on the number of florets on the spike (each floret may last 3-4 days) and flower care in the home.

PESTS AND DISEASES:

aphids, mites, thrips

botrytis, fusarium, *Penicillium*, sclerotinia, septoria

virus - pea mosaic, cucumber mosaic.

RECOMMENDED READING:

MIN. AGR. FISH. FOOD (1961): Gladioli, p. 27-31 *in* Bulb and corm production. H.M.S.O., London.

SALINGER, J.P. (1965): Gladioli for cut flowers and corms. N.Z. J. Agr., 110(1): 85-91

IRIS

I.x hollandica fam. Iridaceae

In 1967 the area of iris grown for cut-flowers was 13.7 ha: a further 4.8 ha being grown predominantly for bulb sales. A small area (90 m^2) was grown under glass.

Bulbous iris don't require such cool winter temperatures as narcissi or tulips and are grown predominantly in the North Island. Several hectares are grown in Canterbury.

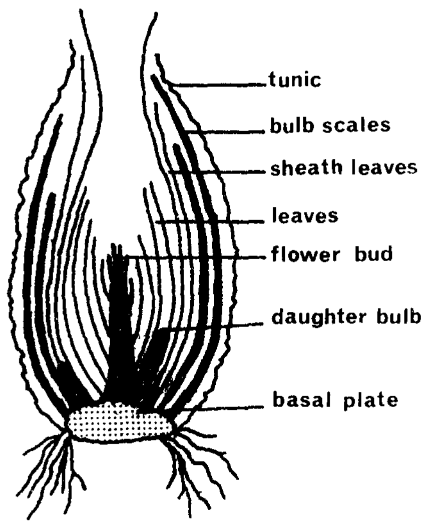
VARIETIES:

The only group of irises grown commercially for cut flowers are the bulbous Dutch iris (*I.x hollandica*) whose origins are based on crosses between the spanish iris, (*I. xiphium*) and *I. tingitana*.

The main cultivar grown, 'Wedgewood', has light blue flowers, is early flowering (September - North Island) (early October - South Island) and responsive to forcing treatments. Other cultivars grown commercially include Imperator (deep blue), Golden Harvest (yellow), Prof. Blaauw (blue), White Excelsior (white) and H.C. van Vliet (gentian blue).

PROPAGATION:

The main flowering bulb in iris is renewed annually. The daughter bulb, formed nearest the centre of the parent bulb, grows rapidly after the main bulb has flowered and is fully formed by lifting time (Dec-Jan). Several smaller bulbs are also produced and irises are normally lifted every 1-4 years.



IRIS BULB

SOIL:

Best growth and flowering is obtained on well drained sandy soils with adequate organic matter and a pH of 6.0 - 6.5.

Deep soil preparation is essential and the bulb plantings should be rotated regularly to minimise the build-up of soil-borne diseases.

PLANTING:

The growth cycles of many bulbous plants are adapted to the climatic conditions of the areas of origin. Dutch irises, although hybrids, show adaptation to the hot dry summers and mild winters as experienced by the parent species.

The growth cycle for iris is longer than for most bulbs - they are the first to emerge in autumn and the last to die down in summer.

Bulbs should be lifted, cleaned and graded when the tops begin to die and when the bulb coat begins to turn brown - around December-January. As they are susceptible to bruising and subsequent fungal attack, the bulbs must be handled carefully.

Flowering-sized bulbs are usually greater than 5-8 cm in circumference depending on the cultivar but independent of bulb age.

Smaller bulbs are replanted and left until they attain flowering size. Immature bulbs do not divide so annual lifting is not necessary. Large flowering sized bulbs are replanted in the field for natural seasons flowering or stored for forcing treatments to obtain earlier or less commonly, extended flowering. As with most other bulb flower crops, forcing must be considered essential in competitive markets.

Bulbs are planted from January to April (preferably February) for flowering in the natural season of September-November, which depends on the cultivar.

Planting 10 cm deep, 5 cm apart in single rows, double rows or beds 60 cm apart is practised for field planted crops.

Bulbs for forcing can be spaced 10 x 10 cm apart in 10 cm deep flats with the top of the bulb level with the soil surface.

WATER:

Irises, whether field grown or forced under protective structures, require adequate water. This is particularly important in forced crops, since, in addition to poor vegetative growth, water stress can result in 'bud blast' - abortion of the flower buds.

FERTILISER:

Iris can be grown in less fertile soils than most bulb crops. However, preplanting base fertiliser applications or light sidedressings through the growing season, particularly of nitrogen, may be beneficial.

High nitrogen levels may delay flowering and encourage the production of weak stems.

FLOWERING:

Flower initiation and development to anthesis in iris is different from that shown in narcissi or tulips, and requires some knowledge of the bulb structure.

A fibrous tunic, consisting of the bases of last season's leaves, surrounds the bulb. Four sheath leaves emerge from the soil to enclose and protect the true leaves.

The number of leaves formed is variable. At lifting, approximately 3 leaves will have formed in the new main bulb. A small bulb that doesn't flower has 3-4 leaves while a flowering sized bulb may form up to 10 leaves. It appears that leaf primordia initiation past the critical number of 7-8 is required before the growth apex becomes receptive to the flower-inducing conditions.

Therefore, potential flower-bud initiation is promoted by factors allowing for this continued initiation of leaf primordia.

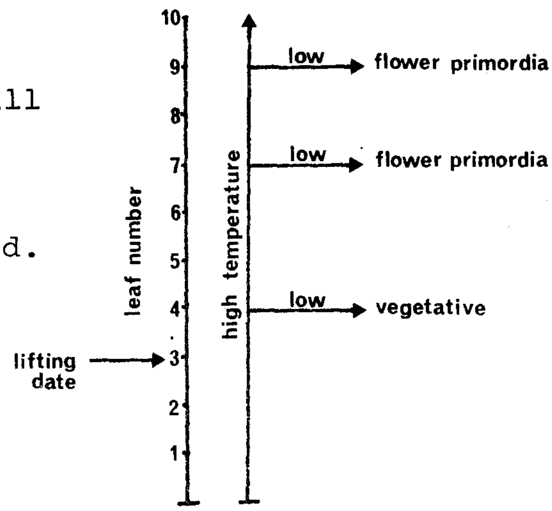
After flowering in spring the bulbs naturally receive a warm temperature treatment in summer. During this period, high soil temperatures of around 18-20°C inhibit flower initiation and promote increased leaf primordia initiation.

The duration of this "pre-induction" treatment determines whether the bulb becomes potentially floral or not.

Therefore at lifting in early autumn, no flower-buds have been initiated in the bulb.

Flower-bud initiation and development requires a period of low temperatures - the optimum temperature for initiation being between 9-13°C depending on the cultivar. This cool temperature treatment occurs naturally in late autumn to early winter (April-May). Flower initiation is normally complete within 3 weeks of the start of cool temperatures.

Flower initiation in iris will only occur on transfer from warm to cool temperature if the critical number of leaf primordia have been initiated. For example -



Using the natural temperature requirements, the flowering rate can be regulated by forcing treatments.

The warm temperature 'pre-induction' and cool temperature 'pre-cooling' treatments are usually given to the bulb in the form of: 30-35°C for 4 weeks followed by 6 weeks at 10°C. This higher pre-induction temperature of 30-35°C, if applied to the bulbs within 1 week of lifting results in earlier flowering, increased flower size and induces a greater percentage of flowers than bulbs treated at 25°C or left in the ground at 18-20°C.

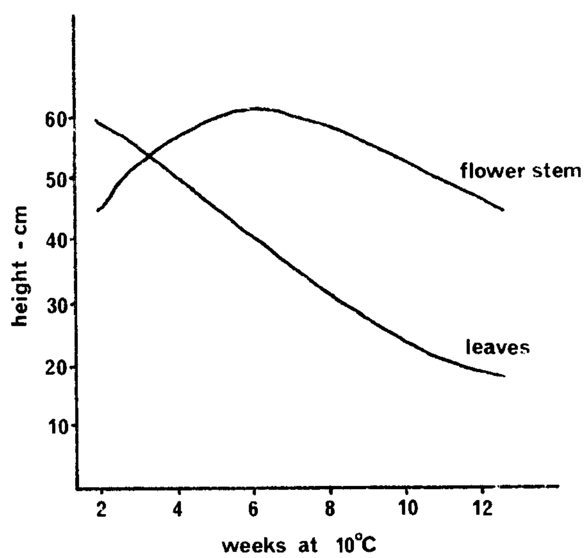
Marginal sized bulbs can be induced to flower by storing the bulbs at the warm temperatures to encourage additional leaf initiation. These smaller bulbs are however more subject to blindness and flowering failures than the larger bulbs. For this reason, it is often preferable to prevent these bulbs from flowering so that the bulb develops for better flowering the following season. The bulbs are stored at 10-15°C so that additional leaf primordia are not formed and initiation cannot occur on transfer to cooler temperatures.

Iris cv "Wedgewood"

pre-induction temperature	bulb size	%flowering
5°C	5-6 cm	0.7
	6-7	2.0
	7-8	2.6
10	5-6	4.4
	6-7	7.0
	7-8	17 0
25	5-6	12.4
	6-7	69.7
	7-8	77.0

The length of the pre-cooling treatment is critical with respect to leaf size and flowering stem height. Pre-cooling for 6 weeks at 10°C results in long flower stems while avoiding excessive leaf growth.

Flower quality, highest after 6 weeks, drops if pre-cooling is extended past 9 weeks.



Iris bulbs can be planted directly after the pre-induction treatment as long as temperatures are kept low, but initiation and flowering are delayed compared with bulbs receiving the dry pre-cooling treatment.

DUTCH IRIS

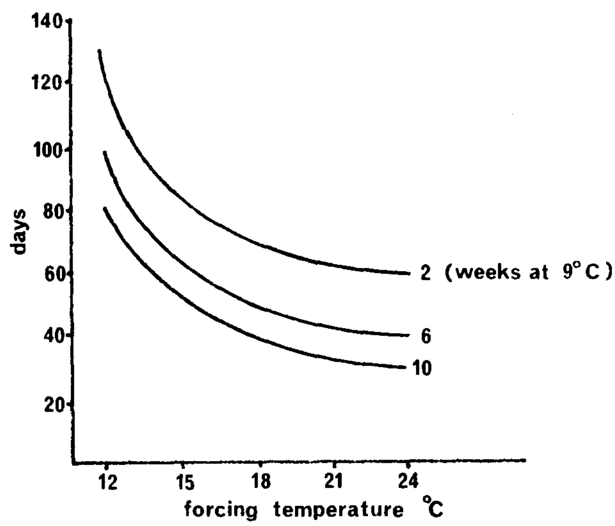
In both the pre-induction and pre-cooling treatments, the bulbs should be well aerated and the relative humidity kept below 70% to avoid root extension and subsequent damage at planting.

After the pre-cooling treatment, the bulbs should be immediately planted to avoid nullification of flower initiation. The flats must be kept cool for a further 4-6 weeks, allowing for the rapid root growth essential before bulbs can be forced, and for initial shoot growth. The flower buds may abort if the temperature rises above 15-20°C during this period.

When the leaves are 5 cm high, the flats should be shifted under cover for forcing.

The usual forcing temperature is 13-15°C but this depends on bulb size and cultivar. For early flowering, bulbs 8-12 cm in circumference are forced at 13-15°C while smaller bulbs (5-8 cm) are forced at the slightly lower temperatures of 10-13°C.

The time to flowering depends on both the length of the pre-cooling period and the forcing temperature.



Growth to anthesis in iris is partly dependant on current photosynthesis. Factors contributing to a poor carbohydrate supply - poor light, small bulbs, high temperatures and dryness invariably lead to flowering failures. High temperatures may also reduce colour formation resulting in lighter coloured flowers.

As the forcing period approaches the natural flowering period, the response to forcing treatment decreases. However forcing can hardly be justified for near natural season flowering since earliness and marketing advantage are required to offset the costs of the operation.

Flowering can be delayed by extended storage at 25°C. One month before the bulbs are required for planting, they are transferred to 10°C to promote initiation.

It can be seen that very accurate scheduling of flower production in iris is possible through the choice of cultivar, bulb size, storage and forcing temperatures.

HANDLING OF FLOWERS:

Iris flowers should be cut at the bud stage just as the true colour shows. Flowers can be stored dry at -1 to 0°C for up to 2 weeks or at 5°C for 4-5 days. If the flowers are stored any longer than these periods, the vase-life, normally 5-6 days, deteriorates.

Iris bulbs undergo a period of rapid bulb development after flowering so as many leaves as possible should be retained on the plant when cutting the flowers.

PESTS AND DISEASES:

bulb and stem nematodes, aphids, thrip, bulb mite, lesser bulb fly.

crown rot, leaf spot, botrytis, bulb rot.

virus - mosaic.

RECOMMENDED READING:

REES, A.R. (1972): The growth of bulbs. Academic Press, London. 311 p.

SAY, J.S. (1964): Irises for cut flowers. N.Z. J. Agr. 108(4): 403-409.

WALLA, I. & KRISTOFFERSEN, T. (1969): Some factors affecting the result of early forcing of Iris x hollandica 'Wedgewood'. Acta Hort. 14: 187-194.

LILY

Lilium fam. Liliaceae

Unlike the situation in Japan, the Netherlands and America where glasshouse culture of lilies is predominant, commercially grown lilies in New Zealand are mainly grown outdoors.

In 1967 the areas were; cut flowers - 6.0 ha, bulb sale - 5.0 ha and 360 m^2 grown under glass.

As with many other bulb crops, the production of flowers is usually combined with bulb production for sale.

The main centres of production are Palmerston North and Levin.

VARIETIES:

Lily hybrids from several species are grown for cut flowers.

In the northern hemisphere countries mentioned, controlled glasshouse production of "Easter lily" (*L. longiflorum*) cultivars for cut flowers and potted plants predominates.

In New Zealand, longiflorum cultivars, asiatic and aurelian hybrids are grown outdoors.

Lilium auratum and *L. speciosum* hybrids are more suited to North Island climates and are grown there in quantity in several areas.

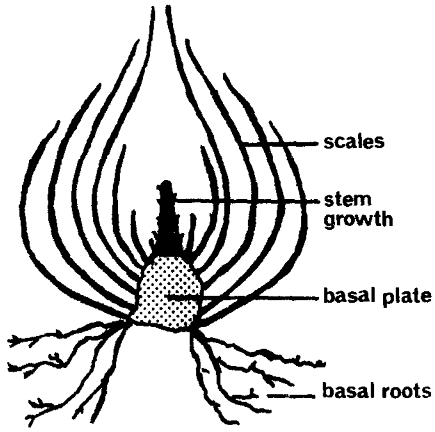
Lilium regale, the so-called "Christmas lily" is in the home-garden category.

PROPAGATION:

Lilies can be propagated by seed, scales, bulblets, bulbils and by natural bulb increase.

Seed propagation is normally used only when certain varieties come reasonably true from seed, and has the assumed advantage of producing virus-free plants. Plants flower within 1-5 years depending on the variety.

Commercially, propagation from scales is the most common method. Scales are the fleshy adapted leaves that comprise the bulb. These are spirally arranged about a short axis, the basal plate. The outer scales are detached from the parent bulb and placed in moist media in polythene bags or in flats containing peat/sand.



LILY BULB

A temperature of 23°C for 6 weeks encourages optimum bulblet development. The small bulblets can be planted out in the summer or, following a temperature regime of 23°C (6 weeks), 17°C (4 weeks) and 5°C (12 weeks), in the following spring. The latter treatment is used when propagating in late summer or autumn.

Scaling immediately after flowering gives more and larger bulblets than at other times of the year.

Bulblets may also form at or below ground level on the flowering stem, and bulbils are formed in the leaf axils of several species and their hybrids.

Scale bulblets, bulblets and bulbils usually flower within 1-3 years, and are lined out in the field until they attain flowering size.

Natural increase is usually too slow for commercial purposes.

SOIL:

As lilies are extremely susceptible to root rot, and bulb and root damage, excellent drainage is essential.

A peat/sand mix for glasshouse crops or a soil with a high organic matter content for field crops is desirable, as is a pH of 5.5 - 6.5.

Crop rotation is essential - bulb plantings are normally lifted every second or third year to minimise soil-borne fungal problems, particularly fusarium.

Many lily cultivars are stem-rooting and a mulch of organic matter around outdoor grown plants ensures maximum stem-root development.

PLANTING:

Lily bulbs are usually lifted any time between February and April - early lifting and replanting are favoured for field crops as the bulbs can commence new root activity before the onset of winter.

Unlike narcissi and tulip bulbs, lily bulbs never become "dormant" and must not be allowed to dry out. Bulbs are commonly held in moist sphagnum moss or sawdust between lifting and replanting.

The soft fleshy scales are easily damaged during lifting and replanting, and to avoid bulb fungal problems, careful handling is essential.

Bulbs for glasshouse culture or forcing are normally graded into size groups as larger bulbs produce more flowers and flower slightly earlier than smaller bulbs - important if uniform flowering is required.

The bulbs should be planted 8-15 cm deep in flats, pots, glasshouse beds or in the field. Shallow planting can reduce the time to flowering by up to 5 days.

Spacings depend on the method of culture and the cultivar but are usually 10-15 cm apart in rows 45-90 cm apart in the field, 1 bulb per 15 cm pot or 12 x 10 cm in glasshouse beds or flats.

WATER:

The irrigation practices should relate to the soil type or mix to ensure adequate and uniform moisture levels while avoiding waterlogging. Semi-automated trickle irrigation systems are useful in glasshouse crops.

Fluctuations in moisture level are harmful - dry soil encourages the loss of flowers through bud blasting while wet soils enhance root-rot fungi infestations.

FERTILISATION:

Lilies are intolerant of excessive fertiliser and high soluble salt levels, so fertilisation should be kept in moderation. High fertiliser or soluble salt levels injure the plant's roots, dwarf subsequent growth and reduce flower-bud count.

Adequate fertilisation in the early stages of growth is essential and fertilisation should commence with a sidedressing of a "complete" fertiliser when the stem is 2-5 cm high.

Liquid fertilisation systems can also be used.

LIGHT:

Lilies require full light intensity. Any reduction in light, through shading for temperature control or through high planting densities, will increase stem length but reduce the number of flower-buds per stem.

Lilium cv. 'Georgia'

light level	stem height	av. flower number
100%	38.6 cm	13.3
75	44.4	12.7
50	47.6	11.9

Lilium is particularly sensitive to low light when the stem is about 10 cm high - less than 50% light at this stage seriously affects flower-bud initiation.

In glasshouse crops, supplementary lighting has been used in low temperature/low light periods to maintain vegetative growth to ensure continued floral development and to reduce flower-bud abscission that can occur in low light intensities.

High light intensities during or following cool weather, or high temperatures after low light periods, may promote bud blasting.

DAYLENGTH:

Lilium is a long-day plant. Daylength affects flower-bud initiation, stem height and the amount of vernalisation (cool temperature treatment) required before flower initiation can occur.

Anthesis is reached up to 10 days earlier under long days than short days depending on the cultivar, and plant height in 18 hr photoperiods is frequently 1½-2 times the height in 9 hr photoperiods.

In naturally short-stemmed cultivars, the internodes can be lengthened (stem height increased) by artificial lighting - a "night-break" of 4 hrs of incandescent light being most effective. The treatment should be maintained from the time the stem emerges from the soil until the flower-buds become visible - about 10 weeks after planting.

The main effect of daylength on flowering is associated with the vernalisation requirements of the bulb.

Normally, bulbs require a period of exposure to low temperatures before flower initiation can occur. However, non-vernalised bulbs can be flowered and anthesis accelerated by 30-45 "long-day" photoperiods, achieved through "night-break" lighting, after shoot emergence. This replacement of part or all of the vernalisation requirement by long days is a feature of many plants with such a requirement.

Lilium cv. "Georgia"

treatment	mean flowering date
unvernalised	48
vernalised	15
unvernalised + LD	1 = base

TEMPERATURE:

Temperature is the dominant factor controlling flowering in lilium.

Before flower initiation can occur during the intial stages of stem growth, it is necessary that a minumum cool temperature requirement be satisfied. This factor is subject to the effect of photoperiod on vernalisation, as discussed under "Daylength".

Although temperatures up to 20°C have been shown to vernalise, the optimum and commercially used cool temperature treatment is 5°C for 6-8 weeks.

Bulbs not vernalised may still flower but the growth rate is slow and anthesis considerably delayed.

Natural winter chilling overcomes the vernalisation requirements of field-planted bulbs for natural season flowering, but for controlled glasshouse forcing, the low temperatures should be given as a precooling treatment to the unplanted bulb.

Commercial glasshouse flower growers overseas usually obtain the bulbs from specialist suppliers or propagators who normally give the bulbs the necessary temperature treatments before they are sent to the grower. In New Zealand, these treatments are carried out by the flower grower.

Late lifting of lily bulbs in autumn complicates the assessment of the cool storage period required for controlled flowering since the bulbs may be partially vernalised before lifting. Accurate scheduling of flower production then becomes extremely difficult.

The controlled flowering of lilies under glass is dependent on manipulation of the bulb storage period and the forcing temperatures. Cool storage is the primary controller of flowering time while the forcing temperatures enable fine adjustment for crop scheduling.

Precooled bulbs of the longiflorum type usually flower 110-120 days after planting when grown at the normal forcing temperatures of $16^{o}N/21^{o}D$.

Longer cool temperature treatment results in a shorter forcing time but reduced flower number.

Lilium cv. "Croft"

weeks at 5°C	days to flower	av. flower number per stem
0	196	10.0
2	160	9.1
4	123	6.4
6	110	5.6
8	109	5.2
10	103	4.9
14	100	4.4

Stem growth emerges 3-4 weeks after planting depending on the temperatures. Night temperatures of 16°C and day temperatures of 21°C are maintained during the early growth stages as prolonged exposure to temperatures above 21°C before flower initiation will cause devernalisation of the bulb.

Flower initiation occurs 5-6 weeks after planting, when the stem is about 10-15 cm high. The optimum temperature for initiation in *L. longiflorum* cultivars is about 20°C; varying between 13-23°C for the different lily types.

After flower-bud initiation, the glasshouse night temperature can be increased to 21°C (i.e. 21°N/21°D), if the light intensity is high, to hasten anthesis. Reducing the temperature will slightly delay anthesis. If the light intensity is low, increasing the temperature may cause bud blasting.

With proper storage to ensure a continuous supply of bulbs for successional plantings, potted or cut lilies may be produced on a year-round schedule.

For delayed planting and forcing, lily bulbs can be held at 21°C until 6-8 weeks before they are required for planting. They are then transferred to the cool vernalising temperatures.

FLOWERING:

Although most of the literature refers to the Easter lily (longiflorum) type, other types of lilies can be controlled by similar cooling and forcing temperatures.

However, the time from planting, or the start of the forcing temperatures, to anthesis varies according to the type and cultivar.

type	approx. forcing period
L. auratum and L. speciosum hybrids	140 - 180 days
'Mid-Century' hybrids	90 - 100
asiatic hybrids	90 - 100
cf. longiflorum hybrids	110 - 120

Despite the extent of lily forcing overseas and the marketing advantages of such a system, lilies are not forced in New Zealand.

They flower naturally according to the type, from November/December ("Mid Century"), December (longiflorum), December/January (aurelians and asiatics) to February/March (auratum and speciosum).

HANDLING OF FLOWERS:

Lily inflorescences (heads) or single florets are cut 1-2 days before opening depending on the requirements of the market. Marketing before the flowers open prevents bruising the petals.

Potted lilies are sold in flower. If the plants are maturing too early, flowering can be delayed by storage at $0^{o}C$ for up to 2 weeks from when the lowest bud is swollen and just ready to open.

Flower heads can be held at 2-$5^{o}C$ for a maximum of 12-14 days before flower quality deteriorates.

Each lily floret may last up to 5 days, depending on the cultivar and room temperature, and total vase-life is determined by the number of florets in the head.

The removal of pollen to avoid staining is advisable although naturally pollenless cultivars are now available.

PESTS AND DISEASES:

aphids, nematode

botrytis, fusarium (basal rot), pythium, rhizoctonia (root rots)

virus - cucumber mosaic, fleck

RECOMMENDED READING:

LANGHANS, R.W. & KIPLINGER, D.C. (1967): Easter lilies - the culture, diseases, insects and economics of easter lilies. N.Y. and Ohio Lily Schools. 158 p.

ROCKWELL, F.F. et al. (1961): The complete book of lilies. Doubleday and Company, Inc., New York. 352 p.

NARCISSUS

Narcissus fam. Amaryllidaceae

The traditional spring flowers, narcissi are the main flower bulb crop grown outdoors in New Zealand. In 1967, 61 ha were grown for cut flowers and 17 ha for bulb sale.

As with most other flowering bulb crops, growers of narcissi sell both flowers and bulbs although there are several growers specialising solely in the production of bulbs for sale - mainly of show varieties.

Unlike tulips which show a marked aversion to the warmer North Island winters, narcissi tolerate a wider range of temperatures and are grown in most areas of New Zealand.

The major commercial flower growing areas are South Auckland and Canterbury.

VARIETIES:

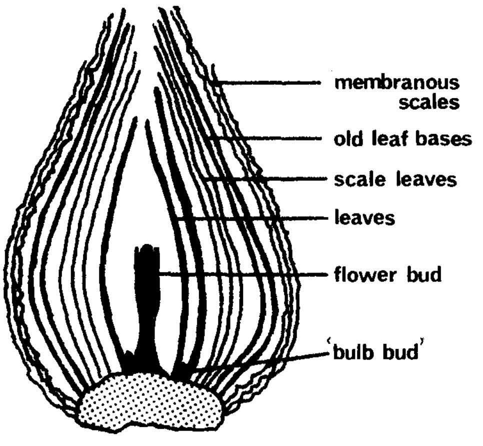
Of the thousands of narcissi cultivars, few are suitable for commercial flower production. Breeding emphasis has been on the development of show-table qualities with the result that few cultivars grow, multiply, flower and keep well to commercially acceptable standards.

Trumpet and large-cupped narcissi are the main types grown for cut flowers although smaller numbers of small-cupped, tazetta and double types are also grown.

PROPAGATION:

Narcissi are propagated by natural "division" of the bulb. Unlike iris and tulip bulbs, the narcissus bulb does not renew itself completely every year.

Each season, the apical meristems in the leaf axils of mature bulbs produce 2, 3 or 4 scale leaves, 2-3 leaves then a flower bud. These new bulbs enlarge and cause gradual disintegration of the previously intact outer bulb scales.



NARCISSUS BULB

This factor, plus the variable rate of bulb increase, results in a range of basic structures. Normally, all bulbs, with the exception of small "offsets" are capable of flowering.

For hybridising purposes only, narcissi can be grown from seed, taking 4-6 years before flowering.

SOIL:

Narcissi are not very demanding concerning their soil requirements but best growth and flowering is obtained on well-drained soils with a moderate water-holding capacity. Subsoiling or deep soil preparation is advisable as the bulbs are deep rooting.

A pH of 6.0 - 6.5 is suitable.

Bulb plantings are usually rotated every 2-3 years to avoid disease and weed problems.

PLANTING:

The rate of bulb division of narcissi is not as rapid as that of tulips and annual lifting is seldom practised. Bulbs left up to 5 years may still give reasonable flower production, although flower yields and quality decline from the third or fourth year.

The bulbs are normally lifted in December or January after the leaves have turned yellow/brown.

Mechanical bulb planters are available for planting and bulbs can be lifted either by adapted potato diggers or by exposing the bulbs by ploughing.

After lifting, the bulbs should be placed in shallow trays and dried in an airy position before bulb treatments.

Soft bulb tissue usually indicates the prescence of bulbfly larvae or eelworm. These bulbs should not be planted unless given the standard hot-water treatment of 44°C for 3-4 hours, after drying and within 2 weeks of lifting.

Insecticidal and fungicidal dips are normal preventative procedures applied to all bulbs after lifting and drying.

Subsequent storage treatments depend on the type of flower production required.

Bulbs for natural season field flowering are replanted, without any further treatment, from February to April.

If early flowering is required, the bulbs undergo various temperature treatments depending on the degree of earliness desired.

Spacing of bulbs depends on the soil type, cultivation and weed control practices and the number of years the bulbs are to remain planted.

For field planting and flowering, bulbs should be planted 10-15 cm deep depending on bulb size, 10-15 cm apart in single, double or triple rows separated by 60-80 cm wide paths.

Ridged planting may be practised on marginally drained soils.

Bulbs required for forcing are closely planted in 12 cm deep flats with the top of the bulb just below soil level.

WATERING:

The growth of foliage and flowers is just an expansion of previously differentiated tissues therefore a moist soil is required during all stages of growth and flowering, especially for glasshouse crops.

FERTILISER:

Although the basic requirement is a soil of naturally good fertility, preplanting fertiliser applications are recommended.

High soil nitrogen levels promote bulb increase and result in longer flower stems, but can cause slight delays in the time of flowering.

Both high nitrogen and potassium levels appear to encourage basal rot infestation with resultant loss of flower production and bulbs.

FLOWERING:

Many features of the narcissi's growth and flowering behaviour can be related to their original habitat - the genus is centred on Portugal and coastal Spain. These are more temperate areas than the habitat of tulips, and although the summer dormancy as exhibited by tulip is less obvious in narcissus, the seasonal growth patterns and temperature requirements are basically the same.

Recognition of flower development stages within the bulb is important to determine the timing of temperature treatments for inducing early flowering.

Flower-buds are initiated in mature narcissi bulbs about the November before flowering and in most cultivars flower differentiation is complete by February.

The process of flower-bud differentiation must continue throughout the remainder of the growing period following initiation. This continued differentiation is most rapid at 15-17°C. These temperatures are normally experienced in the naturally warm summer soils but for bulbs lifted early in preparation for forcing, they may have to be provided artificially.

NARCISSUS

In addition, there is a low temperature requirement after the completion of flower-bud differentiation, which must be satisfied before normal extension growth can occur in the warm temperatures of spring or in the glass-house in the case of forced bulbs.

Bulbs grown outdoors in temperate climates have this low temperature requirement satisfied by the naturally low temperatures of winter.

Narcissi can be readily forced to give an extended flowering season but in New Zealand are flowered during the natural season only.

Natural flowering starts in early winter (June) with the "tazetta" group, i.e. "Paper White", "Erlicheer" and "Soleil D'or". The trumpet and cupped narcissi groups continue flower production through the main flowering period of August/September to October.

Forcing narcissi consists of giving the bulbs the combination of high temperature storage after lifting and low temperature treatment artificially at a time of the year when these temperature regimes are not possible naturally. After these treatments, the bulbs are transferred to warm temperatures to hasten anthesis.

Within 1 week of lifting, the bulbs should be stored at 17^{o}C for 3-4 weeks to hasten flower-bud differentiation.

After the warm temperature treatment, the bulbs can be planted in flats to experience the cool temperatures naturally during winter. However, if the bulbs are given part of the cool temperature treatment as a precooling treatment before planting, and the remainder after planting, flowering can be hastened by up to 14 days.

As with tulips, a total of 12-14 weeks of cool temperature treatment is required for successful flowering.

Bulbs are usually precooled at 9^{o}C for 6-8 weeks. They are then immediately planted in flats and placed outdoors in a cool position at around 9^{o}C for a further 4-6 weeks for initial foliage, flower and root growth. The roots, necessary before forcing can commence, grow rapidly and are extensive 3-4 weeks after planting.

Control of the post-planting (rooting) temperature is important for early flowering. Bulbs are stored at 9°C - less than 7°C affects flower quality while temperatures above 11°C are of little advantage for early flowering.

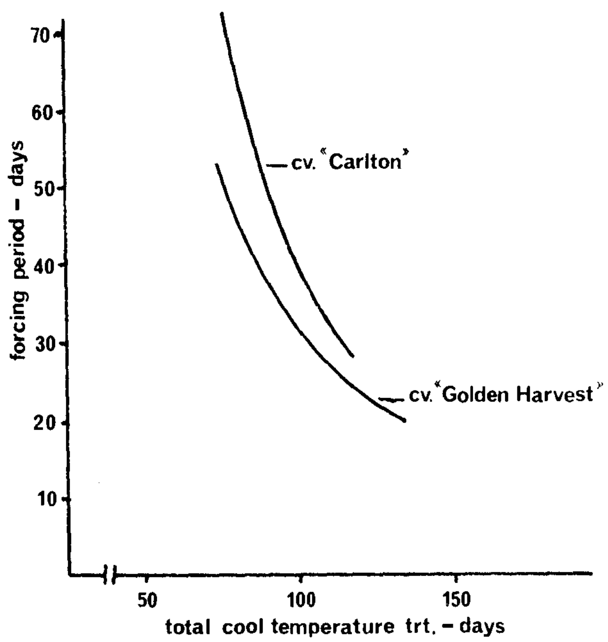
Narcissus cv. "Carlton"

rooting temperature	mean flg. date
9 °C	1 = base
11	4
13	24
15	31

pre-cooled: 9°C, 6 weeks

The post planting 9°C treatment should be continued until the flower-buds become visible at the base of the expanding leaves - about 4-6 weeks after planting.

At this point, the flats should be shifted into a glasshouse or under cover and the temperature gradually increased to 13-16°C to force the flower-bud to anthesis. Anthesis is reached more rapidly at higher temperatures, e.g. 16°C (35 days), 18°C (28 days), but quality may be reduced. About 10 days before anthesis, the temperature can be reduced several degrees to improve flower quality.



Certain cultivars, particularly those with orange and red "crowns" are better coloured when forced at lower temperatures or when stored at lower temperatures prior to marketing - the final intensity of the colour increases with decreasing temperature.

Narcissi should be grown or forced in full light while photoperiod appears to affect only plant height - flower stems are longer in longer daylengths.

The "precooled-rooting" system of cool temperature treatment usually precludes very early forcing, since the cool temperatures required after planting cannot normally be satisfied by the still warm temperatures of late summer and early autumn. As with tulips, the whole of the cool temperature period can be given artificially. After the 17°C warm period, the bulbs are precooled at 9°C for 12 weeks, planted, then immediately forced at 16°C. However, the flowers are shorter stemmed, are often of reduced quality and flower a few days later than "precooled-rooted" bulbs.

Still earlier forcing can be achieved by lifting the bulbs 3-4 weeks earlier than normal, storing the dried bulbs at 30-35°C for 1 week to hasten flower-bud differentiation, followed by the normal 17°C for 2 weeks. Through this method, bulbs can be flowered up to 15 days earlier than bulbs stored at 17°C only, although both flower size and stem length may be slightly reduced. Caution must be exercised during this treatment as too high temperatures can damage the flower-bud causing blindness.

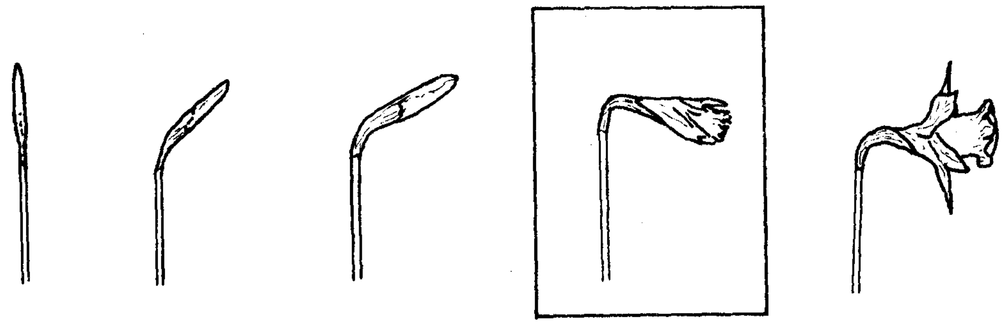
Flowering can be retarded by continued warm temperature storage at 25-28°C, but bulb keeping quality is adversely affected.

A temperature regime of 30°C (for 12 weeks from lifting), 0°C (9 weeks) then 25°C (8 weeks) retards anthesis by more than 6 months without affecting the bulbs, and is now the preferred method of retardation.

Retarding of bulbs is normally only used when shipping bulbs from one hemisphere to the other, but when complemented by the 12 week 9°C precooling treatment for early flowering, can be used to produce narcissi flowers all year round.

HANDLING OF FLOWERS:

Trumpet and 'cupped' narcissi should be cut at the fat "gooseneck" stage when the perianth is coloured and just about to open.



Flowers of most cultivars picked earlier than the tight gooseneck stage are generally of reduced quality and decreased stem length, flower size and vase-life.

Tazetta and multi-flowered narcissi are usually picked when the lower 1-2 florets have opened.

Temperature affects the rate of flower opening - development is very slow at less than 8°C and flowers last longer if opened at between 8-16°C. If the temperature is controlled, flowers remain closed during marketing, and open for the consumer.

Flowers store well, either in water or in dry storage polythene bags, at 2°C for 10-14 days.

The average vase-life of narcissi flowers is 7-8 days at 16°C but this varies considerably with the cultivar from 5-12 days.

PESTS AND DISEASES:

aphids, bulbfly (large and small), bulb mites, eelworm

basal rot, botrytis, leaf scorch

virus - mosaic, yellow stripe

RECOMMENDED READING:

MATHER, J.C. (1961): Commercial production of tulips and daffodils. W.H. and L. Collingridge Ltd, London. 212 p.

MIN. AGR. FISH. FOOD (1951): Narcissus culture. Bul. 44. H.M.S.O., London. 39 p.

SALINGER, J.P. (1964): Narcissus culture for cut flowers and bulb trade. N.Z. J. Ag., 109(3): 258-265.

ORCHID

fam. Orchidaceae

Orchids are a large and complex group of plants requiring specialised cultural techniques so therefore only an outline of production recommendations is possible.

Solely a glasshouse or shadehouse crop, orchids, while accounting for only 11% (8560 m^2) of total glasshouse flower crop area, are a crop of major importance because of their high value.

The climatic requirements of commercially grown orchids and the economics of production concentrate their production in the milder Auckland and Bay of Plenty areas. The major growers are in Whakatane, Napier, Auckland and Levin.

VARIETIES:

Although the orchid family Orchidaceae exceeds over 20,000 species, only a few genera and their hybrids are used in commercial flower production.

Cymbidium is the only orchid genus produced in quantity for cut flowers, although smaller numbers of *Paphiopedilum* (syn. *Cypripedium*), *Cattleya* and *Phalaenopsis* are also grown. Some of the newer hybrids from these genera are in great demand.

The colour range varies between genera, species and cultivars and includes cream, yellow, green, rose, pink, purple and bronze shades.

Orchids are very long lasting flowers and are grown basically for 'occasions'. The growing of many different cultivars and the modification of certain cultural practices is required to ensure continuity of flower production throughout the year.

PROPAGATION:

Extensive hybridising of orchids is carried out by specialist propagators. However, the 4-8 year period before flowering normally precludes this method of propagation from consideration in commercial flower production.

Terminal meristem methods enable rapid stock build-up, especially of the newer cultivars, but as with seed propagation, it is a specialised technique which for reasons of facilities and technical ability, is limited to the specialised propagators.

It is necessary to describe the types of orchid growth before considering vegetative propagation.

Orchids have either sympodial or monopodial growth habits.

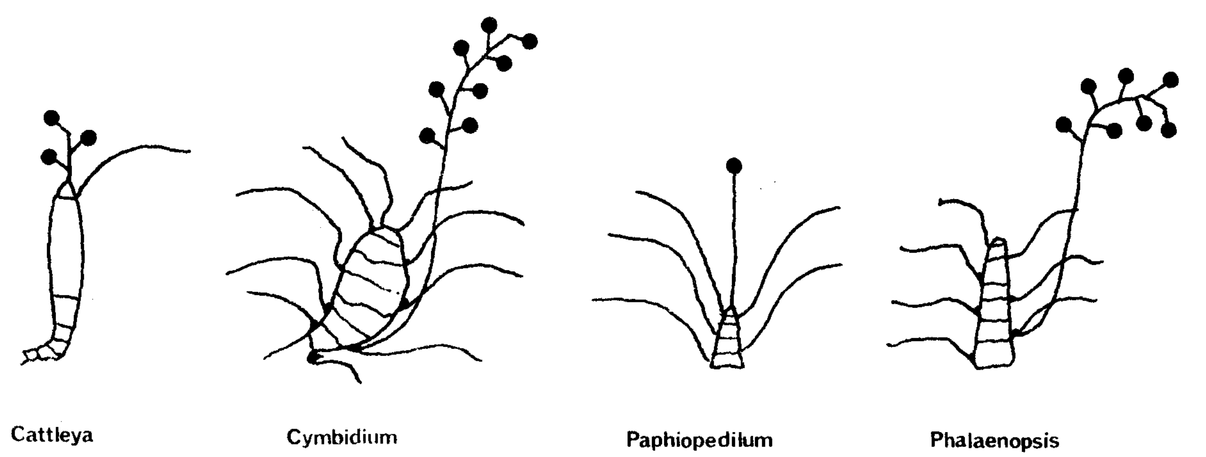
Cattleya and cymbidium exhibit sympodial growth. A prostrate rhizome terminates periodically with an upright pseudobulb, leaf and flower spike. The flowers are terminal and after flowering a vegetative bud at the base of the pseudobulb continues rhizome growth. Paphiopedilum, although having a sympodial growth habit, does not form pseudobulbs.

The growth habit of phalaenopsis is monopodial - an upright stem continues uninterrupted terminal growth producing closely spaced leaves. Flower stems arise from the leaf axils and aerial roots may form at the leaf nodes.

Orchids with pseudobulbs are propagated by division. Sections of 4 pseudobulbs are cut from the parent plant, ensuring that virus spread through contaminated cutting tools is minimised. The pseudobulb section is struck in peat/sand with bottom heat of 18°C in moist humid surroundings. The new plants are potted on when the new leaves are 15 cm long.

Paphiopedilum is propagated by division of the rhizome.

Monopodial types such as phalaenopsis are propagated from 'plantlets' which may form at the nodes of the flowering spike. These are removed from the parent plant, placed in peat/sand and potted up when the roots are 1-2 cm long. The more common method of propagation is from sideshoots that may develop from the base of the plant. These can be removed and potted up after root growth commences.



GROWTH HABITS AND FLOWERING CHARACTERISTICS

SOIL:

Orchids are grown in coarse, well-drained potting mixes normally in containers to simulate the natural condition to which these epiphytic and semi-terrestrial plants are adapted. Recommended potting mixes incorporate osmunda fibre (now substituted by peat), shredded bark, perlite, coke, etc., depending on the species. Plants grown in containers are usually repotted every 2-3 years.

Species requirements differ but a pH of 5.5 - 6.0 is generally suitable.

WATERING:

Irrigation, adapted to the seasonal requirements of the plant, should be adequate to leach the soil mix periodically to avoid soluble salt build-up and to keep the plants uniformly moist.

Subirrigation (the pot sits on moist sand or gravel) and trickle irrigation systems are frequently used.

Relative humidity of 50-70% is desirable and good air circulation is required to prevent fungal problems.

FERTILISER:

The growth of some orchids is very slow therefore high fertiliser applications are not required. The faster growing genera such as cymbidium do however benefit from regular fertilisation.

Fertilisation during the growing season with liquid fertiliser is preferred to dry base or sidedressings.

LIGHT:

Depending on the species, high light intensitites (therefore high temperatures) may cause leaf burn and yellowing through excessive water loss, while low light delays plant development.

Seedlings and young plants require shading from high light - 70% shade is recommended.

Mature orchids usually require partial shading of 50-80% depending on the species. Cymbidium is the most tolerant genus to high light levels - best growth and flowering is obtained at around 50,000 lux or 50% shade at midsummer sunlight levels.

FLOWERING:

Temperature is the main factor controlling flowering in cymbidium and paphiopedilum.

Cymbidium hybrids normally flower in winter and early spring following flower initiation in the previous autumn. The flower spikes are produced by young developing pseudobulbs of the current season's growth. Mature pseudobulbs usually produce vegetative shoots only, but may flower if environmental conditions are suitable.

Flower bud initiation is promoted by cool night temperatures (10°C) - in milder areas, cymbidium can be grown outdoors in shadehouses.

Day temperatures of 15°C and high light intensities (i.e. 50% shade) are also conducive to good initiation. A slight reduction in light intensity during flower-bud development may result in better flower colour and reduce bud blasting.

There is no obvious response to photoperiod - short days result in weak growth while long days stimulate vegetative growth. However, best flowering is achieved in long days, high light and cool temperatures.

To slightly extend the flowering season beyond winter and early spring, summer temperatures must be controlled. The use of evaporative fan and pad and mist cooling systems enable good temperature control in the warmer parts of the year.

Hybridisers of cymbidiums are attempting to extend the flowering season by breeding naturally early and late flowering cultivars.

"Paphiopedilum" hybrids, the result of extensive hybridising with other genera, can be flowered all year round while the main flowering season for paphiopedilum species is winter and spring.

CYMBIDIUM x

Most paphiopedilums produce a single flower per stem, although some types are multiflowered. Flowering stems arise from the centre of recently matured growths.

The main group of paphiopedilum orchids grown for cut flowers are grown at temperatures of 12°N/18°D. Paphiopedilum is less tolerant of high light intensities than cymbidium and heavy shade (80%) is advisable in summer.

Flower initiation, promoted by 12°C night temperatures, appears unaffected by photoperiod. Night temperatures of 18°C or above can be used to prevent initiation, thereby delaying flowering.

The time from initiation to flowering can be up to 6 months, and after cool temperature flower bud initiation, the night temperature may be increased to 18°C to increase stem length and hasten development to anthesis.

Flowering in cattleya and phalaenopsis is mainly photoperiod dependant although the response to daylength is modified by temperature.

While most cattleya species are short-day plants, a number of 'day-neutral' species exist. In these plants, initiation can occur under both long and short days.

However, flower bud <u>development</u> to anthesis in all cattleyas is promoted by short-day photoperiods. Flower bud development may follow immediately after initiation (in which case the plants would flower from 10-17 weeks later) or it may be delayed several months. Therefore buds initiated under long days (i.e. on day-neutral species) may not develop until the daylength begins to shorten.

Despite this photoperiodic factor tending to limit natural flowering to several periods in the year, the introduction of less daylength dependant multi-generic hybrids have allowed "cattleyas" to be flowered naturally all year round. It is these hybrids of cattleya that are grown commercially in preference to the various species.

The optimum temperature for initiation in the cattleya group of orchids is 12°C (night) and plants often remain vegetative or give poor flowering at 18°C. Plants are grown at 15°N/21°D.

For specific cultivars, the use of artifical light to extend daylength enables the grower to control flowering time to coincide with better markets. Black cloth can be used to advance the flowering date. It is more usual however, to use different cultivars flowered naturally to extend the flowering season rather than to control flowering through lighting or shading programs.

The phalaenopsis species flower naturally in late summer to winter and are grown at temperatures of $18^{o}N/24^{o}D$. Initiation and development appears dependant on a period of lower night temperatures (15-18°C) and short-days. Like cattleya, long-days do not inhibit flowering in phalaenopsis but can delay it by at least 2 months. Continuous short-day cycles have resulted in continuous flowering, indicating that controlled lighting or darkening operations may be used to extend the natural flowering season of certain cultivars. As with paphiopedilum and cattleya, intergeneric phalaenopsis hybrids can be flowered over most of the year.

Both cattleya and phalaenopsis require heavy shade in summer and in common with all orchids, continuous air movement is essential for uniform temperatures.

<u>HANDLING OF FLOWERS</u>:

The individual flowers, on opening, are tagged and dated, and cut about 3-5 days after bud burst. After cutting, the flowers are placed in water with a surrounding air temperature of 12-15°C; temperatures less than 10°C cause flower disorders or irrevocable flower wilting.

Orchid spikes can be cut when the last flower of the spray is open.

Although most orchids will keep up to 3 months after cutting, cymbidium flowers are the preferred cut-flower since, unlike most other orchids, flower-buds continue to open after cutting. This is particularly important if orchid spikes are being cut.

Flowers are injured by air impurities and for this reason, orchids should be grown away from cities or areas of pollution.

For transit, the orchid stems are inserted through rubber caps into vials of water and preservative and taped to the bottom of the container.

PESTS AND DISEASES:

aphids, mealy bugs, thrips, slugs, scale, mites.

root rot, botrytis.

virus - cymbidium mosaic, cattleya mosaic.

RECOMMENDED READING:

AUSTRALIAN ORCHID REVIEW

EIGELDINGER, O. & MURPHY, L.S. (1971): Orchids - a complete guide to cultivation. J. Gifford Ltd, London. 224 p.

NEW ZEALAND ORCHID REVIEW

NORTHEN, R.T. (1962): Home orchid growing. D van Norstrand Co. Inc., New York. 309 p.

ROTOR, G.B. (1952): Daylength and temperature in relation to growth and flowering of orchids. Cornell Univ. Agr. Exp. Stn. Bul. 885. 47 p.

RANUNCULUS

Ranunculus asiaticus fam. Ranunculaceae

As with the closely related anemones, ranunculus make ideal winter and early spring cut flowers.

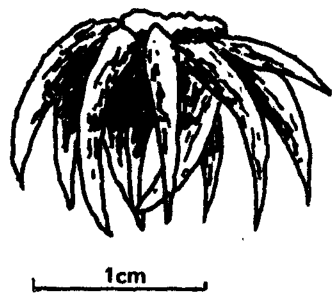
R. asiaticus is the parent species of the varieties grown for commercial flower production.

In the "Tecolote" strain, the 8-10 cm diameter double blooms are carried on 30-40 cm stems. Tubers are offered in separate shades of pink, red, orange, yellow, gold and white, in both individual colours and colour combinations.

The double and semi-double strain "Claremont" is available in a similar colour range.

The tubers are raised from seed sown in October or November. Pregermination of seeds in cool, moist sand for 15 days followed by sowing in a shaded seed bed has given good results.

The seedlings must be kept moist at all times during the following summer as the best flowering is obtained from the larger, not necessarily the older, tubers.



RANUNCULUS TUBER

From an October or November sowing flowers may be produced from March/April till September/ October. Later sowings may not be sufficiently well developed for flowering in autumn and winter and should commence flowering in early spring.

One year old tubers are preferred for consistent flower production.

For autumn to spring flowering, larger sized ranunculus tubers are planted in December or January. As with late sowings of seed, late planted or smaller tubers may develop slowly during summer, especially if not kept moist, and flowering is delayed. Tubers are planted 5 cm deep, 15 cm apart in staggered double rows or in multiple rowed beds as they are less susceptible to overcrowding problems than are anemones.

Other aspects of culture and flowering are the same as for anemones.

ROSE

Rosa hybrida fam. Rosaceae

Roses are a major glasshouse flower crop in New Zealand, in terms of both area grown and economic value.

In 1967, the area grown under glass was 5020 m^2: the bulk of the rose production generally being produced by a few specialised growers with large operations. 8.5 ha of outdoor roses, for both plants and flowers were also grown; the quality and production of outdoor blooms being inferior to glasshouse produced flowers.

The main flower production areas are Christchurch, Nelson and Auckland.

VARIETIES:

The main glasshouse forcing rose type is the 'hybrid tea'. Productive and fragrant, the large terminal flowers are available in a multitude of colours.

Some *R. floribunda* cultivars are grown. Unlike hybrid tea cultivars, these are not disbudded and give a spray effect.

The choice of cultivar is determined by market demand and grower experience - although most roses will force under glass, cultivars bred for glasshouse growing give better production and are preferred.

A good colour range, incorporating red, pink, yellow and intermediate colours, is essential. Demand for white roses appears limited to 'occasions'.

PROPAGATION:

Commercial flower growers usually obtain their planting stock from commercial propagators. In New Zealand, scion material is T-budded onto *R. multiflora* stock. Disease free planting material is essential and virus free rose rootstocks are obtainable from the Levin Horticultural Research Centre.

Rosa multiflora is reportedly not entirely suitable for winter production and the introduction of other possible rootstock species including *R. manettii* (the main glasshouse rose rootstock in U.S.A.), *R. indica* major, *R. canina* and *R. inermis*, are advocated to improve this situation.

Roses can also be grown on their own roots. Softwood cuttings, treated with hormone powder (0.3% IBA) and placed under mist with bottom heat, root in about 10-15 days. Although such plants are weaker than budded plants, this disadvantage may be offset by the cheaper production costs.

SOIL:

As roses are a long-term crop, replanted on a 4-5 year cycle because of yield and quality decline, special attention must be paid to soil preparation.

A deep, well-drained porous soil with a high organic matter content and slightly acidic pH (5.5 - 6.5) is desirable.

Soil sterilisation between plantings is advisable due to the susceptibility of roses to soil-borne fungal diseases and pests.

PLANTING:

Budded, dormant-eye plants are normally obtained from the propagator in winter (May-July). Late winter planting is preferred as the light is better for subsequent shoot and leaf development.

Rooted cuttings can be planted at any time of the year.

Plants should be planted shallowly, with the bud union 5 cm above the soil, spaced 30 x 30 cm apart in beds of 4-5 rows, and mulched heavily.

Side wires, to keep the stems within the beds, and cross wires, to support the flowering stems, are satisfactory at 30-40 cm intervals.

A humid atmosphere and moist soil after planting ensures even 'bud-break' and development.

WATERING:

Roses require considerable watering, depending on the stage of growth, temperature and light level.

The soil should be kept uniformly moist at all times consistent with adequate soil aeration. If the soil dries between waterings reduced vegetative growth and increased blindness may result.

Semi-automated irrigation systems with directional fan nozzles alongside the beds, or overhead misting are commonly used.

The plants should be watered early in the day to allow them to dry before night otherwise fungal diseases may develop.

FERTILISER:

Base dressings of lime, to adjust the pH as required, and phosphorus are applied before planting. In properly prepared soils with a high organic matter content, no additional feeding should be required in the first year.

Commencing in the second year, regular sidedressings of soluble (liquid or dry) nitrogen and potassium fertilisers should be made according to the seasonal demands of the plant.

High soluble salt levels cause thin stems and small, poor quality flowers.

LIGHT:

Vegetative growth and flower production are primarily affected by the level of incident sunlight.

The yield of flowers follows the same pattern as seasonal sunlight levels - production increasing in summer and decreasing in winter.

Rosa cv. 'Baccara'

light level	flowers / plant / year *
100%	48
50	34
33	26

* at 18°C

Therefore full light intensity is recommended although light shade in summer may be required to reduce sunburn of leaves and flowers. Extractor fans and cool water pads for this temperature control are preferred to shading.

As the sunlight increases or decreases, growers modify the practices of watering, fertilising, cutting and pinching to adjust flower production rate.

Supplementary lighting in low light periods has given up to a 40% increase in flower production and has reduced the time to flower development by 2-9 days in many varieties.

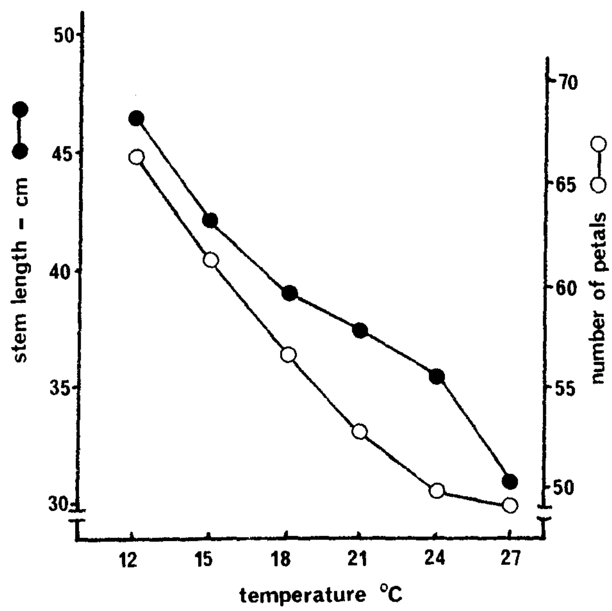
Although daylength has no obvious effect on flower-bud initiation, longer daylengths, therefore increased photosynthetic activity, may result in faster vegetative growth and improved flower production, especially if the optimum light intensity and temperature conditions are maintained.

TEMPERATURE:

The rate of flower-bud development is positively correlated with temperature.

Most glasshouse rose cultivars require night temperatures of 16-18°C - day temperatures are less critical and 18-24°C, depending on the cultivar, are satisfactory.

Higher night temperatures result in faster flower production, smaller flowers with fewer and smaller petals and shorter flowering stems than at lower temperatures. Flower quality is therefore lower at high temperatures.



Accurate temperature control at all stages of growth is essential to prevent flowering disorders.

Blindness, the failure to initiate flower-buds, is promoted by low temperatures and low light. High temperatures are recommended after cutting back, to ensure flower bud initiation in the young developing shoot.

Partially developed flowers, termed bullheads, are common at 12°C but rarely occur at 21°C.

Temperature also affects flower colour. The best quality and coloured flowers are obtained at 16-18°C night temperatures. At higher temperatures, gold and yellow coloured cultivars may pale and in red cultivars, a blackening of the petals can occur at low temperatures. Poor flower colour is also accentuated by low light - colour being correlated to the net photosynthesis of the plant.

Good ventilation is essential for temperature control and to deter the development of fungal diseases.

PINCHING AND TRAINING:

After planting, the plant is pinched to encourage cane development from the base of the plant and to build up the desired shape and habit.

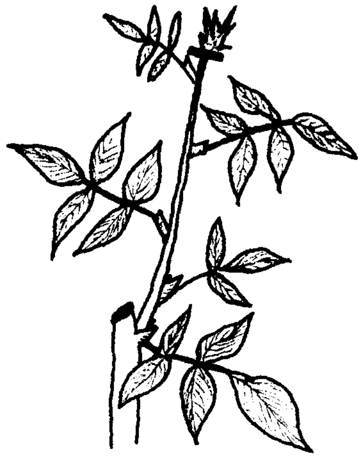
Subsequent pinching or stopping treatments are used to regulate cane growth and diameter, to encourage the production of longer stemmed flowers and to adjust the timing of flower production.

When cutting a flower stem or pinching for crop timing, the placement of the cut or pinch is important.

At about the centre of a flowering stem, there are 2-5 five-leaflet leaves - above and below these are three-leaflet leaves. In the axils of the five-leaflet leaves and the lower group of three-leaflet leaves are blunt rounded vegetative buds which develop the best flowering stems. The pointed buds in the axils of the upper group of three-leaflet leaves invariably develop into poor quality stems.

An early pinch of a developing lateral encourages more vigorous growth from weak canes. The pinch should be made above 2 or 3 five-leaflet leaves which are just unfolding.

When the first flower buds appear on a heavy cane, a soft pinch is made above the top five-leaflet leaf. This pinch forces the development of the lower buds resulting in a longer flower stems.



A soft pinch takes 3-7 days longer to produce a flower than an early pinch.

The period between pinching, or cutting, and flowering is dependant on both light intensity and temperature and will be discussed under "Flowering".

Depending on the stage of growth and the age of the plant, extensive pruning may be carried out to regulate the size of the plant and to remove weak, blind or diseased canes.

The flower production of hybrid tea roses, although reduced in winter, is continuous throughout the year. Pruning is best carried out in summer when the growing conditions are more favourable for new shoot growth and the price for flowers is lower.

Pruning all at once is generally not favoured since the plant is weakened by the drastic reduction in leaf area, there is no flower production for several months and subsequent flowers may initially be of poor colour.

Gradual pruning incorporated with normal flower harvesting procedures is preferred.

Normally, it is recommended to allow 2 five-leaflet leaves to remain after the flower stem is cut. This is especially important before winter when as much foliage as possible should be retained for maximum winter growth and flower production.

In summer, leaving 2 five-leaflet leaves below the cut, especially on vigorous canes, will result in the plant becoming too tall, and the cut would best be made further down the stem.

FLOWERING:

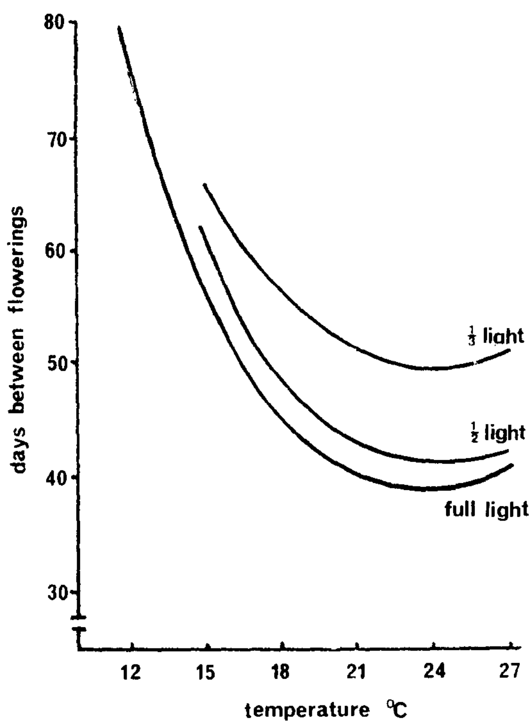
After the flower stem has been harvested or the canes cut back to shape or prune the plant, vegetative buds in the leaf axils or dormant buds below the cut start to grow.

Flower primordia are initiated within 5-10 days after active growth starts when the shoot is less than 10mm long. Flower-bud differentiation is usually complete after 20-25 days of active growth. Flower-bud initiation terminates leaf primordia initiation and subsequent flower-bud development to anthesis is accompanied by stem elongation.

Lateral buds which develop on the flowering stem of hybrid teas are disbudded leaving the terminal flower-bud to develop. On floribundas, the lateral buds are left and the terminal bud may be removed to improve the flower arrangement.

The rate at which buds are initiated and develop is determined by both light intensity and temperature.

From planting, or following renewal pruning, flowers may be produced within 2-4 months, while the period between successive flowering flushes may vary between 6 weeks in summer to 8-10 weeks in winter.



HANDLING OF FLOWERS:

The stage at which the flower is cut differs with the cultivar.

Yellow coloured cultivars are best cut tight, when the calyx begins to loosen around the petals, while red and pink types are cut when the outer petals start to unfold. Flowers cut when too tight often fail to open.

Roses should be cut late in the day. After the lower leaves are removed, the stems should be put in warm water before being placed in the coolstore for a minimum of 12 hours at 4°C. This cool temperature treatment reduces post-harvest respiration and extends subsequent cut-flower life which normally varies between 2-10 days.

Blooms can be held at 2°C for up to 2 weeks in water or, depending on the variety, packed dry in air-tight containers at 0°C. On removal from dry storage, the flowers must be conditioned by recutting the stem and placing in warm water.

Preservative solutions should be used in all post-harvest storage and marketing stages.

PESTS AND DISEASES:

aphids, thrips, leafroller, mites, eelworms.

botrytis, blackspot, downy mildew, powdery mildew, rust, stem canker, verticillium.

virus - rose wilt, rose mosaic.

RECOMMENDED READING:

MASTALERZ, J.W. and LANGHANS, R.W. (eds) (1969): Roses - a manual on the culture, management, diseases, insects, economics and breeding of glasshouse roses. Penns. Flr. Gr., N.Y. Flr. Gr. Assn. Inc. and Roses Incorporated. 331 p.

MIN. AGR. FISH (NZ) (1971): Commercial flower production - glasshouse roses. 7 p.

TULIP

Tulipa fam. Liliaceae

Tulip bulb production is limited to areas that have at least 2 months of sub 10°C soil temperatures. Unless the growers have extensive cool storage facilities, commercial flower production is normally limited to these areas also.

In New Zealand, tulips are grown as a commercial flower crop predominantly in the southern part of the South Island. The estimated area of commercial flowers is 20 ha; the major growers being in Canterbury, Balclutha and Invercargill.

VARIETIES:

There are many thousands of cultivars but their suitability for commercial flower production varies.

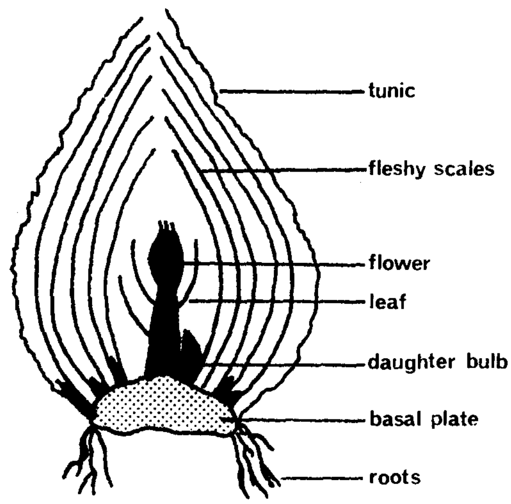
Darwin, Triumph, Breeder and Cottage hybrids are the main types of tulip grown.

Florists prefer red tulip flowers and cultivars such as Apeldoorn and Red Matador are much in demand. Other colours available include orange, yellow, mauve, purple and white, and a multitude of shades.

PROPAGATION:

Tulips are propagated by natural division of the parent bulb which is renewed annually.

A large flowering sized bulb produces several daughter bulbs in the bulb scale axils. The innermost daughter bulb grows rapidly and is fully formed after flowering of the now shrunken parent bulb. Several smaller, non-flowering sized bulbs are also produced.



TULIP BULB

Under favourable temperature conditions, the flower-bud in the new bulb will be completely differentiated by April and will bloom naturally the following spring.

Because tulips are vegetatively propagated, virus diseases are a problem and roguing before and during flowering is essential.

SOIL:

Tulips will grow well in any sandy soil that is well drained and not subject to seasonal drought. A soil pH of 6.5 - 7.5 is recommended.

The plantings are normally rotated annually in at least a 3 year cycle to prevent the build-up of soil-borne fungal diseases.

PLANTING:

After natural season flowering in September-October, the bulb continues to develop until the leaves die down in November-December.

The bulbs are lifted annually because of the fast natural increase, either by ploughing the bulbs out with a single furrow plough, or manually.

After drying in shallow trays, the bulbs are cleaned and graded. This is especially important if the bulbs are required for forcing as bulb size affects flower size (larger bulb, larger flower) and earliness (larger bulb, slightly earlier flowering).

During growth, flowering sized bulbs can be distinguished from non-flowering bulbs by having 3 or more foliar leaves instead of one. Large flat-sided bulbs are produced from flowering sized bulbs and are more likely to flower than round bulbs. Grading should be based on these criteria and that of bulb size, which is preferably greater than 10 cm in circumference.

Bulbs for natural seasons flowering are replanted from March to April, 8-12 cm deep (depending on size) in rows 45-90 cm apart or in beds of 5-6 rows with 20 cm between rows.

Planting the bulbs on ridges has improved growth and yield in marginal soil types and drainage conditions.

Immature bulbs are lined out in rows until they reach flowering size.

For glasshouse forcing, flowering-sized bulbs are usually closely planted in 10 cm deep flats with the noses at soil level.

WATERING:

High moisture levels, while avoiding waterlogging, encourage increased stem length, increased flower size and faster development to flowering.

In forced glasshouse crops, automated irrigation systems may be beneficial in maintaining an adequate moisture level.

FERTILISER:

As with many other bulb flower crops, little quantitative work has been done on fertiliser requirements. The usual recommendation is "fertile soils".

However, the effects of nitrogen and potassium on growth and flowering are dominant. Flowering is slightly retarded by both low and high nitrogen rates so fertiliser should be applied in moderation.

Sidedressings of soluble nitrogen and potassium fertilisers at three periods during growth up until flowering have resulted in increased bulb weights compared with these fertilisers being applied before planting only.

LIGHT:

Although full light intensity is recommended for growing and flowering, longer stems, increased quality and an increase in the number of flowers harvested can result from crops grown under the protection of light shade cloth. Light shade can also be used to draw longer stems from naturally short stemmed cultivars.

Daylength has no obvious effect on the time of flowering but long-days (18 hrs) increase stem length by up to 50% compared with short-days (9 hrs).

FLOWERING:

The natural habitat of Tulipa sp., Asia Minor and the Mediterranean, indicates the climatic condition these bulbs require for growth and flowering.

The growth cycle of tulip shows a cool temperature requirement as an adaptation to cold winters and a short growing season, early spring flowering and summer dormancy in response to hot, dry summers.

To flower tulips at any time other than natural season, these temperature requirements must be understood.

When tulips are lifted in January, the apex of the new bulb is still vegetative. Flower initiation and differentiation occur progressively throughout the remainder of the storage period.

Temperature is the most important factor affecting flower-bud initiation and subsequent flower development.

Flower initiation in the dormant bulbs occurs faster under warm temperatures, but the time to flowering is hastened by cool storage after the flower-buds have differentiated.

For these reasons, the bulbs for both natural season flowering and forcing are usually held in dry storage in well aerated 5-8 cm deep trays at 20°C. This initial warm period, corresponding to the high temperature "curing" treatment the bulb would receive during summer in its natural habitat, promotes the initiation of 3-5 leaf primorida followed by flower-bud initiation.

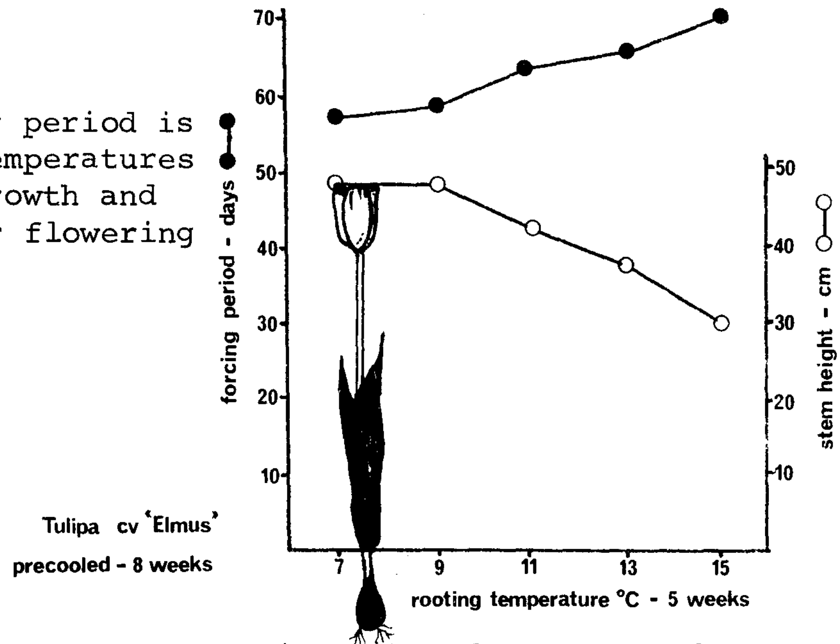
After flower-buds have been initiated, normally after 3-4 weeks of this warm temperature treatment, the temperature is reduced to 8-10°C to satisfy part of the bulbs cool temperature requirement and to promote rapid flower-bud development upon planting. This cool temperature treatment, termed pre-cooling, is maintained for 6-8 weeks.

The bulbs for natural season flowering are replanted from March-April until June and normal winter chilling overcomes the remaining cool temperature requirement.

Planting before March is not recommended as the still warm soil temperatures cannot fulfil the remaining cool temperature requirement and flowering disorders frequently result.

Certain tulip cultivars can be readily forced to give earlier flowering. Following the precooling treatment, the bulbs are immediately planted in flats which are placed in cold frames or a cool position for a further 4-6 weeks or until leaf growth is evident. This post-planting cool temperature treatment or the "rooting period" satisfies the remaining cool temperature requirement of the bulb. During this period, root growth is rapid and extensive, a pre-requisite for successful forcing.

If the rooting period is too short, or the temperatures too high, stunted growth and delayed flowering or flowering failure may result.



When the leaves are 3-5 cm high, the flats should be shifted under glass or some protective structure where the forcing temperatures can be controlled.

The forcing temperature for the first 2 weeks should be kept at 10-12^{o}C to avoid too rapid and 'soft' growth. After this, the normal forcing temperature of 16-20^{o}C, depending on the cultivar, is maintained until the flower starts to colour, when the temperature is reduced to 13-16^{o}C to "finish" the flower and improve quality.

Generally, lower temperatures such as 13^{o}C result in better quality blooms and later flowering while warm temperatures (e.g. 18^{o}C) hasten flowering, but may cause the stems to be undesirably soft.

The aim of the higher temperatures after the rooting period is to bring the plants to anthesis as rapidly as possible, noting that for every 2.5^{o}C increase in temperature, flowering is advanced 1 week.

Even earlier flowering can be obtained by lifting the bulbs slightly earlier than normal and subjecting them to a short period of high temperatures. Storage at 34°C for 1 week followed by the normal 20°C and 8-10°C storage treatments results in flowering 7-10 days earlier than bulbs stored at 20°C and 8-10°C only. Accurate temperature control must be maintained as excessively high temperatures can kill the young flower-buds.

A limit to very early tulip forcing is imposed by the warm soil temperatures in February-March. These temperatures are ineffective in satisfying the cool temperature requirements after planting.

For this reason, a method known as "five degree" forcing was developed whereby the whole of the cold temperature requirement can be given to the bulbs while still in dry storage, i.e. precooling at 5°C. The normal 8-10°C temperature treatment given to "dry" bulbs can supply the total cool requirement, but flower quality suffers through the longer storage period required for effectiveness.

Good quality cut tulips can be produced from bulbs, precooled at 5°C for 9-12 weeks before planting directly in the field or forcing in flats or glasshouse beds.

Tulipa cv "Apeldoorn"

	precooling temperature (12 wks.)			
	2	5	7	9
forcing period - days	41	44	56	66
stem height - cm	49	49	40	16

forced at 18°C

Because of the drastic transition from the warm temperatures (34°C, 20°C) to cold temperatures (5°C) it is recommended to hold the bulbs at an intermediate temperature of 17°C for 2 weeks to prevent flower-bud abortion that can otherwise occur.

This 5°C method of forcing requires very accurate preplanting and forcing treatments and success largely depends on the grower's skill in manipulating these temperatures.

In common with many other bulbous flower crops, most of the vegetative growth and floral development up to the flowering stage in tulips is dependant on bulb reserves built up during the previous season.

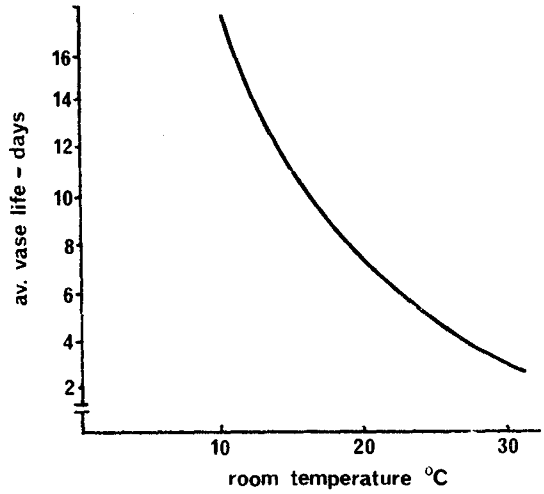
Growing conditions during the forcing temperatures are not ideal for vegetative growth and development. For this reason, bulbs cannot usually be forced for several years in succession - after one forcing season forced bulbs are either discarded or replanted in the field to recover.

HANDLING OF FLOWERS:

Flowers should be cut 1-2 days before full-bloom depending on the market destination and requirements.

Tulips keep reasonably well at 0-5°C for 2 weeks. Flowers can be stored dry in air-tight containers at 0-5°C for 5 days without any detrimental effect on subsequent quality and vase-life.

The popularity of tulips has suffered in recent years because of their relatively short keeping period. However, this is more a function of the room temperature to which the flowers are exposed than to inherently poor vase-life.



Vase-life differs between cultivars but is usually 4-11 days (at 16°C).

PESTS AND DISEASES:

aphids, thrips, bulb mites, eelworm.

Botrytis tulipae, *Sclerotinia* (grey bulb rot), *Phytophthora* (root rot).

virus - "tulip breaking"

RECOMMENDED READING:

MARCUSSEN, K.H. (1957): Commercial tulip culture in New Zealand. N.Z. J. Agr., 94: 20-31.

REES, A.R. (1972): The growth of bulbs. Academic Press, London. 311 p.

RECOMMENDED READING

Physiology of Flowering:

BICKFORD, E.D. and DUNN, S. (1972): Light for plant growth. Kent State Univ. Press, 221 p.

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SALISBURY, F.B. (1963): The flowering process. Pergamon Press, London.

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GOULD, C.J. (ed) (1957): Handbook on bulb growing and forcing. Northwest Bulb Gr. Assn. 196 p.

LAURIE, A., KIPLINGER, D.C. and NELSON, K.S. (1969): Commercial flower forcing. 7th ed. McGraw-Hill, New York. 514 p.

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POST, K. (1952): Florist crop production and marketing. Orange Judd, New York. 891 p.

Specific Culture:

ACTA HORTICULTURAE:

Symposium on flower regulation in florist crops, Vol. 14, 1969.

First International symposium on flower bulbs, Vols. 23 (I and II), 1971.

Symposium on cultivation of flowers under protection in the Mediterranean regions. Vols. 43 (I and II), 1974.

Second International Symposium on flower bulbs, Vol. 47, 1974.

Protected cultivation of flowers and vegetables, Vol. 51, 1975.

HORTICULTURAL ABSTRACTS

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Specific references and recommended readings are given at the end of each flower crop section.