Table 1: Seasonal and daily changes recorded by the "Light Integrated Meter".

Date	Calories	Date	Calories
Winter		Spring	
June 18	126	Sept 10	346
19	53	11	437
20	41	12	380
21	46	13	170
22	106	14	573
July 23	222		
24	239		
25	87		
26	246		
27	246		
		Summer	
Aug 8	393	Jan 10	635
9	405	11	563
10	216	12	420
16	464	13	567
22	104		
23	63		

Table 2. Daily range of recordings by the "Light Integrated Meter" (setting of 20)

Time	Calories Recorded on Oct. 8, 1984
7 30 a m	
10 00	36
12 30 p m	107
3 00	63
5 00	17

GERBERA PRODUCTION AND ITS PROBLEMS

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For the past ten years the Transvaal daisy or gerbera (*Gerbera jamesonii* H. Bolus ex. Hook f.) has steadily become more popular, thanks to advertising campaigns that have promoted the gerbera as a cut and pot flowering plant and as a bedding plant to be used and grown in the landscape. There are presently several strains of gerberas in the trade. In the U.S.A. the earlier Jongenelen material (double), semi-dwarf

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Happipot (singles and doubles), Florist strain (doubles), Park Mix (singles), Express series (singles and doubles), Tropic, Galaxy and Ceres 2000 series, and the University of California breeding lines from Dr. Harding and his associates, are readily available.

Other gerbera sources outside continental U.S.A. are in the Netherlands, France, Italy, Japan, India, Australia, and New Zealand. Most of the commercial lines are grown and sold from seed, although some are propagated vegetatively through tissue culture means. The clonal lines are usually disease and insect free, and have gone through a rigorous selection process in terms of growth habit, substance, foliage, flower color, productivity, and uniformity. Originally gerberas were grown for cut flowers and only recently has the concept emerged to use gerberas as a florist pot crop and for outdoor use as bedding plants. A California group under Dr. Harding's supervision has developed strains that are exclusively to be grown outdoors; their major criteria in selection, therefore, are somewhat different than those intended for cut and pot specimen. Other commercial seed companies presently are breeding pot specimen and cut flower lines, mainly to be grown as greenhouse crops.

PROPAGATION FROM SEEDS.

Gerberas grown from seeds are somewhat like geraniums in terms of price, and can range from the cheapest selection costing 3.6 cents a seed to the more expensive at 90 cents a seed. Gerbera seeds usually do not germinate 100%; 70% germination is usually considered to be good. It is, therefore, not a cheap plant to start with, especially when better strains are used.

Pot gerberas are widely used in the trade for either 10 or 12.5 cm pot plants. These gerberas are also excellent for use in the landscape as bedding plants, especially where nights are cool (15 to 18°C). Seedling-grown Happipot cultivars, however, do not result in uniform growth or flowering. There will be variations in foliage size, flower color, head size or shape, and peduncle length. Flower buds of seedling-grown plants may not initiate or develop at the same time, and this time differential may vary from 1 to 4 weeks. These are not major problems, however, for the smaller grower who needs limited quantities, and no large amount of a particular flower color. It actually helps improve sales by having a wide selection of color and types. This poses a serious problem, however, for large scale producers who prefer to have entire benches of one color or shape, or benches where all the flowers appear at one time and all plants can be shipped at a specified time.

Producers that lack the facility for seed germination with controlled chambers and lights would be better off buying seedlings rather than seeds. Gerbera seedlings, once purchased, need warm temperatures for rapid growth (26 to 29°C day and 18 to 20°C night). Cold and wet soils are a sure invitation to *Pythium* and other pathogenic fungal organisms. Young, vigorous seedlings do not grow well when soil temperatures fall below 15.5°C.

PROPAGATION FROM CLONAL MATERIAL

Another alternative for growing gerberas is from tissue culture, clonal material. Clonal selection generally results in more uniform growth and flowering. These selections vary from laboratory to laboratory, hence, one must select cultivars that have the attributes that meet certain objectives. Clonal selection will depend not only on flower size and growth but also stem thickness, length, and the way the flowers face at maturity. Wiry stems are more weather resistant and tolerate rains and water stress more than cultivars with thick shorter stems. Cultivars with upward-facing flowers are ideal for landscape plants, while those tending to face one side makes them excellent for window box plantings. Some clones are best used as holiday or patio plants rather than for bedding or window boxes. These plants bear larger flower heads, have thicker stems, and are less weather resistant. Water stress often causes stem break on these clones. Plants used for cut flower purposes obviously need to have long stems, large showy flowers, and last but not least, high flower productivity. There are three ways to secure clonal (tissue-cultured gerberas). The cheapest one, but not necessarily the easiest, is to order directly from tissue culture laboratories where plants are shipped at stage 3, wherein the growers themselves separate plants from the tissue-cultured containers and transplants them in flats. *This method is, however, very risky, especially if the grower is* not set up to grow-on tissue-cultured plants. Another way is to purchase tissue-cultured plants from specialist gerbera propagators in 4 to 5 cm liners, which can be directly transplanted to 10 or 12.5 cm or larger size containers. These take approximately 8 to 10 weeks to flower compared to 16 to 18 weeks from stage 3. Another method is to purchase pre-finished plants in 10 or 12.5 cm containers with flower buds already on plants. Little growing time is required by the greenhouse operator.

Just like geraniums then, gerberas sell for a higher price compared to other pot flowering plants, such as chrysanthemum. However, as gerbera flowers are quite unique, customers seem not to mind paying the extra price for them. Gerberas

are excellent to grow in large containers, with 2 or 3 plants grouped together. It is an excellent plant to use in planters around patios, pool areas, and window boxes.

CULTURE

Soil Medium. Any pre-made artificial medium that does not contain a large percentage of *unprocessed* bark is a good medium for gerberas. It is desirable to add 20 to 30% top soil to a medium for stability, but only if steam or chemical sterilization facilities are available. Gerberas require an abundant supply of moisture, but will succumb under waterlogged conditions. A medium that has adequate pore space and yet retains substantial amounts of water should be used. Peat moss and peat-like substances (processed bark), therefore, are essential ingredients in the preparation of media for gerberas when growers mix their own. The addition of 20 to 30% soil is a good idea since it improves the buffering capacity of the medium and acts as a stabilising factor to prevent pots from tipping over, especially when the medium is dry. The soil pH should be adjusted to between 5.5 to 6.2 for optimal gerbera growing conditions. In very acid soils this can be achieved by adding either limestone or dolomite to the soil mix three weeks prior to planting.

Transplanting. The most important factor in gerbera production is *transplanting*. Problems such as crown rot can usually be traced back to improper transplanting depth. Gerberas need to be transplanted with the *crown at* or preferably *above* soil level. The crown should be visible at all times, and should be allowed to dry out between irrigations. It is not necessary to root prune when transplanting.

Fertilisation. Three kilos of slow-release fertiliser, such as Osmocote 14/6.1/11.6, plus 1 kg of a minor element additive such as Micromax™, should be mixed in thoroughly with each cubic meter of medium prior to transplanting. This should be supplemented with 100 to 200 ppm N and K at every watering, or 350 ppm twice weekly. If liquid fertiliser injectors are not available, 5 kg instead of 3 kg of Osmocote should be added to the mix when plants are ready to transplant. Fertilisers containing a high percentage of an ammonia-type nitrogen should be avoided. Fertilisation studies have shown that a high percentage of ammonium-type nitrogen (30% or more NH_4-containing fertilisers) results in reduced number of flowers and a delay in flowering. The ideal fertiliser combination for gerberas, with respect to nitrate to ammonium form, is 6 to 3. (70% NO_3 and 30% NH_4). This can be achieved by mixing equal weight of ammonium nitrate and potassiumn nitrate and

calculated to dispense either 100 to 200 ppm N at each watering, or 350 ppm N biweekly. Media incorporating slow-release fertilisers should be kept dry prior to use and should be used as soon as possible to prevent release of nutrients and build-up of soluble salt levels. Slow-release fertilisers should be mixed in with the soil *after* the soil medium is steam sterilised, *not before*.

Light, Temperature and Water. Gerberas are adaptable plants and will grow under a wide range of environmental conditions. They should be grown under full sun in New Zealand, although 20% shade may be required in the summer months. Optimum growth and yield, however, is best achieved under full sun. Under 20% shade, plants develop dark green leaves and, while flowering will not be delayed, they will develop longer petioles and have a more erect growth habit than plants grown under full sun.

The objection to longer petioles for pot plant purposes can be easily overcome by judiciously timed applications of growth regulators. Tissue-cultured gerberas will bloom within 70 to 80 days following transplanting of liners (from 5 cm containers) from spring through fall. Flowers will be 20 to 30 days later on plants transplanted late fall through late winter. A reasonable time estimate would be 10 to 11 weeks to first bloom, depending on when plants were transplanted.

There is nothing unique in growing gerberas. Most sound cultural practices for other plants apply to gerberas. Overwatering should be avoided. The soil should be permitted to dry between watering and the plants allowed to dry (wilt) occasionally. This is extremely important, especially during winter and heavy overcast weather where cold night temperatures and high relative humidity in the greenhouse prevail. Disease infestation will be less a problem when this is practiced. Plants grow best when night temperatures can be maintained no lower than 16°C and no higher than 26°C. Lower night temperatures slow growth and flowering and increase the incidence of soil-borne diseases.

Growth Regulators. Growth regulator application on gerberas is not a standard practice and plants not so treated are equally saleable and attractive. Application of growth regulators add to the expense but the benefits from them are:

(a) Plants develop darker green leaves, which enhances their attractiveness.
(b) Length of leaf petiole and flower stem are shortened, making plants more bushy and compact.
(c) Facilitates easier handling and less shipping damage.

(d) Plants can be grown with closer spacing, therefore increasing production per unit of area.

The only growth regulator effective on gerbera to date is A-Rest™ which can be applied either as a spray or soil drench. It should be applied 2 to 4 weeks after liners are transplanted into larger pots (usually 12.5 to 15 cm) at rates of 0.125 mg to 0.25 mg a.i. per pot as a soil drench to give up to 80% petiole length and 40% flower stem length reduction (flower size not affected). A-Rest™ as a foliar petiole should be applied at the rate of 33 to 66 ppm a.i. and will produce similar petiole and flower stem length.reduction. One application should be adequate. Growth regulator application has been most beneficial when applied to plants grown under 20% shade in greenhouses. A-Rest™ soil drench and spray can be prepared as follows:

A-Rest™ Drench:

Mix 30 ml A-Rest™ concentrate in 4 l of water. Apply 120 ml of this solution to 12.5 or 15 cm pot; this is the equivalent to 0.125 mg a.i./pot. If 0.25 mg a.i./pot is preferred, mix 30 ml A-Rest™ to 2 l of water and apply the same amount (120 ml) of the solution to the same size pots.

A-Rest™ Spray.

Add 480 ml A-Rest™ concentrate into 4 l of final solution. This is equivalent to 33 ppm solution. Double the amount (960 ml) to make up a 66 ppm solution. Spray evenly to foliage until it glistens. Each litre of solution should treat 4.5 m^2 of area when plants are grown pot to pot.

Insects. In general, relatively few insects attack gerberas, especially when plants are kept in a healthy, vigorous growing condition. Insects that do attack gerberas may be divided into three groups according to the damage they cause. These are sucking insects, chewing insects, and leaf miners.

Sucking insects include aphids, thrips, broad mites, cyclamen mites, and spider mites. They insert their mouth parts into plant tissue and suck the juices. Symptoms often go unnoticed for a period of time which allows the pests to become established and increase in numbers, resulting in considerable plant damage. Symptoms of sucking pests are: curled or stunted leaves, discolored (stippled or russeted) leaves, chlorotic spots on leaves.

Caterpillars are the primary chewing pest found infesting gerberas. They are the immature stage (larvae) of various moths. The most prevalent are army worms, cut worms, and loopers.

Leafminers are especially destructive to gerberas. The lar-

vae or maggot stage feeds between the epidermal layers of the leaves, leaving long meandering tunnels of blotch-like mines in the leaves.

Production and maintenance of quality plants depends on growers' recognizing the insect, mite, or other pests that infest gerberas, as well as a knowledge of their life cycle and management practices. Obviously, pest damage will seriously reduce the value of plants or render them unsaleable. Therefore, a diligent scouting program followed by prompt and accurate pest management strategies is a necessity.

Diseases. One of the most damaging diseases on gerbera is crown rot, caused by *Phytophthora cryptogea*. Crown rot is the most feared gerbera disease in culture as a heavy infestation can wipe out entire greenhouses of gerberas. This disease is prevalent only in European countries and New Zealand, and is primarily carried from plant to plant by cuttings or vegetative division.

Symptoms. This fungus causes root and crown rot and can kill gerbera plants in as short a time as 16 days. The crown deteriorates and becomes mushy. Infection is more severe at higher temperatures.

A number of other diseases affecting other plants affect gerberas as well. The most serious is bacterial blight caused by *Pseudomonas cichorii* (Swingle) Stapp. The bacterial infection and symptoms usually are not severe during the cool season but become damaging during hot weather in late spring, summer, and early fall. An infection is aggravated when plants are irrigated overhead, which aids the spread of this disease from infected to healthy leaf tissue.

Symptoms. The first sign of bacterial blight infection is the appearance of spots on the leaves. These spots are usually variable in size, circular, or irregularly shaped and are brownish-black in color. Often concentric rings form within the lesions. Occasionally, the spots may coalesce into large brown areas which can extend from the leaf margins and taper towards the mid-vein. The bacterium has recently been found to cause petiole and crown rot, which can result in plant death. Early detection of the disease, with roguing of badly-diseased plants, combined with standard control methods, helps keep the disease in check.

Botrytis blight. This disease, caused by the fungus *Botrytis cinerea*, attacks weakened or dying tissue. It is normally fa-

vored by cool, wet conditions, but can occur at times when the temperatures are warmer.

Symptoms. Initial infection causes pinpoint yellow or brown dots, which enlarge and cause extensive decay of old leaves, flowers, and flower stems. The fungus produces large spore masses and, when heavily infested plant parts are shaken, a grayish cloud of spores can be seen.

Phytophthora crown rot. Phytophthora crown rot (*Phytophthora* sp.) usually becomes established when the soil remains wet for long periods of time. Plants affected gradually lose vigor and finally wilt. When wilted leaves are pulled, the crown or part of the crown containing the younger foliage breaks off with the leaf. Infected plants die once the crown is attacked. Infected specimens should be rogued and thrown away.

Symptoms. Plants look normal, but gradually appear less vigorous and remain slightly wilted, even though the soil is moist. Leaves will eventually wilt completely and the entire crown becomes soft and is easily pulled from the other parts of plants.

Pythium root rot. The watermold fungus, *Pythium ultimum*, attacks gerberas during periods where soil temperatures remain cold and wet. An ideal situation is created during cool weather when soils are kept excessively wet or kept moist for cold protection. Roots are attacked first and gradually, as the infection becomes severe, all plant parts below the crown or at the soil line are attacked. Plants lose vigor, wilt, and eventually die. In mild infestations, a new set of adventitious roots may develop below the crown.

Symptoms. Root tips become brown and look unhealthy, soft, and watery. If an infected root is pulled, the outer layer of tissue will part away from the stele (inner tissue). If plants are pulled, the crown remains intact and usually is not affected.

Powdery mildew. Gerberas are not completely resistant or tolerant to powdery mildew, caused by the fungus *Erysiphe cichoracearum*. In most instances, gerberas are usually free of powdery mildew. There are times, however, during the cool weather in spring and fall when powdery mildew can become a problem, especially where plants are grown close together where leaves overlap and high humidity prevails, where air circulation is poor, and when foliage remains wet for long periods of time. To prevent powdery mildew from becoming a problem, plants should be adequately spaced, and leaves that overlap should be removed. Relative humidity should be re-

duced and adequate ventilation provided to facilitate air movement between leaves and among plants.

Symptoms. Powdery mildew can be easily identified by the whitish powdery-like fungal growth on either leaf surface. Powdery mildew thrives under very high humidity conditions and cool temperatures, and these environmental conditions should be minimized during the time where night temperatures naturally become cool in early spring or early winter and where condensation of water on leaves is a common occurrence.

Alternaria leaf spot. This fungus disease has been reported on gerberas for many years in Florida, becoming more prevalent in the last 10 years. Heavy infection can cause the plants to be unsaleable.

Symptoms. Leaf spots are first round to irregular shaped, later becoming larger with concentric rings within and dark brown to purplish in color. The spots may coalesce to form large areas of necrotic tissue.

Cercospora leaf spot. This fungus leaf spot disease has also been fairly common through the years on gerberas. It is most prevalent in the late summer and fall.

Symptoms. Disease lesions are tan to dark brown in color, with purple margins a characteristic symptom. The centers of the spots occasionally drop out.

Nutritional Problems. Despite monitored fertilization practices, deficiency problems sometimes develop on gerberas. Most symptoms exhibited by plants may not be due to lack of a particular mineral element in the soil but to unavailability of the element. Unavailability of elements alone, or in combination, may be caused by many factors, including culture, temperature, pH, and antagonism between nutrient ions.

Any factor(s) that contribute to root injury, such as disease organisms, mechanical injury, excess water, or high pH of the growing medium, may eventually result in the expression of a deficiency symptom(s). Growers should constantly be on the lookout for presence of pathogenic organisms that may attack healthy roots and take corrective and/or preventive measures to keep roots healthy for maximum utilization of available mineral nutrients in the growing medium. Root damage can result also by over or under watering and excessive cold or hot temperatures.

Deficiency symptoms might appear rapidly on plants grown out-of-doors during winter in containers where ambient temperatures may drop to or lower than the freezing point and

where high day temperatures often overheat the container medium.

The use of overhead irrigation with high pH water gradually increases soil pH causing mineral elements to become insoluble and thus unavailable for plant use. Another common factor contributing to nutritional imbalances in gerbera is the selection of soil media. Media mixtures for long term growing of gerberas should have high cation exchange capacities and water holding capacities, be well aerated and free draining, sufficiently heavy to anchor the plants, and have a slow decomposition rate and low soluble salt levels.

Post Harvest Handling. One of the major problems of cut gerberas with respect to the length of their postharvest life is wilting followed by stem breakage, caused by water stress. Gerbera flowers have a tendency to develop bent neck. Bent neck in gerberas is usually followed by stem break. Flower heads do not wilt severely when bent neck occurs and, even after stem break, individual florets usually remain turgid. Water stress affects the integrity of the weak, herbaceous stem 10 to 15 cm below the flower head before the flowers wilt. It is also this part of the stem that has the smallest circumference.

Experiments with flower preservatives have shown that the postharvest life of gerberas can be increased two-fold and premature bent neck and stem break prevented. Nevertheless, in order to obtain maximum postharvest life the use of floral preservatives should be combined with other procedures as noted here.

(1) Recut stems after harvest but immediately before they are placed into fresh holding solutions.
(2) To prevent crooked stems do not allow flowers to dry and keep flower stems erect.
(3) Use clean containers to hold flowers.

Author's Note: The use of trade names is solely used for example purposes only. The mention of trade names does not constitute endorsement of the product nor exclude similar products not mentioned

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PLUGS: USE AND FUTURE IN NEW ZEALAND

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Climate and lifestyle in New Zealand are very conducive to bedding plant growing. This is evident in the extensive use of flowering annuals in both public and private gardens. The production of bedding plants, until recent years, has involved a very traditional approach. Because bedding plants can be grown year-round in New Zealand there is a tendency to produce small seedlings in an open-pack to be sold at the green stage. Difficult economic times and high inflation have created an awareness amongst growers of the need to increase production efficiency instead of simply increasing prices to counter rising costs.

A need for increased productivity is shared amongst bedding plant growers worldwide. Over the past decade, some new approaches to production techniques have arisen.

Direct seeding mechanically into the final container is one such approach. This eliminates the necessity for hand sowing and alleviates the need for pricking out. Interest in this system has seen the development of several types of automatic and manually operated equipment (3,10,11,13). A manually operated vacuum type seeder has been developed and marketed in New Zealand and direct seeding with this has been extensively used. However, the one major disadvantage growers have found with the system is the extra space required at the germination stage. Because of this some have used less than adequate environmental conditions for germinating trays. Often this has led to poor germination and consequent frustration with the system.

Pre-germinated seedlings are now offered by some seed companies as a means of reducing crop time and the risk involved with germination. These pre-germinated seedlings