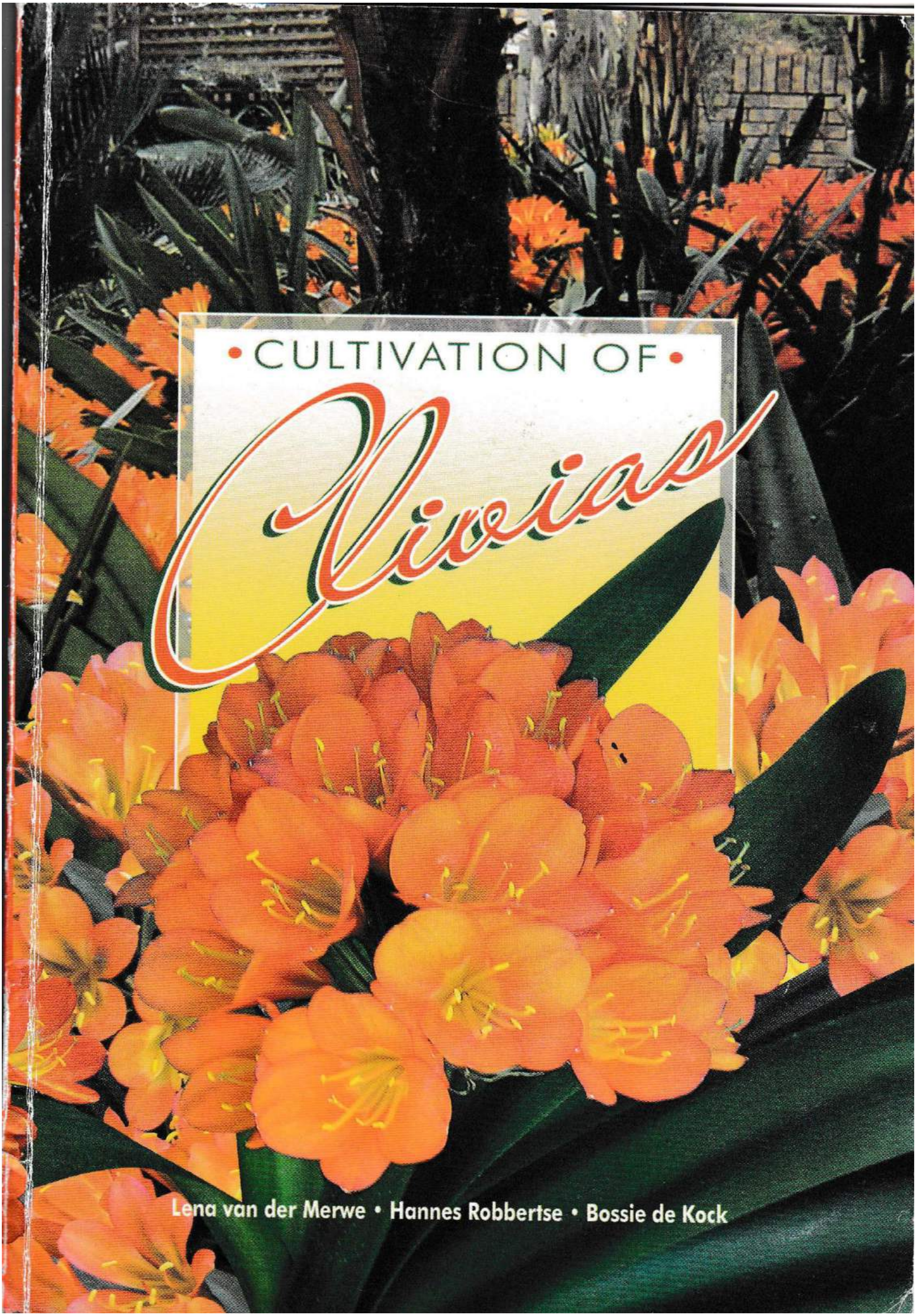

•CULTIVATION OF• Clivias

Lena van der Merwe • Hannes Robbertse • Bossie de Kock

Acknowledgements

FROM THE CLIVIA SOCIETY

Thank you for obtaining a copy of Cultivation of Clivia. Your support is greatly appreciated and we trust that you will find the growing hints to be of great value. If you follow the basic guidelines your clivias should flourish and be of great satisfaction to you.

On behalf of the Clivia Society, I wish to express our sincere thanks to two members without whose dedication, enthusiasm and hard work the publication of this book would not have been possible.

- Lena van der Merwe who, as chief editor, was responsible for the contents
- Bossie de Kock for many hours of proof reading and for obtaining the advertisements.

Chris Vlok

CHAIRMAN: CLIVIA SOCIETY

FROM THE EDITORS

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Lena van der Merwe, Hannes Robbertse & Bossie de Kock

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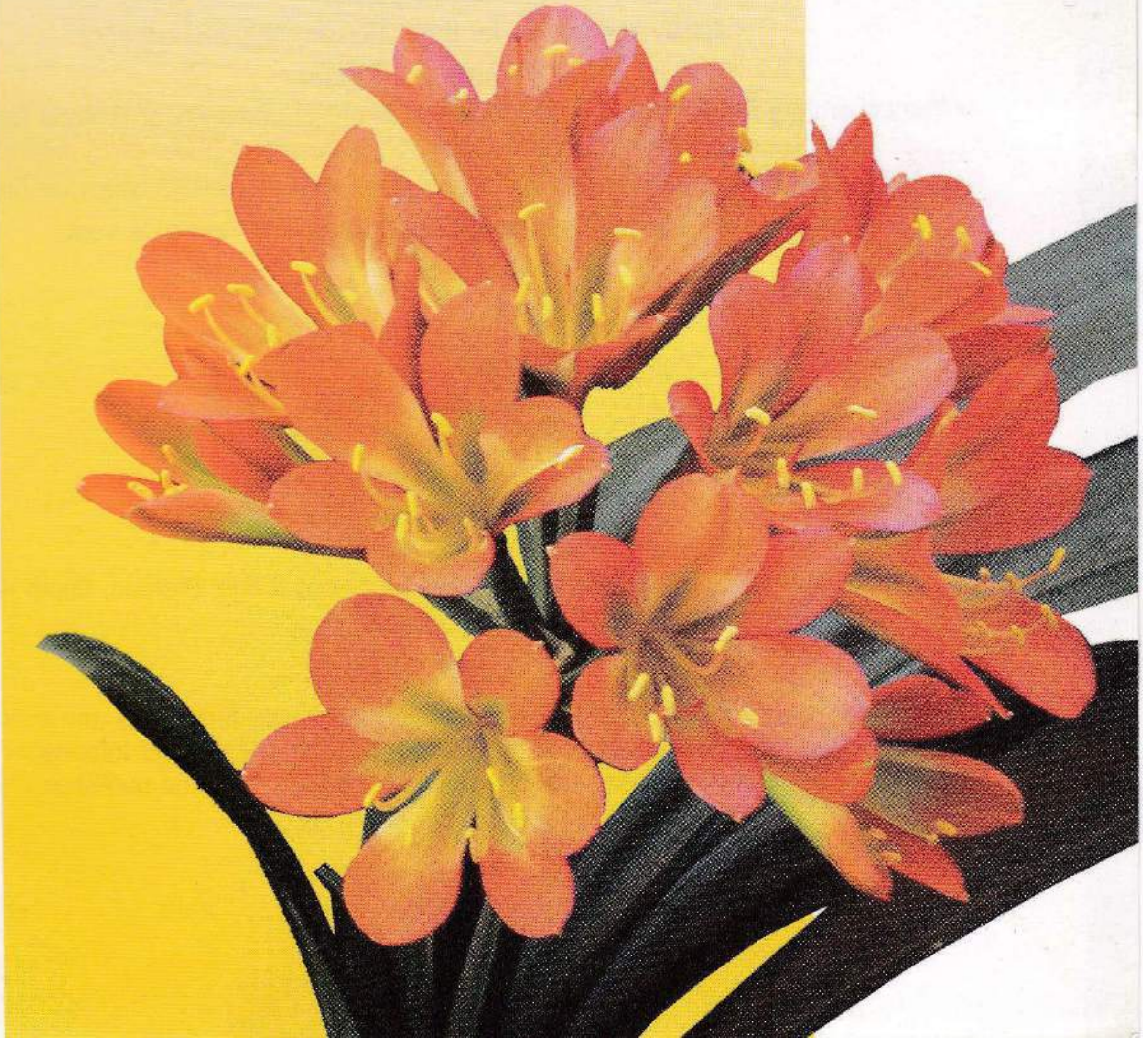


Contents

CHAPTER 1

The Clivia Society

Nick Primich from Johannesburg, RSA, started in July 1992 with a newsletter to Clivia Enthusiasts worldwide. James and Connie Abel joined in 1993 and initiated meetings and excursions to the natural habitat of clivia. The Clivia Club was founded on 22 January 1994 in their house. As the first Chairman, James and his committee hosted the first Show and Conference at the National Botanical Gardens in Pretoria on 17 September 1994.

Membership grew and in 1995 the KwaZulu-Natal Clivia Club was formed. The Western Province Interest Group was founded on 22 January 1997 with nine members. On 5 September 1998 it was decided to separate the Northern Clivia Club from the overseas enthusiasts.

The Clivia Society came into being on 19 May 2001 in Pretoria with the adoption of the Society's constitution that is based on a federal system.

The Clubs are autonomous and any group that accepts the Clivia Society's constitution may on application become a constituent Club of the Clivia Society.

The aims of the Clivia Society are

- to coordinate the interests, activities and objectives of constituent Clivia Clubs and Clivia Enthusiasts resident outside South Africa;
- to participate in nature conservation activities in relation to the protection and conservation of the genus *Clivia* in its natural habitat, to promote the genus *Clivia* and in that context also to promote the observation of conservation laws and practices;
- to promote the cultivation, conservation and improvement of the genus *Clivia* by the exchange and mutual dissemination of information amongst constituent Clivia Clubs and Clivia Enthusiasts; where possible, the mutual exchange of plants, seed and pollen amongst constituent Clivia Clubs and Clivia Enthusiasts; and the mutual distribution of specialized knowledge and expertise amongst constituent Clivia Clubs and Clivia Enthusiasts;
- to promote the increase in knowledge of the genus *Clivia* and to advance it by enabling research to be done and by the accumulation of data and dissemination thereof amongst constituent Clivia Clubs and Clivia Enthusiasts;
- to promote interest in and knowledge of the genus *Clivia* amongst the general public; and
- to do all such things as may be necessary and appropriate for the promotion of the abovementioned objectives.

More information on the Clivia Society can be obtained on the
Web site: www.cliviasociety.org

or

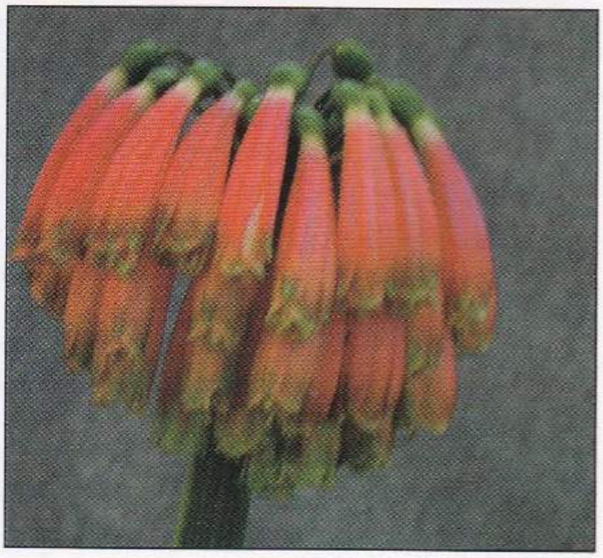
Postal address: Clivia Society, PO Box 74 868, Lynnwood Ridge, 0040 Pretoria,
Republic of South Africa

Tel /Fax: +27 12 804 8892
E-mail: cliviasoc@mweb.co.za

Clivia caulescens

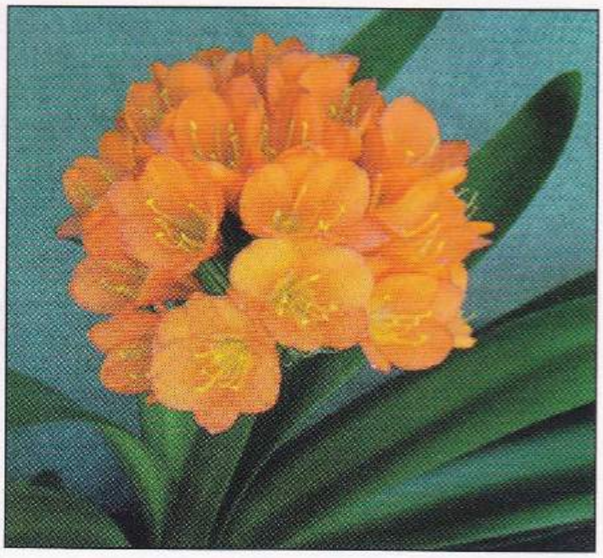
Clivia gardenii

Clivia mirabilis



Clivia nobilis

Clivia robusta



Clivia miniata

CHAPTER 2

History and main characteristics of Clivia species

The Bush Lily or *Clivia* is indigenous to the Republic of South Africa and Swaziland (Figure 2.1). William J Burchel discovered the pendulous flowered Bush Lily at the Great Fish River mouth in the Eastern Cape. John Lindley of Kew Gardens who named it *Clivia nobilis* described this plant species in October 1828. The next to be described was the trumpet flowered *Clivia miniata* in 1854, then *Clivia gardenii* in 1856, C*livia caulescens* in 1943, *Clivia mirabilis* in 2002 and *Clivia robusta* in 2004.

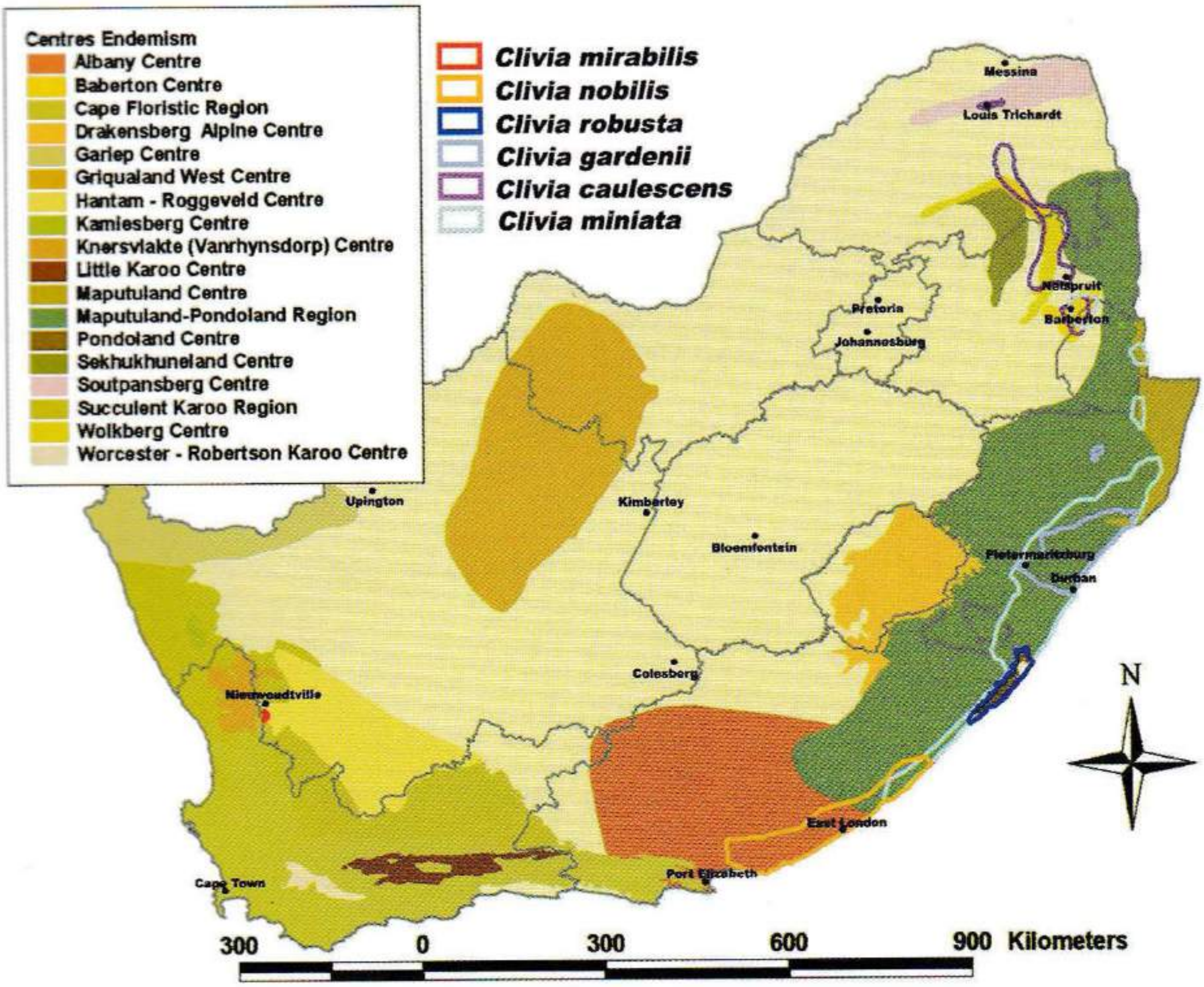


Figure 2.1 Distribution map of Clivia species in Southern Africa (Swanevelder, Z.H. 2003. *Diversity and population structure of Clivia miniata Lindl. (Amaryllidaceae): Evidence from molecular genetics and ecology*. M Sc, University of Pretoria, Pretoria).

The differences and features of the different species are listed in Table 2.1

Table 2.1. Comparison of the species of Clivia*

	C. mirabilis	*C. nobilis*	*C. robusta*	*C. gardenii*	*C.caulescens*	*C. miniata*
Habitat	Arid humic sandstone scree	Sandstone slopes to coastal sand dunes	Swamp forest in wet sand, drainage at cliff ledges	Humic scree on sandstone	Epiphytic on sandstone / trees in moss, humus on sandstone	Humic scree on sandstone, rhyolites, dolerite
Flowering Time	October to mid-November (late Spring)	August to January (Spring - Summer)	Late March - early August (Autumn - Winter)	May to July (late Autumn to mid-Winter)	September to November (Spring)	August to November (Spring - early Summer)
Peduncle, pedicels and ovary colour	? Red	Reddish becoming green	Reddish becoming green	Reddish becoming green	Green	Green
Perianth shape	Pendulous tubular	Pendulous tubular	Pendulous tubular	Pendulous tubular	Pendulous tubular	Upright trumpet
No of flowers	20-48	20-50	15-40	10-20	14-50	10-40
Stigma & style	Not exserted	Protruding 6 mm	Various	Exserted > 7 mm	Protruding 6 mm	Various
Fruit Ripens	February - April 4-7 months	Winter - 9 months	Winter - 9 months	Winter - 15 months	Winter - 6 months	Winter - 9 months
Stem	Non-aerial	Non-aerial	Aerial to 450 mm; buttress roots in swampy conditions	Non-aerial	Aerial, up to 3 m in mature specimens	Slightly aerial with age
Leaf median	Pronounced	Moderate to weak	Weak to none	None	None	None
Leaf	Stiff	Stiff	Soft	Soft	Soft	Soft
Leaf margin	Smooth	Rough	Smooth	Smooth	Smooth	Smooth
Leaf apex	Rounded point	Indented	Rounded	Pointed	Pointed	Pointed

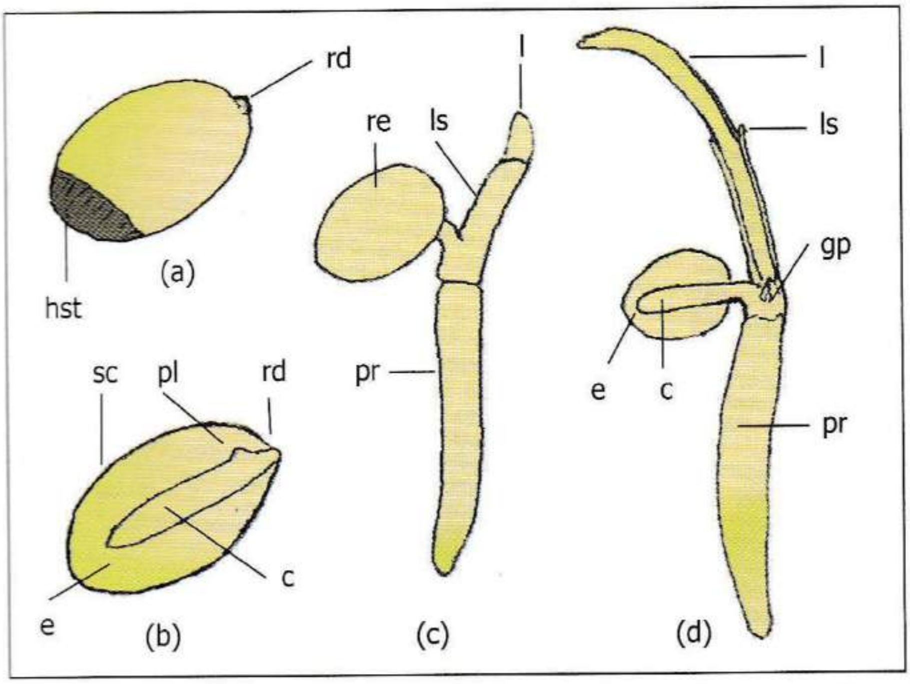
*Listed in this table are general trends and exceptions may be encountered.

CHAPTER 3

Clivia Terminology

3.1 TERMINOLOGY OF THE SEED AND VEGETATIVE PARTS

The vegetative plant starts with the germinating seed. Clivia seeds are recalcitrant, which means that they can germinate spontaneously, even inside the ripe fruit. They can only be stored for a limited period of time and will die if desiccated below a certain moisture content. A seed can be defined as " a baby in a box with food" where the "box" represents the seed coat, the "baby" represents the embryo and the "food" represents the endosperm. In the clivia seed, the seed coat is intimately attached to the endosperm enclosing the embryo. The embryo consists of one cotyledon (c) in Figure 3.1b), a plumule and a radicle. Being a monocotyledonous plant, the embryo contains one cotyledon. The whole embryo is embedded in the endosperm. The tip of the radicle can be observed as a small round spot opposite the larger brown spot/ patch (hypostase) on the side of the seed where it was connected to the placenta. During germination the cotyledon produces enzymes responsible for digesting the endosperm before absorbing the digested nutrients. It then starts to elongate to about 0,5 to 1 cm, thus pushing the plumule and radicle out of the seed, whilst the radicle starts to elongate to become the primary root. The primary root immediately produces a collar of root hairs behind the root tip, and continues to do so as the root grows. The primary root (pr in Figure 3.1c) normally does not form secondary roots. It has a limited life span and is soon overgrown by adventitious roots originating from the embryo axis (Figure 3.3). In orange and red clivia the sheath (Figure 3.1d, ls) of the first leaf is pigmented.



rd radicle tip
hst hypostase - brown patch
sc seed coat
e endosperm
c cotyledon
pl plumule
pr primary root
re remains of endosperm
ls leaf sheaf of undeveloped first leaf
l first true leaf
gp growing point of stem, producing leaves

Figure 3.1 Clivia seed and seedling. (a) Seed. (b) Longitudinal section of seed. (c) Seedling after germination. (d) Longitudinal section of seedling.

During the youth phase, the growing point of the seedling produces about 13 leaves after which it gives rise to an inflorescence bud. An axillary bud from the last-formed leaf then produces a new terminal bud from which about four leaves and a new inflorescence bud will be produced. Further growth is therefore modular with each module consisting of four leaves and an inflorescence bud.

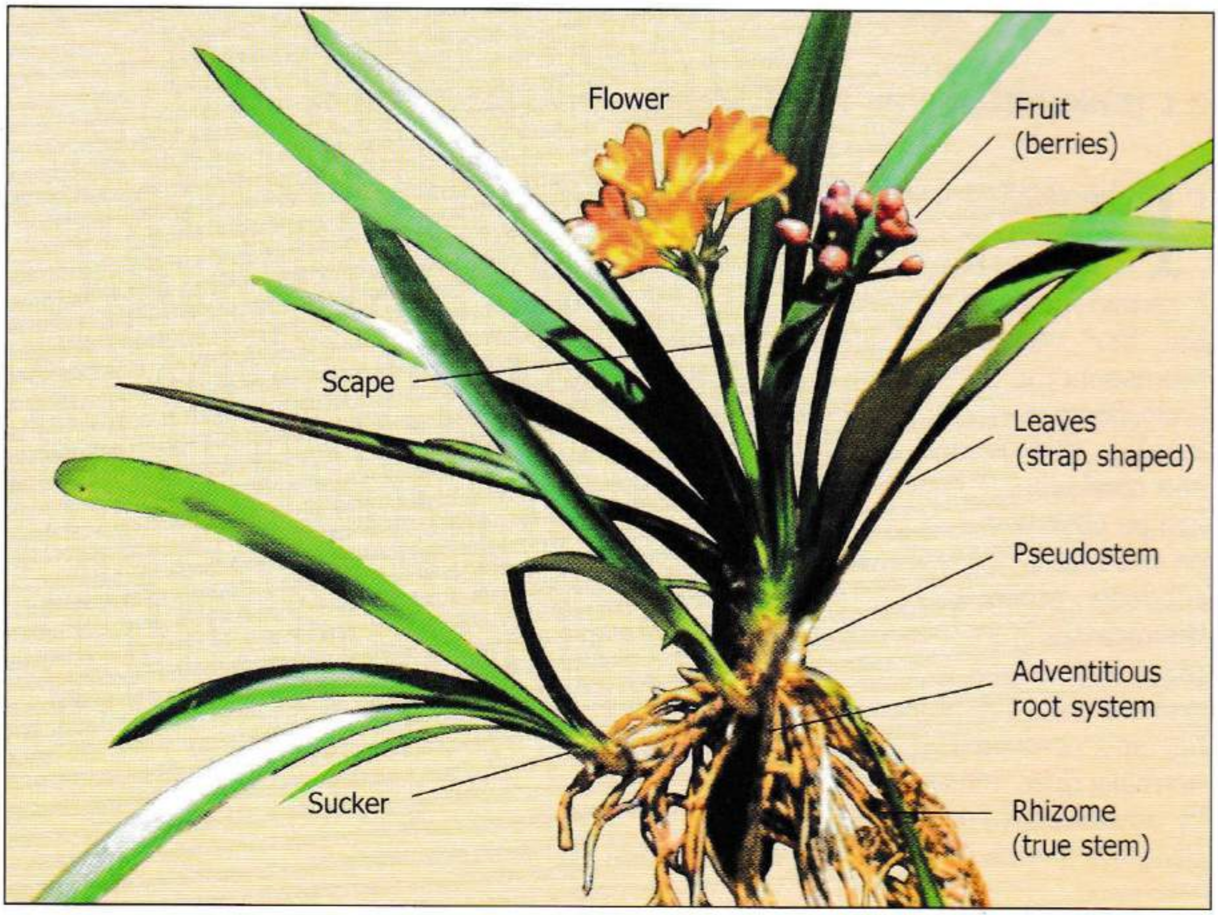


Figure 3.2 Complete flowering clivia plant with open flowers on inflorescence, fruit on a older scape and lateral shoots (suckers) developing from the true stem (rhizome).

Figure 3.3 Stem base of young clivia plant showing the origin of the succulent adventitious roots.

The true stem of the mature plant is a rhizome, with very short internodes from which the succulent adventitious roots develop (Figure 3.2 and 3.3). The leaf sheaths enveloping the apical part of the rhizome forms a pseudostem, which encloses the delicate growing point of the stem as well as young inflorescence buds.

3.2. TERMINOLOGY OF REPRODUCTIVE PARTS

The branch system bearing the flowers in clivia is called an inflorescence. In clivia, the type of inflorescence is classified as an umbel. It consists of an elongated, leafless branch, called the scape (Figure 3.2), which emerges from one of the leaf axils and extends up to the point where the flowers are borne - all more-or-less at the same level on an extremely compacted axis. Each flower is attached to the inflorescence axis by means of a flower stalk, called the pedicel (Figure 3.4). We then find the ovary of the flower (Figure 3.4), situated below the perianth (Figure 3.4). The perianth consists of three outer and three inner perianth members, called tepals (not sepals). Inside the perianth, are the six stamens, each consisting of an anther, containing the pollen and a filament, which is the stalk of the anther. The stigma and style, situated in the centre of the flower, are attached to the ovary, and together, the three parts form the pistil. The ovary in the clivia plant has three cavities or locules, each containing about eight to ten ovules. After pollination and fertilization, each fertilized ovule will form a seed. The developing seeds will stimulate the ovary wall to grow and become the succulent part of the fruit.

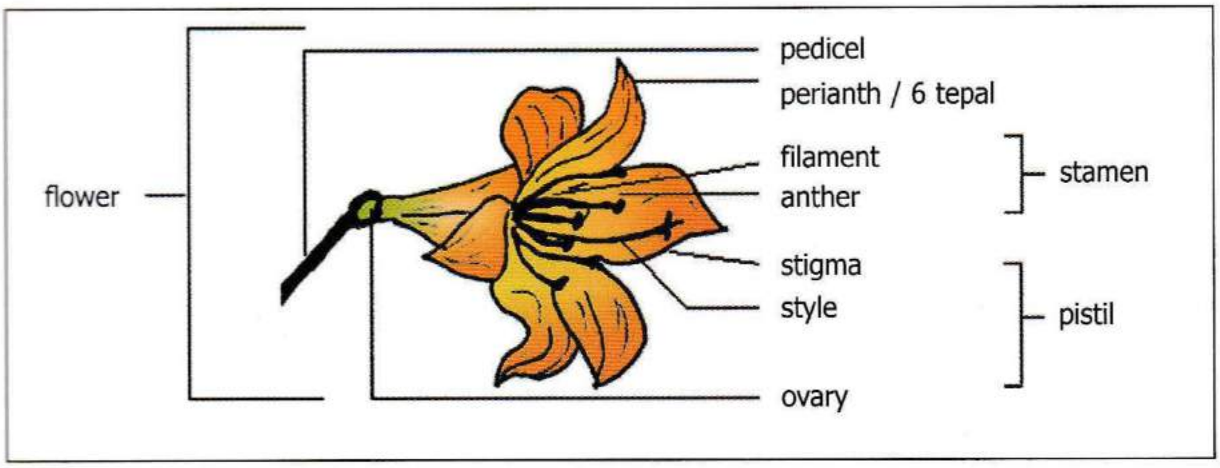


Figure 3.4. Diagram of clivia flower with annotations.

The clivia fruit developing from the ovary is called a berry (Figure 3.2 and 5.5), containing one to 24 seeds depending on how many of the ovules inside the ovary had been fertilized. Some of the fertilized ovules (now called young seeds) may also abort at an early stage, thus reducing the number of seeds per berry. The membranous layer covering the seeds in each fruit locule is part of the inner layer of the fruit wall or endocarp. The fruit wall (derived from the ovary wall) consists of three layers, namely the outer, pigmented exocarp, the fleshy mesocarp and the inner membranous endocarp. The suffix -carp refers to fruit.

Please note that the clivia fruit is not a pod or seed pod as so often referred to in the literature. Pods are the fruit of peas, beans and other leguminous plants. The clivia is certainly not a legume. The clivia fruit is also not a seed, since the seeds are contained inside the fruit, which is classified as a berry.

In future, please use the names given in the above paragraphs.

CHAPTER 4

Development of the flower and its parts

4.1 ORIGIN OF THE FLOWER

Each flower develops from a dome of cells (apical meristem) at the stage when the young inflorescence is still concealed in the leaf sheath, long before actual flowering. Being a monocotyledonous plant, the Clivia flower consists of whorls of three units each: one outer and one inner whorl of tepals, outer and inner whorls of stamens and one whorl of carpels. The three carpel primordia (initials) giving rise to the pistil are the last whorl of flower parts formed by the apical meristem. During the development of the tepals and stamen initials (Figure 4.1), the apex becomes concave so that at the time the carpel initials appear, the young flower base is cup-shaped with the tepal and stamen initials situated at the rim of the 'cup' and the carpels developing inside the 'cup'.

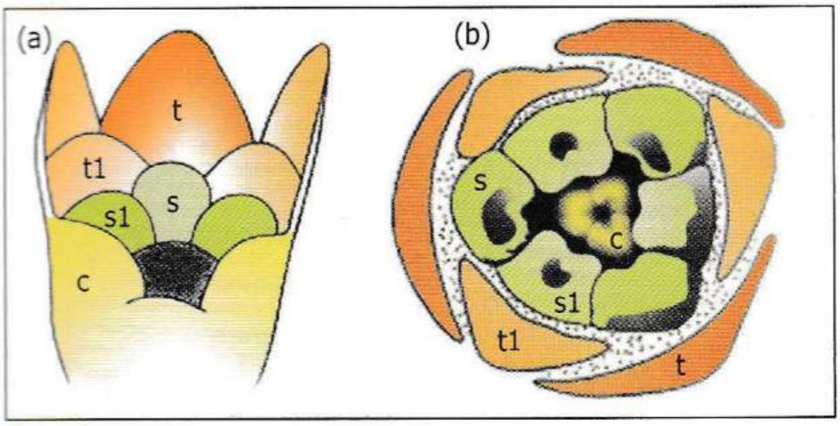


Figure 4.1. Stages of flower bud development. (a) - Semi-diagrammatic view of a longitudinal section of a very young flower bud (ca. 2 mm long). (b) - Improvised top view of young flower bud; slightly more advanced stage than (a), and with tepals removed to see the stamen and carpel primordia.

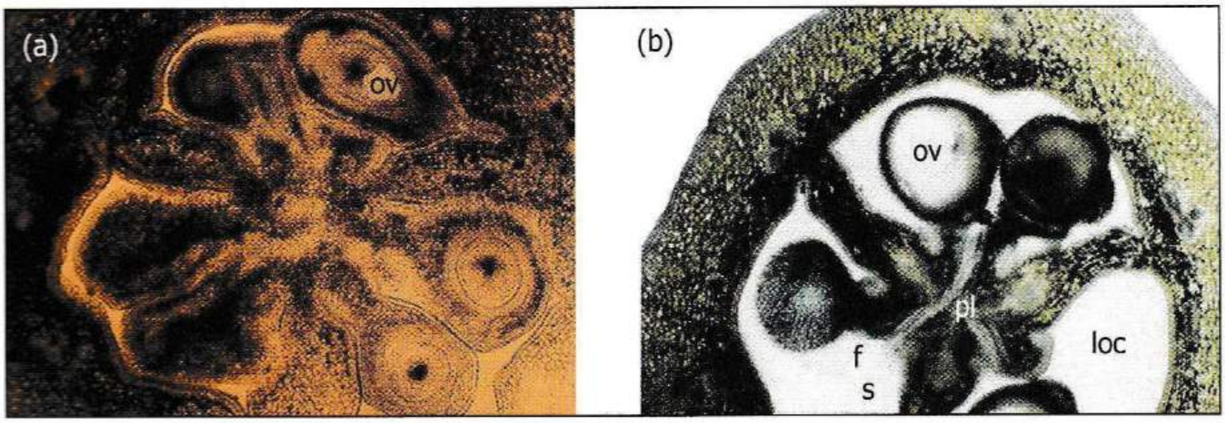


Figure 4.2 Cross-sections of *Clivia miniata* ovary at the stage of (a) - inflorescence just appearing from the leaf sheath and (b) - opening of the flower. f = funicle; loc = locule (ovary cavity); pl = placenta; s = septum (wall separating locules).

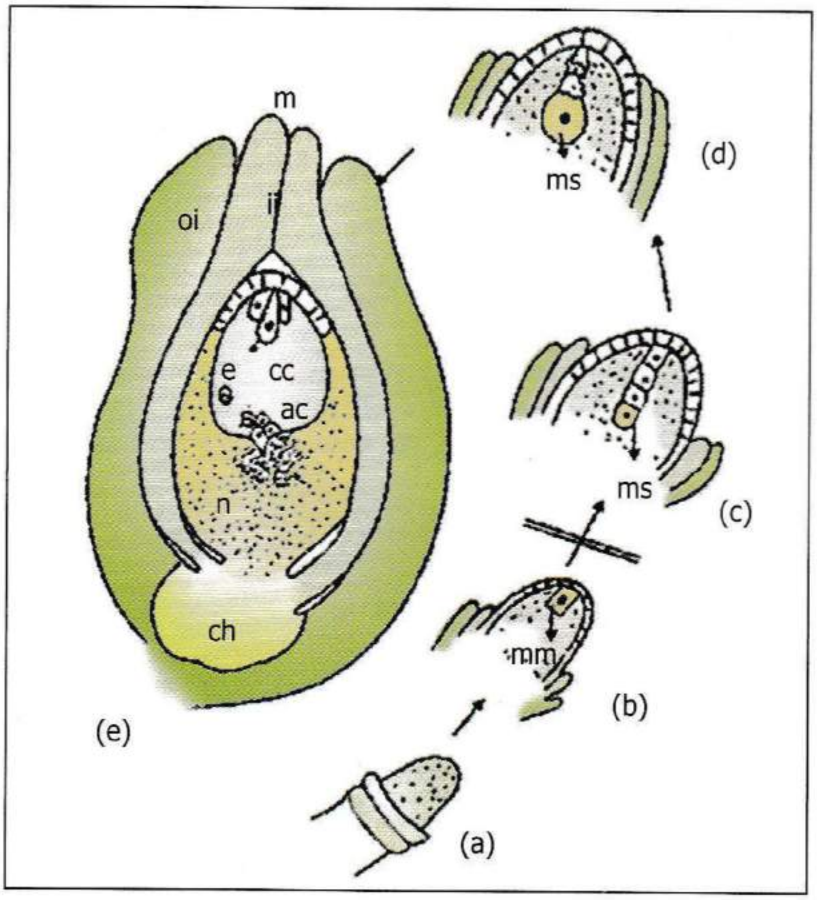
The terminal ends of the folded carpel initials can be seen as three separate units (Figure 4.1b). They remain separate to form the three lobes of the stigma, while the fused middle parts elongate to form the style. The basal parts of the carpels give rise to the three-locular ovary, embedded in the flower base (receptacle). The carpels do not only fuse sideways with the adjacent carpels, but each carpel also fuses at its margins to form a closed ovary cavity (locule).

The ovules develop from the inner margins of each carpel and are therefore arranged back-to-back in two rows in each locule (Figure 4.2b).

Each ovule is attached to the carpel margin (now the placenta), by means of a funicle containing the vascular elements, which supply the ovule with water and nutrients.

4.2 DEVELOPMENT OF THE OVULE

Similar to the whole flower, the ovule develops from a globular cell mass. The integuments start to develop as ring shaped outgrowths (at a on Figure 4.3) at the base of the globular ovule primordium and finally cover the whole central part now known as the nucellus. One of the sub epidermal cells of the nucellus, close to the apex, start enlarging to form the megaspore mother cell containing a diploid nucleus (with two sets of chromosomes). This cell (at c on Figure 4.3) undergoes meiosis and produces four haploid cells (each with one set of chromosomes). Three of the haploid cells disintegrate (at d on Figure 4.3) and the remaining one gives rise to the embryo sac.



ac = antipodal cells
cc = central cell
ch = chalaza
e = egg cell
ii = inner integument
m = micropyle
mm = megaspore mother cell
ms = megaspores;
n = nucellus
oi = outer integument

Figure 4.3 Diagrammatic illustrations of ovular development (a - d) and a line drawing of a young ovule e.

The embryo sac, ready for fertilization, consists of an egg cell accompanied by two synergid cells, one large central cell containing two nuclei, and three antipodal cells (at e on Figure 4.3). The egg cell contains a fair amount of cytoplasm with plastids. These plastids also contain DNA, which plays an important role in cytoplasmic heredity as in variegated clivia.

4.3 STIGMA

The three lobes of the clivia stigma are the unfused terminal parts of the three carpels. In the bud-stage of the flower, the three lobes are pressed together, but shortly after the flower has opened, they separate and unfold. Only the very tip of each stigma lobe becomes receptive to pollen (Figure 4.4). The receptive stage can be recognized by the appearance of papillae (short hairs) at the tip of each lobe and receptivity will only last as long as the papillae are turgid (swollen with water).

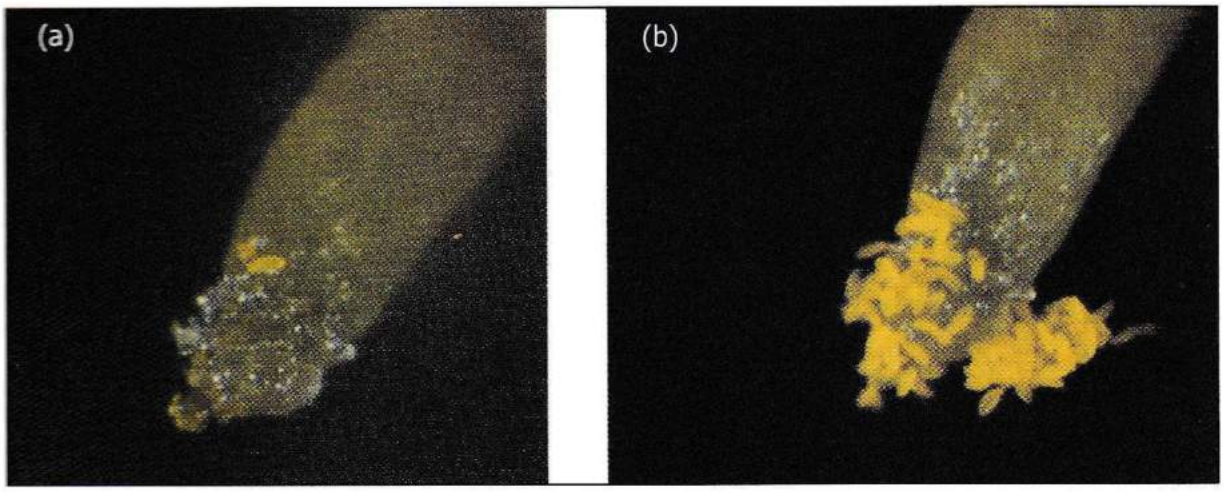


Figure 4. 4 One lobe of the three-lobed stigma (a) un-pollinated (except for one pollen grain), showing papillae on receptive part and (b) with pollen sticking onto the papillae. Note the mass of pollen on the right sticking together.

4.4 POLLEN DEVELOPMENT

Pollen is produced inside the young anthers, at a stage where the flower buds are still very small and the inflorescence still embedded in the leaf bases of the plant.

All vegetative cells of the plant (leaves, roots and stem), as well as the young flower parts, contain diploid nuclei (2n) with 22 chromosomes (each nucleus with two sets of 11 chromosomes). Inside the young anther the spore mother cells (Figure 4.5) are located.

Each spore mother cell becomes encapsulated in a layer of isolating material, called callose, before undergoing two cell divisions, known as meiosis or reduction division. This gives rise to a tetrad of four daughter cells, each containing half the number of chromosomes (11) of the spore mother cell (see Figure 4.5). At this stage, the inner cell layer of the anther wall has become a specialized nutritious layer known as the tapetum.

The single cells of the tetrad, now pollen grains, becomes separated and released from the callose wall through the action of a tapetal-derived enzyme, callase. Their cell walls become thicker, impregnated with substances from the disintegrating tapetal cells and develop its characteristic ornamentation.

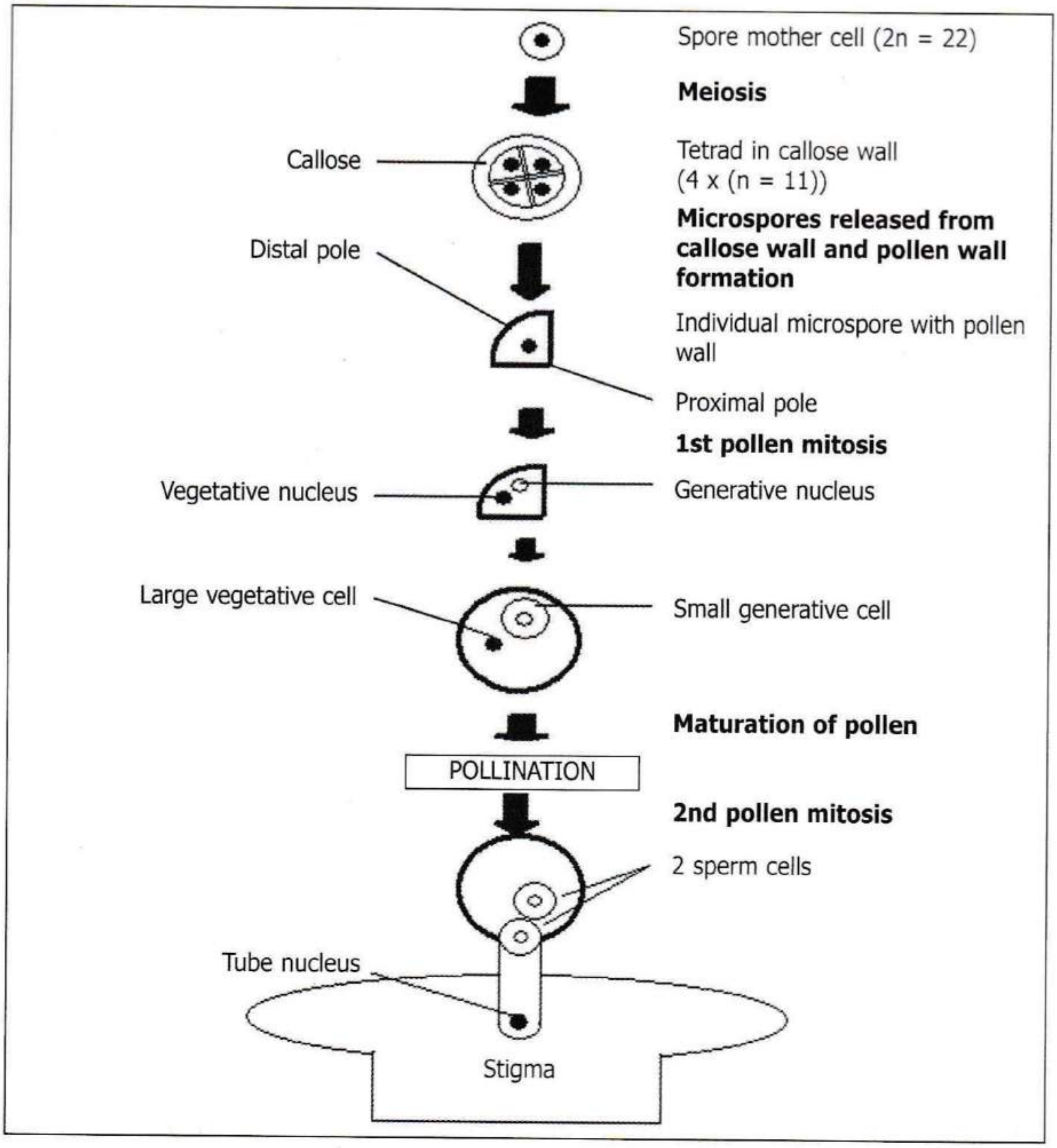


Figure 4.5. Schematic representation of general pollen formation.

The first mitotic cell division in the pollen grain is asymmetrical, resulting in a larger vegetative cell and a smaller generative cell. The latter is engulfed by the vegetative cell and will give rise to the two sperm cells, only after pollination and the formation of a pollen tube formed by the vegetative cell (Figure 4.5).

4.5 POLLEN SHEDDING AND STRUCTURE

The mature anther consists of two lobes, each containing two pollen sacs filled with pollen. The partitioning between adjacent pollen sacks in each lobe breaks down prior to dehiscence of the anther and pollen shedding. At this stage the pollen is covered with another tapetal-derived, sticky substance, called the pollenkit. The latter allows the pollen to stick to pollinators, e.g. insect, bird or brush in the case of hand pollination.

4.6 POLLINATION

When the stigma is receptive, pollination can be a once-off operation provided that an effective pollen load can be provided on each stigma lobe as demonstrated in Figure 4.4b. The fresh pollen, as well as the stigma papillae, is sticky, so that there should be no problem for the pollen to remain on the stigma long enough for germination. If the pollen is recognized by the stigma papillae, the papillae will supply the pollen grains with water and they will start germinating within an hour.

The papillae on the receptive part of the stigma are actually outgrowths of the upper epidermal cells on the 'open' tips of the stigma lobes. This 'upper' epidermis also lines the inside of the stigma and the ovular cavities and forms the transmitting tract for the pollen tube from the stigma to the ovules in the ovary. Under favourable conditions pollen tubes can reach the ovules within 24 hours after pollination. One pollen grain is required for each ovule, since the pollen tube growing from the grain, carries only two sperm cells which are both needed for fertilizing one ovule. However, the more pollen tubes taking part in the 'race' to the ovules, the better the chances for only the strongest to fertilize the ovule.

After reaching the ovule, the pollen tube enters the ovule through the micropyle (see e on Figure 4.3) and the two sperm cells are deposited into one of the synergid cells. From there they move on their own – one fertilizes the egg cell and the other fertilizes the central cell, i.e. double fertilization.

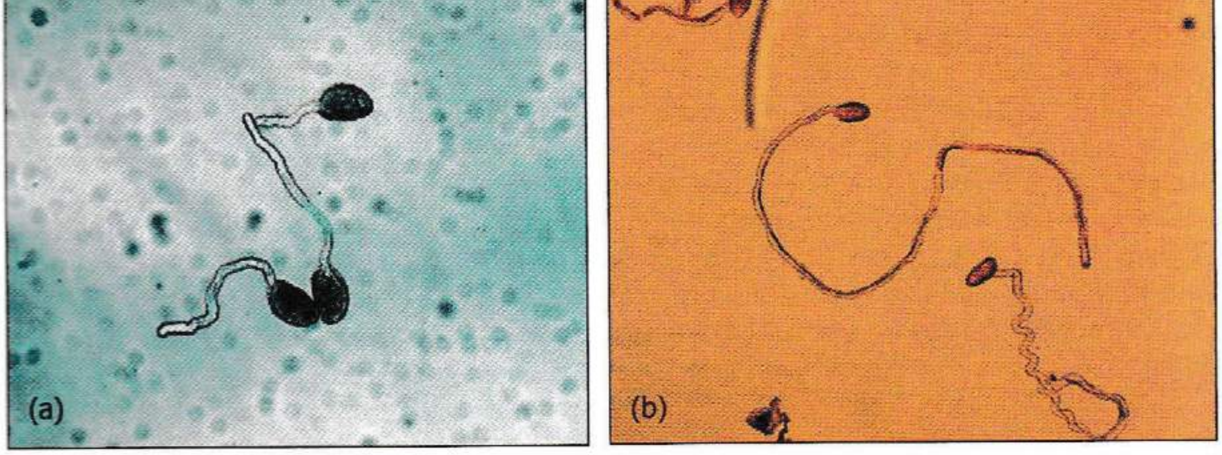


Figure 4.6 (a) shows fresh pollen germinated on an artificial medium at 23 °C, two hours after the pollen was placed on the medium and Figure 4.6b shows the same medium with pollen 24 hours later. For good results stored pollen must be tested before being used for pollination.

4.7 SEED DEVELOPMENT

After fertilization, the zygote (product of fusion) resulting from the fertilized egg cell goes into a resting phase. The triploid nucleus of the fertilized central cell, however, divides rapidly to form a great number of free endosperm nuclei before cell formation will start from the outside, progressing towards the centre of the original embryo sac. The zygote of the fertilized egg cell starts dividing during the free nuclear stage of endosperm development and gives rise to the embryo of the seed.

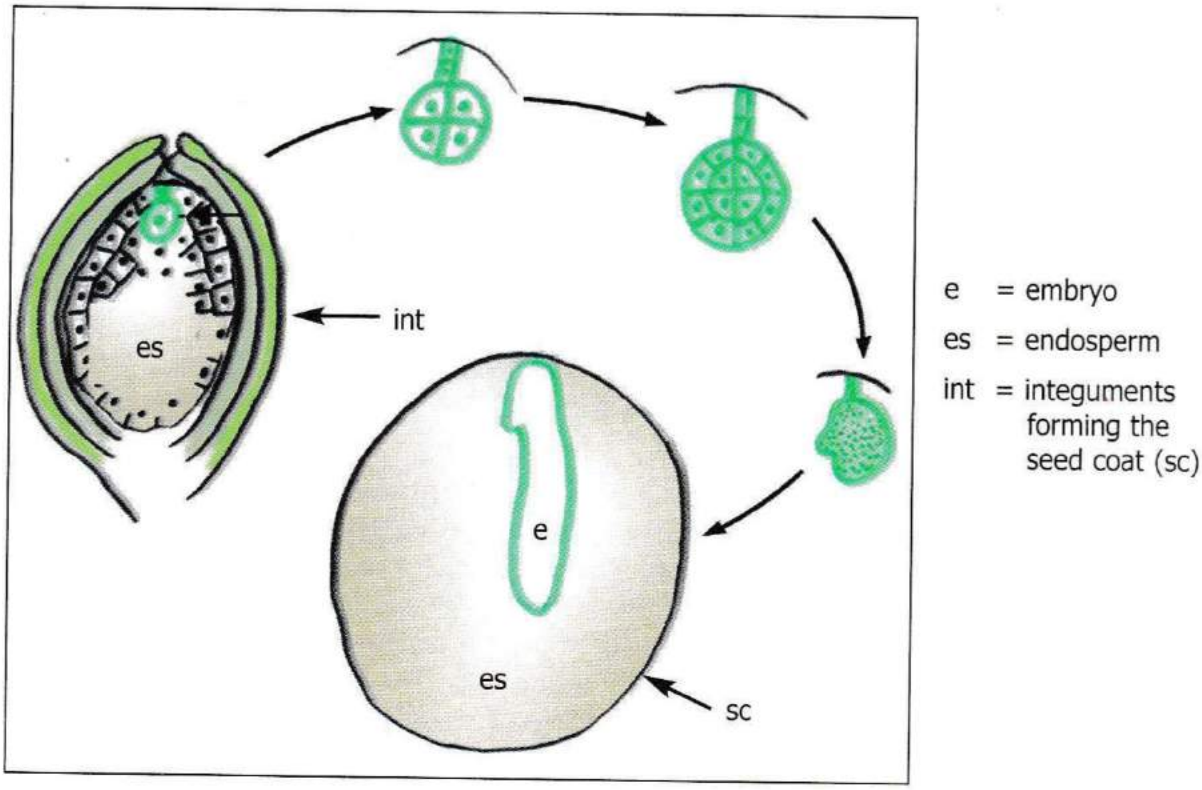


Figure 4.7 Diagram of a traverse section of a young seed of which the endosperm starts to develop [the fertilized egg cell (embryo) is still in a resting phase while the endosperm is developing], embryo development and a longitudinal section of a young seed.

As can be seen in Figure 4.3e, the young ovule contains two integuments. The ovule at e in Figure 4.3 was taken from the ovary of a very young (Figure 4.2a) flower bud (at the stage when the inflorescence was just emerging from the leaf sheath). The two integuments are well developed and the embryo sac is complete. At a later stage (Figure 4.2b), when the flower has just opened, the embryo sac is occupying most of the volume of the ovule and the integuments have deteriorated to merely a few layers of epidermis cells that develop thick walls to form the seed coat (sc in Figure 4.7). The mature seed, therefore, consists of an embryo enveloped in a mass of endosperm and a seed coat. The tip of the radicle (embryonic root of the embryo) can be seen as a round spot opposite the brown spot (hypostase) on the mature seed.

CHAPTER 5

Practical hints about sexual propagation and nourishment of clivia seedlings

5.1 SELECTION OF THE FATHER (POLLEN PARENT) PLANT AND THE MOTHER (SEED PARENT) PLANT

The good or bad of the offspring depends on the genes of the parents. To get good seed production and good seedlings, the selection of parents for pollination is very important. There are certain principles applicable for parent selection such as:

- Parents should have desirable features as far as possible and minimum defects.
- An ordinary seed plant should be pollinated with better quality pollen in order to have better offsprings.
- Variegated leaves are inherited through a variegated-leaf seed parent plant, because variegation genes are located in the plastids of the cytoplasm of the egg cell, which is not present in the pollen (see paragraph 4.2).

5.2 STIMULATION OF CLIVIA IN ORDER THAT ALL PLANTS FLOWER SIMULTANEOUSLY

To delay flowering: place plant under shade and maintain the temperature between 8 - 10 °C.

To enhance flowering: Increase temperature when inflorescence starts to develop. Maintain pot soil temperature between 25 - 30 °C and in good aeration. Do not over-irrigate and apply fertilizer as usual. It is essential to have the father plant flowering first in order to have pollen available when the mother plant is in flower.

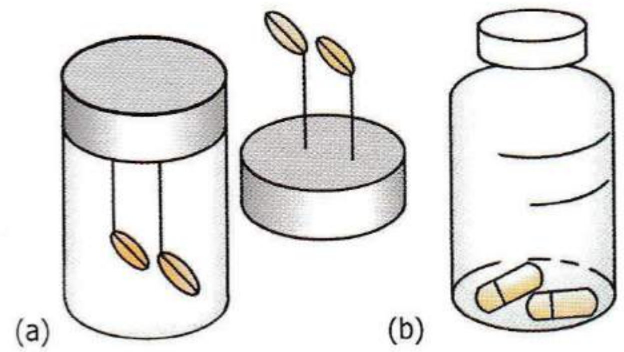


Figure 5.1 Stored pollen. Left (a) anther and filament stuck in polystyrene and then sealed in a glass container. Right (b) cellulose capsules filled with pollen and sealed in a glass container for easy removal of a small quantity pollen.

5.3 COLLECTING AND STORING CLIVIA POLLEN

Select pollen of the father plant. Use a pin to rub the pollen gently into a glass container and cap the container when finished. When collecting a small amount, we can use tweezers (reverse tweezers) to clip and cut the anther then insert it into polystyrene (Figure 2 a). Stick the polystyrene into a glass pill vial and cap to seal the anther inside.

There are many ways to store pollen. Wrapped in aluminium foil, pollen remains viable for about 10 days at room temperature. For longer periods freeze the pollen at -18 °C. If the container is kept dry the pollen should remain fertile for up to 3 years. Remember, once defrosted the pollen should not be frozen again.

5.4 POLLINATION OF CLIVIA

Pollination can take place once the perianth of the mother plant has been open for 2 - 3 hours up to days and there are papillae on the stigma (Figure 5.2). The best time for pollination is between 9:00 - 10:00 in the morning and 14:00 - 15:00 in the afternoon when the stigma is sticky.

Actual practice (Figure 5.3): Use a needle, toothpick, small brush, etc. to collect pollen and dab it (or pollen collected earlier) onto the stigma. After pollination, it should be tagged with the date, time, name of father plant, etc. Robbertse and Pienaar (Clivia Five, 2003) found that, provided viable pollen is used and receptive stigmas are pollinated; one single pollination operation should be sufficient for a good seed set.

Pollinate for three consecutive days (pollinate three times) if in doubt about pollen viability and receptiveness of the stigma. If possible, place the father (pollen parent) and mother plants (seed parent) close to each other to ease transfer of the pollen. This guarantees fresh pollen, safe operation and higher success rate.

Self-pollination (using the same plant or its offsets) gives a lower success rate with fewer seeds. Using different unrelated plants usually yields a high success rate and strong seedlings. Each flower in the umbel may be pollinated with different father plants. Make sure each flower is marked properly stating clearly the name of the father plant, time of pollination and how many times the pollination took place.

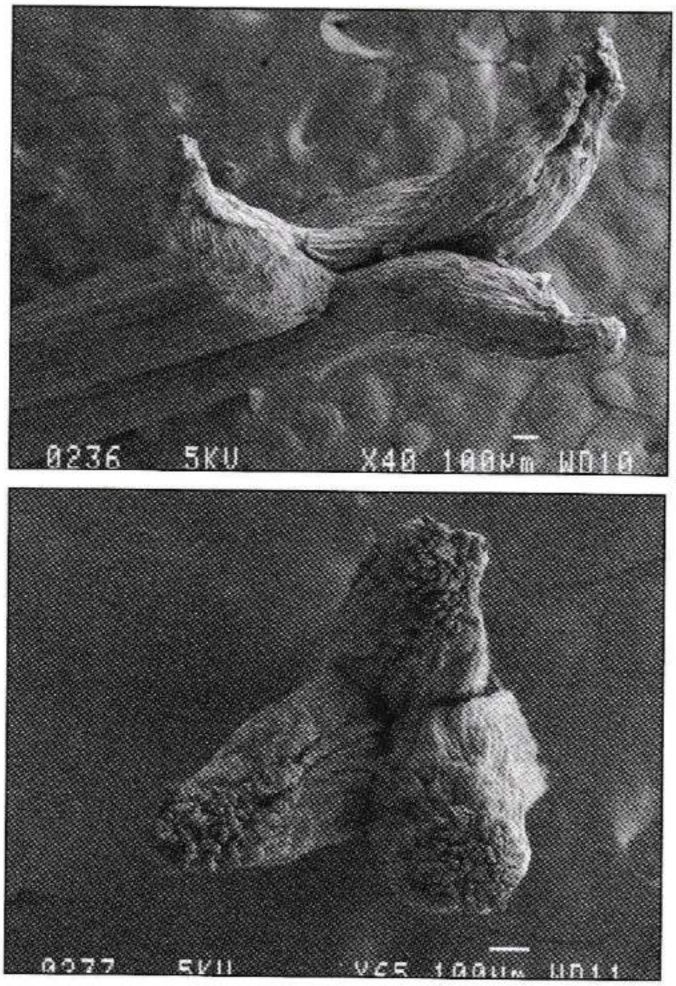


Figure 5.2 Above is the stigma before formation of papillae and below a stigma with papillae ready for pollination (Robbertse, paper presented at NCC on 16 October 2003).

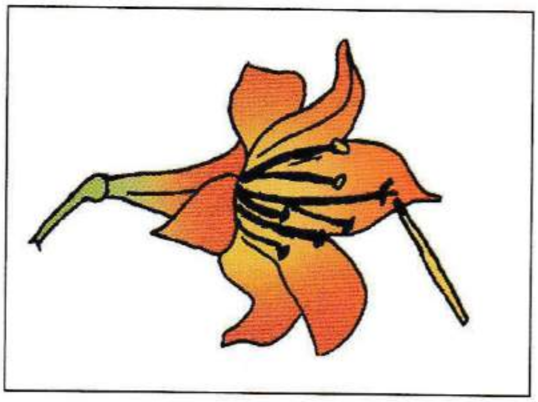


Figure 5.3 Pollination.

After pollination

- The flower will wither quickly
- Ovary will become larger and
- Fruit and seed formation will follow, or
- The ovary will wither and fall off as an indication that fertilization failed.

5.5 HARVESTING THE FRUIT

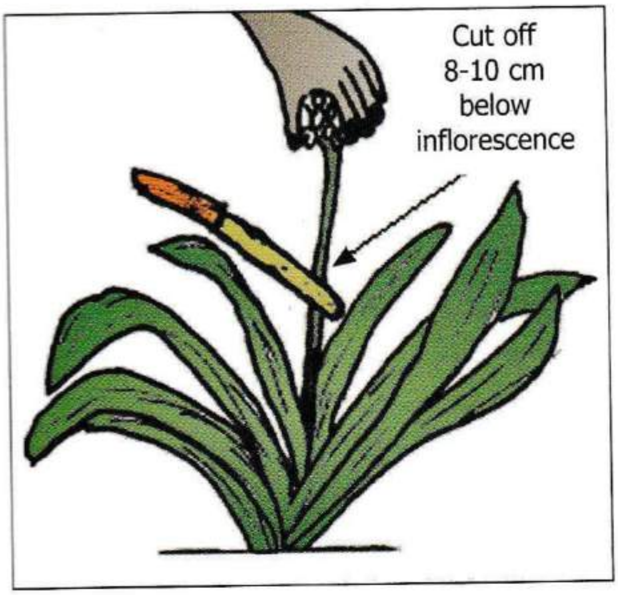


Figure 5.4 Harvesting clivia fruit.

The fruit will turn red/yellow/purple/pink after 8-10 months. When the ripe fruit is soft like a ripe peach or makes a soft cracking sound when lightly pressed, it is mature and ready to harvest.

Cut off the scape 8 - 10 cm below the umbel. Let the remaining part of the scape to dry naturally on the plant before removal. If the fruit has not fully ripened hang the umbel upside down in a good ventilated place for 10 - 15 days to ripen.

Matured, not necessary ripe seed, will, once the endosperm has completely developed, also be viable though the seedling may not grow that well. An accidental breaking off of the peduncle with green fruit may therefore not mean that the seeds are lost.

Christo Lötter (Clivia Yearbook 1998) harvests the fruit after 5,5 months.

Christo Topham, Dorandia, Pretoria North, had success with 4-month-old seed of *C. miniata.*

Sakkie Nel, Lynnwood, Pretoria, had success with 4-month-old seed of *C. miniata*, but it took long to germinate and the seedlings were weak ("*pieperig*").

Roger Dixon, Walmansthal, had success with 5-month-old seed of *C. miniata.*

James Abel, Lynnwood Manor, Pretoria, collected seed at 6 months when fruit is hard and still green.

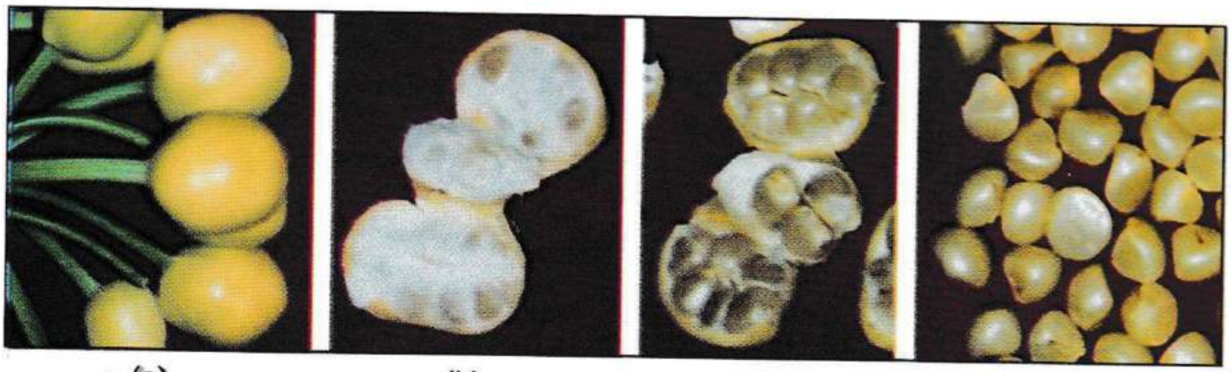
Connie Abel found that hybridised seed (interspesifics) must be fully matured - red/yellow coloured fruit.

5.6 CLEANING THE SEED

Remove the outer red or yellow skin carefully and remove the endocarp (membranes separating the three groups of seed) or

remove the outer red or yellow skin and squeeze the seed bundle to separate them. Leave seed in a cool dry place for a week. The membranes will be removed easily.

Take care to label your seed so that they do not get mixed-up.



(a) (b) (c) (d)

Figure 5.5 Cleaning clivia seed. (a) Berries, (b) Seed covered with the mesocarp in the three locules of the berry, (c) Seed uncovered in berry and (d) Cleaned seed.

Seed may be sterilized with

- Spore Kill: Dissolve 2,0 mℓ into 10 ℓ water.
- Diluted Jeyes Fluid solution: Dissolve 5 mℓ Jeyes Fluid into 5 ℓ water.
- Sunlight Liquid: Dissolve 1 teaspoon Sunlight Liquid in 1 ℓ water.

Leave the seed in the sterilizing solution for about one hour and thereafter rinse with clean water. Take care to label the seed for easy identification purposes.

Brown and Prosch (Clivia Yearbook 2, 2000) washed the seeds for an extended time with water circulating through the seeds. They found that the leaching pre-treatment to remove possible inhibitors was detrimental to the seeds and gave reduced germination.

5.7 STORING CLIVIA SEED

Pre-cleaned seeds stored at 5 °C will retain their viability for up to 360 days (Brown & Prosch, Clivia Yearbook 2, 2000).

Seed stored in their fruits results in loss of viability after 90-180 days and became infected with fungi and rot during storage.

Pre-cleaned seeds may be stored at 5 °C in vacuum-sealed plastic bags.

5.8 BUYING CLIVIA SEED

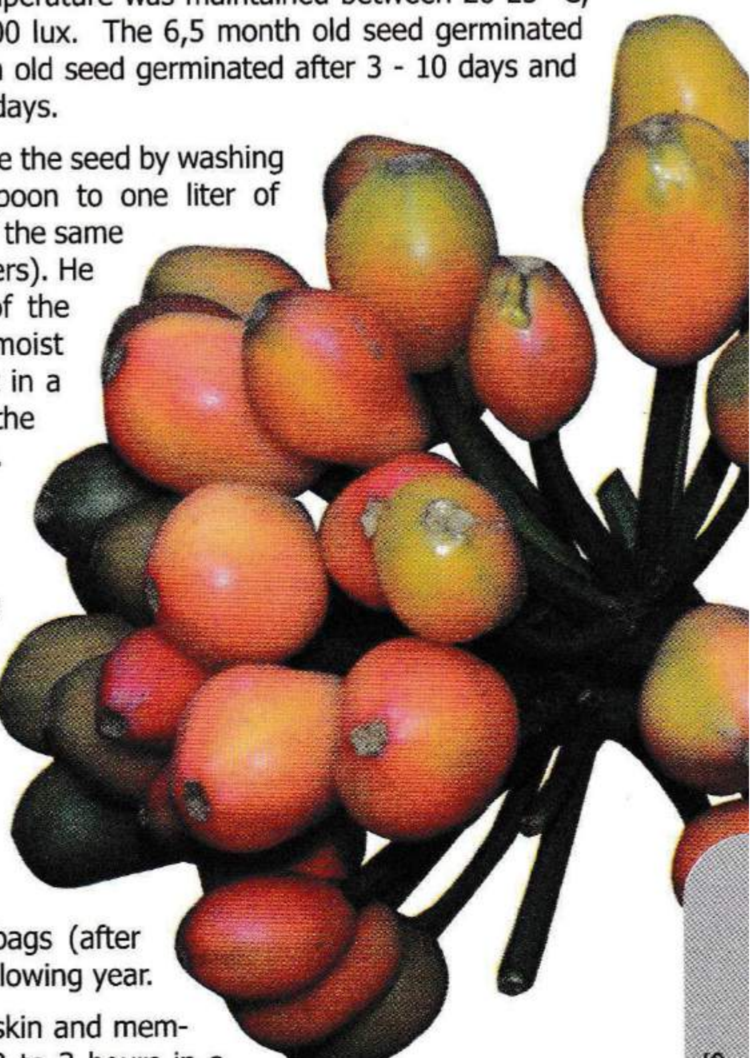
Most matured seed should germinate and give rise to a seedling. However, characteristics of the seedling are unknown. Therefore:

- The seed should be harvested directly from the mother plant when you buy it if possible – do not buy pre-harvested seed unless from a reliable seller.
- Buy fully matured seed – that is in winter when the fruit is red/yellow – with a clearly visible seed radicle tip. Premature harvested seed may seriously affect the growth of the seedling.
- Big seed does not relate to quality. A bright seed is better than a dull one. A clearly seen pop-up radicle tip is better than those without. A plump seed with pop-up radicle tip is better than one that is skinny and flat ended. The shape may be oval or round.

5.9 GERMINATING CLIVIA SEED

Seed may be soaked for 24 h in a growth regulator such as 1 % Promalin or 1 % Regulex or Kirstenbosch Smoke -Plus Seed Primer all of which contain Gibberellins GA4 and GA7 (Brown & Prosch, Clivia Yearbook 2, 2000) to improve germination. Seed may also be soaked for 24 hours in a solution of one drop Super Thrive per liter water. Soaking is more effective for dormant seed and it is not necessary to soak fresh clivia seed.

The Ji Lin Agricultural University conducted an experiment where they collected the fertilized seed in its premature stage of about 6,5 months after pollination, semi-mature stage at 7,5 months and full-mature stage when the fruit was red/yellow. The seed was dried for a while, then put into a growth regulator solution to soak for 20 minutes, washed with clean water and then soaked in 40 °C warm water for 24 hours to absorb water. It was thereafter removed and sown in a nursery bed. The temperature was maintained between 20-25 °C, humidity of 80 - 90 % and light of about 5 000 lux. The 6,5 month old seed germinated after 6 days and up to day 15. The 7,5 month old seed germinated after 3 - 10 days and the fully matured seed germinated after 3 - 5 days.



Christo Lötter (Clivia Yearbook 1998): Sterilize the seed by washing it with Sunlight dishwasher liquid (one teaspoon to one liter of water), followed by rinsing with clean water. Do the same with your containers (plastic ice-cream containers). He places a folded paper towel at the bottom of the container, moistens it, places seeds on moist toweling and closes the lid firmly. He places it in a homemade incubator. After about one month, the radicle should be – at an average – 2 cm long. He uses a container (pot or bag) ±15 cm in diameter and plants about 25 seedlings into a container. A pencil-thick screwdriver or other tool is used to push holes into the seedling medium to receive only the radicle. Push the seed lightly down in the seedling medium and water with a spray can. These seedlings will need protection from rain until the first leaf is about 4 cm long, otherwise they may be washed out. Should the seedlings be lifted by a developing taproot, make a new hole deep enough to receive the entire taproot, and water again. Transplant into individual bags (after ±10 months) at the beginning of spring the following year.

Hennie Koekemoer: After removing all the skin and membranes the seed is treated by soaking it for 2 to 3 hours in a Sunlight Liquid (dish washing solution) or a very dilute solution of potassium permanganate (Condy's crystals). The seed is then thoroughly rinsed in clean water. Better results are obtained with Condy's crystals. The seed is dried for three days and then planted in a prepared plant medium in a plastic container with a sealed lid. The plant medium is prepared by mixing well composed compos with Promis or Nutrog a 8:1:3 fertilizer, sifting it through a 4 mm sieve to get the fine fraction, wetted with a solution containing various chemicals (Jeyes Fluid and/ or Phytex, Spore Kill, Metasystox, or Chlorpyrifos) and then left for 24 hours before using it. The plant mixture should not be too wet – only damp.

The containers are then placed in a germinator room at 25 °C in the dark. Depending on the kind of seed, germination is completed in about 2 to 3 weeks. When the seedlings' leaves are at least 10 mm in length, it is transplanted into a container of 27 x 30 x 11 cm filled with fungicide pretreated plant mix (prepared as mentioned above without sifting it) and left for one to two years before planting it into a separate container. Experience showed that seedlings need more water than full-grown plants. The drainage of the plant mix is critical for determining the amount of water to be applied.

Geoff Meyer: Geoff had good results, especially during the cooler months, in germination with an electrical plant propagator, specifically for clivia seed, from the United Kingdom featuring a 13 watt heated base. He had plants flowering after 2,5 years after sowing.

Frans van Zyl: Use a polystyrene container, such as those used for fish and chips, fill it with wet seedling mix, space the seed 2-3 cm apart and cover with a glass plate. Use under carpet heater underneath the container to keep it warm at ca. 25 °C.

Pierre de Coster (Clivia Yearbook 1998) uses multi-pot trays with a substrate of 50 % pine needle compost and 50 % peat unfertilized at pH 5,5 - 6,0. The seeds are pressed lightly into the soil and kept damp and covered at 18 - 20 °C.

Koos Geldenhuys: Places the seedlings on damp seedling mix in a seedling tray, cover with a wet newspaper and keep it in a warm place. Keep the newspaper wet. Wet weekly with 1 % Spore KillTM solution.

André Calitz: After harvesting the seed, he cleans and sterilizes them with a solution of water and Sunlight Liquid (liquid dishwashing soap). He sows them directly in a mixture consisting mainly of coarse river sand and fine bark. He keeps them moist until the leaves appear before he starts to feed them either Multi Feed™ or Nitrosol™ or Seagrow™.

Gideon Botha uses a sealed 2 ℓ ice-cream plastic container filled with properly washed coarse swimming pool filter sand to germinate the seed in. He leaves it in the sand until the root is about 50 mm long. He then removes it and plants it in a sifted (to remove the coarse particles) composted pine bark growing medium.

Willie le Roux disinfects the cleaned seed with Physan solution or a dilute Sunlight Liquid solution. He fills a clean 2 ℓ ice-cream container 75 % with damp cleaned and disinfected swimming pool filter sand, puts the lid on and stores it in his warmest room or garage which has a fibre cement roof allowing it to get quite warm. Depending on the time of the year, he normally sees results within eight days. He does not water again at any stage. When the leaves are ± 1 cm long he transfers them into the standard seedling trays.

Ian Coates, UK: Growth can be accelerated by a little treatment that allows moisture to penetrate the seed more freely. With a sharp sterilized blade with the sharp edge pointing away from the radicle tip so as not to damage it, carefully remove the seed coat around the radicle tip. A few delicate strokes and the seed coat over the radicle tip can be removed. The root is now free to emerge and the peeled area around the tip allows more rapid absorption of moisture. The seed is now immersed in 1 % hydrogen peroxide solution at about 20 °C overnight. Ian found that on average germination is quicker and a success rate improvement after one month of 30 %.

Daan Guillaume designed a special tool, the Guilli-punch, to remove the seed coat covering the radicle tip. Soak the seeds for 6 to 24 hours (depending on the freshness of the seed) in lukewarm water. Use the Guili-punch and punch out the seed coat covering the radicle and remove it. Do not cut too deep, as the seed coat is only a fraction of a millimeter thick. The seeds are then placed on damp sterilized seedling mix in a seedling tray, cover the container to prevent drying out of the growing mix and contamination with pathogens and place it in a warm place to germinate. Seeds that has been treated in this manner, and left overnight in Super ThriveTM (2 drops per 250 mℓ water), will have a head start.

5.10 TAKING CARE OF YOUR SEEDLINGS

Ian Brown (Clivia Five, 2003) says that the first two years of the seedling is critical if you want the plant to flower in year three. He uses the following growing program:

a. Seeds are sown in August/September (February/March; northern hemisphere). Before then it is often too cold and wet in Cape Town.

b. Use a fairly deep seed tray or pot. A depth of about 10 cm is ideal.

c. Always use a well-drained medium. A mix of two-thirds milled bark to one-third coarse compost (with no manure) works well. Use this for all sized plants.

d. As soon as the endosperm starts to wither away, start fertilizing. He alternates Kelpak TM (sea weed concentrate) and SupranureTM 3N: 2P: 1K(22) i.e. (11 % N; 7,3 % P; 3,7 % K) weekly with occasional doses of ChemicultTM (6,5 % N: 2, 7 % P: 13 % K). All are watered on. This would be too rich in nitrogen for flowering sized plants but gets small plants to produce good leaves and roots.

e. In April transplant the seedlings (one to two leaf size). These go two at a time into plastic bags of about the size of a 17 cm pot.

f. He does not apply much fertilizing between May and July (November and January; northern hemisphere), as it's too wet! From 1 August (February; northern hemisphere) use the same fertilizer program as for the seed trays.

g. In April (18 months) put the seedlings individually into 17 cm or 20 cm pots and leave them in these until they flower.

h. These plants are now treated like all his mature ones and are fed PhostrogenTM (14:10:27) fortnightly from August with a very occasional dose of ChemicultTM. He cuts back on fertilizing in December and January (July and August; northern hemisphere) (often away on holiday!).

i. Of late he puts a little Bounce BackTM into the pots. This is an organic fertilizer made from steam sterilized chicken manure with 30g/kg N: 15 g/kg P: 1g/kg K.

(Note: All the fertilizers mentioned also contain varying amounts of micro and trace elements).

Generally one needs to stimulate plants to produce as many leaves and roots as possible in the first two years by following a balanced fertilizing and wetting programme. At flowering time each year one can check progress: hopefully 4 leaves in the first year, 9 to 10 in the second year and 14 to 16 when they flower in year three. Whatever you do – allow plenty of root space. Plants that are pot-bound in their first three years will not be strong and vigorous enough to flower.

CHAPTER 6

Vegetative (asexual) propagation of clivias

Asexually (vegetative) propagation is the ability of a plant to form new plants through its vegetative parts such as leaves, stems and roots. In asexual propagation the new plant is genetically identical to the mother plant, i.e. a clone of. In the case of clivia the rhizome (stem) is utilized for asexual propagation. This is the natural method of cloning.

Vegetative propagation can be done artificially when a plant does not propagate satisfactorily by itself.

6.1 OFFSETS

Offsets (lateral shoots) as indicated in Figure 3.2 can be removed from the mother plant and planted separately. Division should take place from after flowering till late summer.

Carefully lift the plant and wash away the soil until all the parts are clearly visible.

Remove all offsets with independent roots.

Offsets still attached to the mother plant, which have developed roots, can be carefully cut from the mother plant with a sharp instrument such as a knife. Make sure that the instrument is sterilized before a cut is made. Use an antiseptic agent such as bleach, 'Sporekill' or heat the instrument in a flame. Dust the cut surfaces with fungicide powder to reduce the chances of fungal rot. Suckers (rhizomes) without roots, should not be removed. A bud, which will develop into a sucker, is clearly discernable from the roots. They are light coloured and have nodes.

If necessary shorten any long roots to about 10 cm and place the divisions in a Kickstart™ solution (50 mℓ in 10 ℓ water) for 30 minutes.

Submerge the plants for 20 seconds in a disinfectant solution such as Sporekill™ (2 mℓ in 10 ℓ water) and plant in a container with well-drained potting soil or in the garden.

When planting in a container, sterilize the soil with an insecticide and a fungicide. Water well and again sparingly after 10 days.

6.2 SCORING

Scoring is done by different cuts to the main stem or rhizome. The true stem (rhizome) is usually underground, is hard and slightly woody in older plants. It contains the axillary buds out of which runners will develop.

The pseudostem is above ground and consists of leaf-sheaths covering the terminal part of the true stem or rhizome (delicious nutrition for the lily borer).

Scoring must be made into the true stem (rhizome). It disturbs the hormonal balance in the true stem resulting in the development of underground runners from the axillary buds.

Scoring is a drastic step with risks and may be considered when an exceptional plant does not produce side suckers naturally.

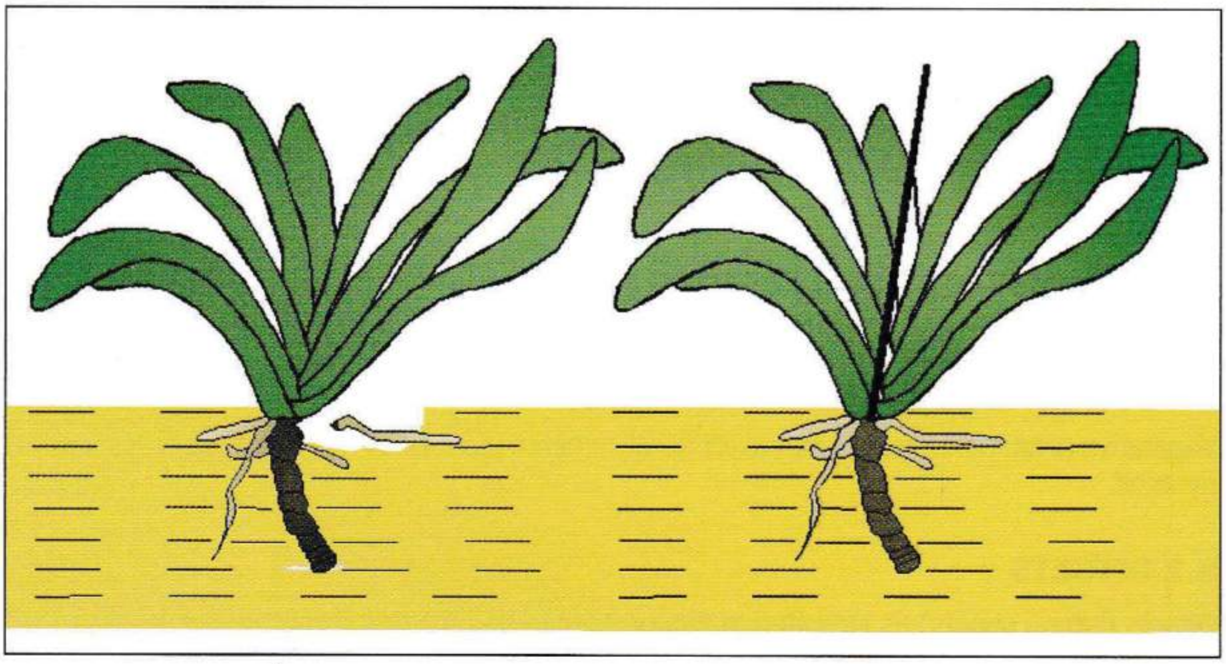


Figure 6.1 Wedge scoring method (left) and heated small metal rod or metal knitting needle method (right).

6.2.1 Wedge scoring method (Figure 6.1)

Do not remove the plant from the soil. Remove just enough soil to expose the top roots. Make 3 - 4 wedge-shaped cuts in the rhizome (stem) about 5 mm deep with a sharp sterile instrument. Sterilize the wounds and soil with Sporekill™ solution (2 mℓ in 10 ℓ water). Repeat the sterilizing during watering with Kickstart™ solution (50 mℓ in 10 ℓ water). Suckers will be produced. These suckers should not be removed until they have produced roots.

6.2.2 Heated small metal rod or metal knitting needle method (Figure 6.1)

Do not remove the plant from the soil. Take a 3.5 mm diameter metal knitting needle or metal rod and heat it in a flame. Press the hot needle or rod right down the crown of the plant into the pseudostem. The idea is to destroy the growing point of the plant, thus stimulating axillary buds to sprout and form new shoots.

6.2.3 Scoring of the rhizome (Figure 6.2)

This is a rather hazardous undertaking. Remove the plant from the soil. Wash the plant rhizome until clean. Prune the roots to about 10 cm. Turn the plant upside down so that the bottom end of the rhizome points upwards. Divide the end of the rhizome into quarters by means of a cross incision about 3 - 4 mm deep and open the incisions as far as possible. Leave in a warm shady place for a day to dry off. Place for 30 minutes in a Kickstart™ solution (50 mℓ in 10 ℓ water).

Separate the quarters with hard plastic strips. Sterilize for 20 seconds in Sporekill™ solution (2 mℓ in 10 ℓ water) and plant back into the soil. Water moderately with Kickstart™ solution and disinfect when watering.

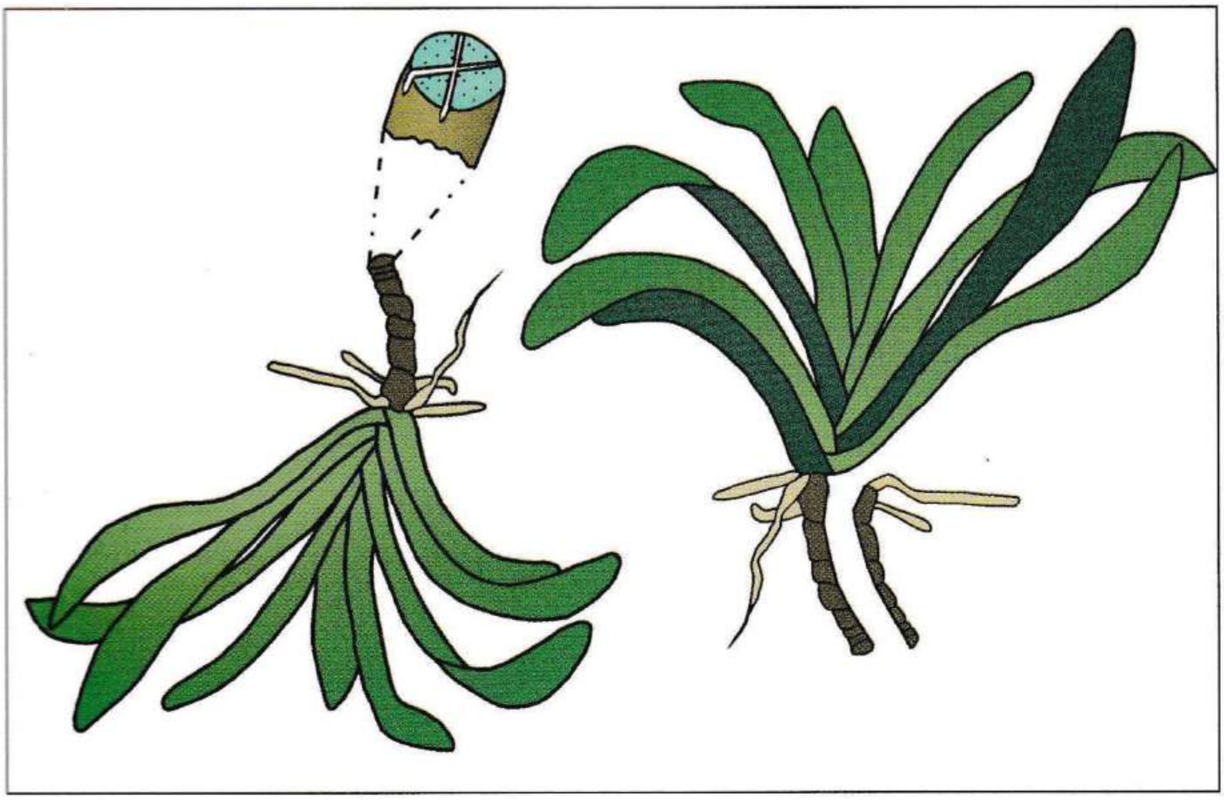


Figure 6.2 Scoring of the rhizome (left) and removing a part of the rhizome (right).

6.2.4 Removing a part of the rhizome (Figure 6.2)

Remove the plant from the soil. Wash the plant rhizome until clean. Prune the roots to about 10 cm. Cut a 45° angle incline about 5 mm deep into the stem and then vertically downward and remove about ¼ of the rhizome. Sterilize the cut surface with fungicide as in above. Allow drying off and replanting as above.

6.3 STONE METHOD (adopted from Hennie Koekemoer)

This is a very safe method and can be used with exceptional seedlings or young plants. When repotting place a golf ball size stone directly underneath the stem and wait for the result. This is a very effective way of stimulating the production of offsets according to Hennie.

A point that needs to be stressed is to sterilize all tools and equipment, hands and working space before and after making any incisions to a plant to prevent contamination – that is not only bacteria or fungi (they are treatable) but also virus infection which are untreatable and must be prevented at all costs. Take all precautions in order to succeed.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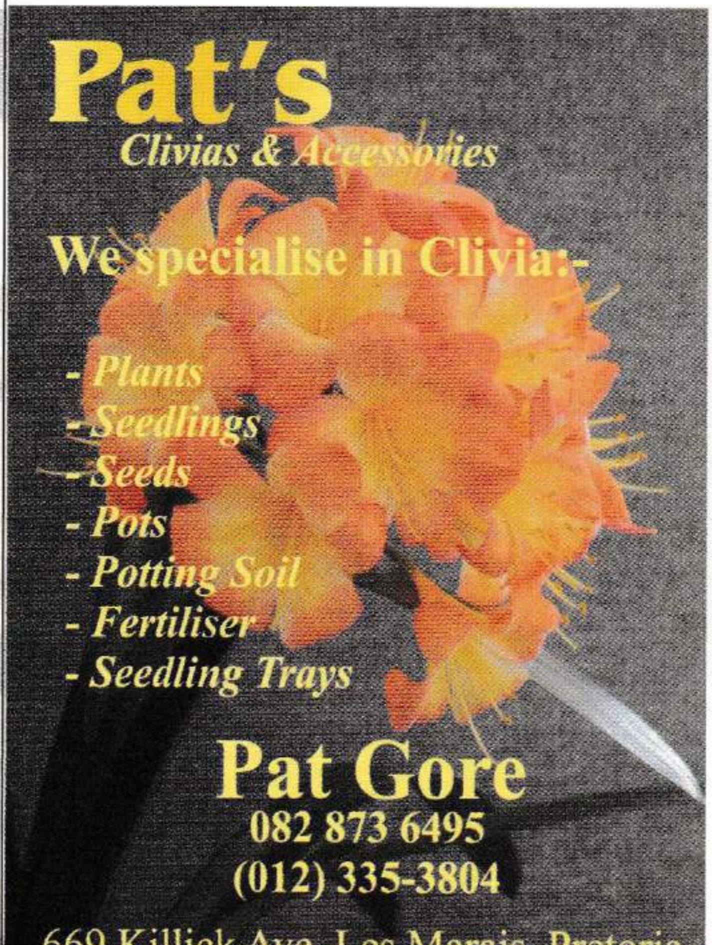
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Growing media for clivias

7.1 REQUIREMENTS

Different growers use different media in containers for growing their clivias. Some of these media are bark, compost or ready-made mixes supplied by organizations dealing in garden supplies. It is, however, also possible to make up your own medium but to do this, there is some basic information that you would need. A good growing medium will continuously supply plant roots with water, air and nutrient elements in balanced proportions.

Plant growth suffers when:

- The air and water in the medium are out of balance with one another (too much air equals drought; too much water equals water logging).
- The nutrient supply is too low or too high.
- The medium is too compacted for roots to easily penetrate.
- There are not enough beneficial living organisms.
- Disease-causing organisms grow unchecked.
- The medium is warmer or colder than preferred by the species being grown.

The three main components of a growing medium are shown in Figure 7.1(a):

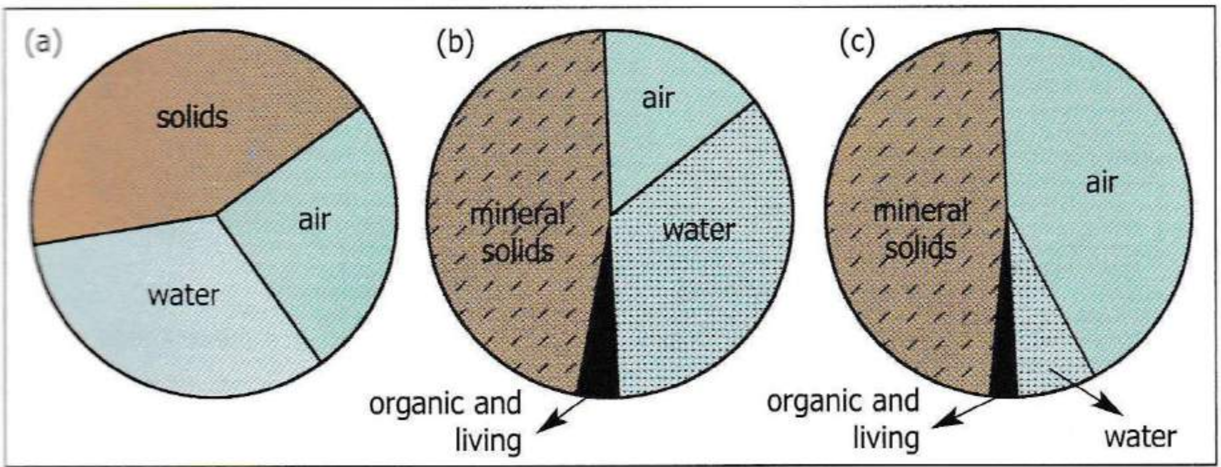


Figure 7.1. Schematic representation of an artificial growing medium (a), composition of most soil (b) and sun-dried soil (c).

7.2 COMPONENTS OF A GROWING MEDIUM

7.2.1 Soil

The size of the particles determines whether soil is classified as clay (very small particles) through loam to sand (larger particles). Soil also contains a percentage organic matter such as humus (Figure 7.1). The openings or pores between the soil particles house the gas or air component that is very important for aerating the soil. Plant roots similar to other living organisms need oxygen for respiration. When watering soil the air is displaced by water and when the soil is allowed to drain the water will first drain from the larger pores. A portion of the water is held in the very small pores and around the small soil and humus particles (Figure 7.2 right) and constitutes the liquid component of the soil that is available to the plant roots. The water retaining capacity of soil is determined by the particle size of the soil and the amount of organic matter present.

7.2.2 Artificial growing media

The solid component of artificial growing media consists of soil and/ or organic matter originating from plants or animals such as bark, compost, peat, horse manure, etc. (Figure 7.1). Organic matter such as bark and compost already consists of small components that ensure good water retention ability and therefore the particles of the medium should be coarse to ensure sufficient drainage. If the bark or compost particles are also small, it will retain too much water and too little air will be available for the survival of the plant roots. The roots will "suffocate" and die because of the waterlogged medium. In their natural habitat clivias grow on the forest floor and even in trees where the roots grow in the leaf litter. It is therefore logical that they prefer a loose, well-aerated compost rich-growing medium. In general the pH of the forest floor is relatively low (not more than 5). This means that clivia prefer an acid growing medium. Most other plants prefer a pH of 5 to 7.

7.3 AIR-FILLED POROSITY

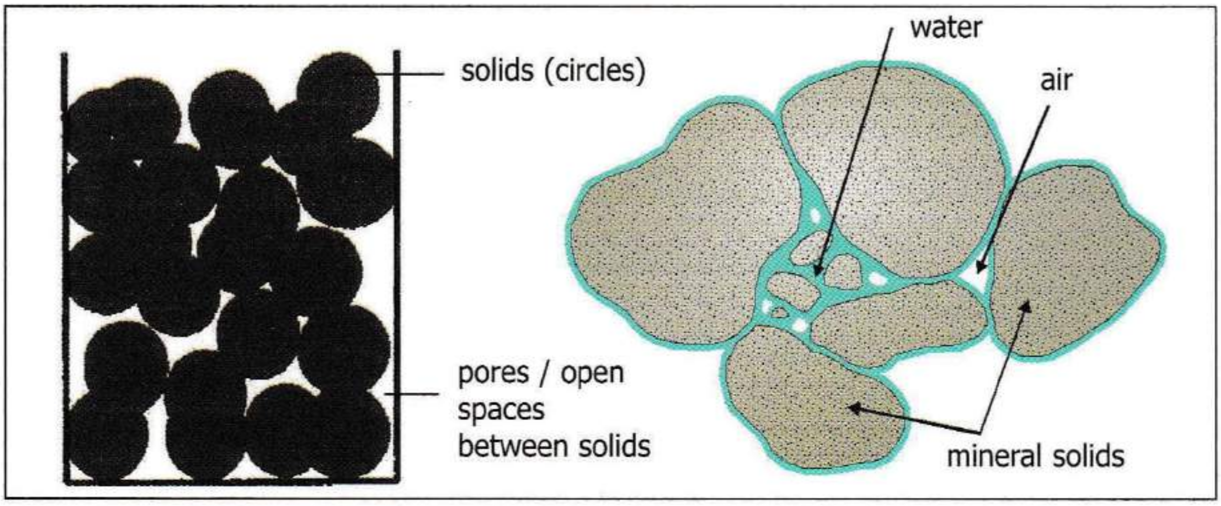


Figure 7.2. Left: Illustration of porosity. Right: Water and air in the growing medium.

The air-filled porosity is the interaction between the air and water components (Figure 7.1 left) and is determined by the solid fraction of the growing medium. In Figure 7.2 the circles represent the solid fraction (medium) and the pores are the open spaces between the circles. If the medium is dry, all the pores will be filled with air, but if the container is filled up with water, the water will replace all the air, in and between particles. If the water is allowed to drain out, some will be retained by the solid particles (Figure 7.2 right), depending on the water retention capacity of the medium. The volume of water that drains out, expressed as a percentage of the total volume of the container, will give you the air-filled porosity (AFP) of the specific medium.

Clivias require a medium with a relatively high AFP of about 20% or more, together with a good water retention capacity and a large specific surface area for the retention of nutrients.

7.4 PRACTICAL IMPLICATIONS OF AIR-FILLED POROCITY (Handreck & Black, 2002)

Immediately after drainage has stopped, the water content decreases to be the least at the top, while the medium at the very bottom of the container remains saturated unless it is sitting on an absorbent surface.

The pore size determines the actual ratio of water to air in the pore space of the growing media in containers of the same height. Growing media with large pores will hold less water (and have a higher air-filled porosity) than media with mainly small pores.

Shallow containers will have higher average water content (and a lower air-filled porosity) than the same medium in taller containers (Figure 7.4), because the height of saturated and very wet growing medium is the same no matter what the height of the container.

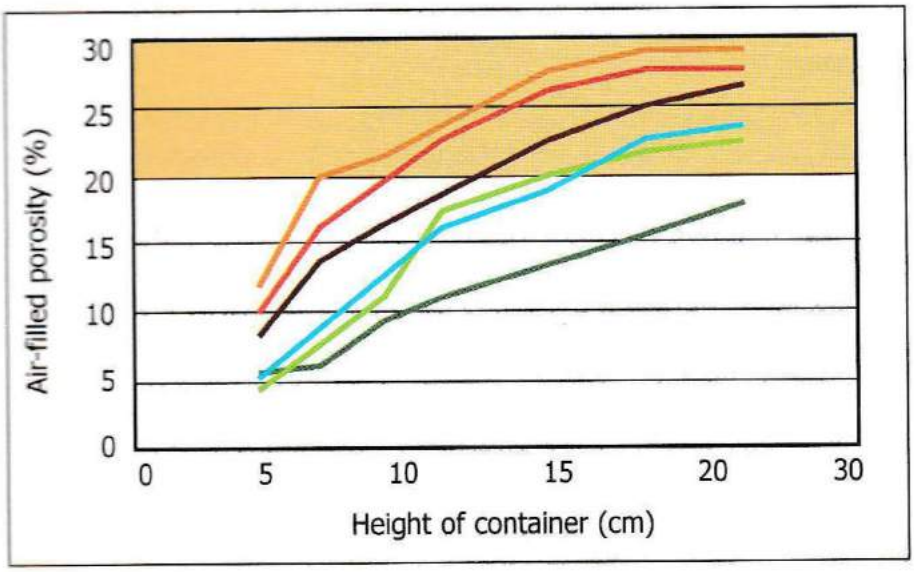


Figure 7.4. Relation between height of container and air-filled pores (AFP) of six pine bark growing media of different particle size. Shaded area shows required AFP for clivia.

Decrease in particle size from - > - ≈ - > - > - ≈ -.

The average percent water in tapered pots is lower (and the air filled pores higher) than the percent in vertical-sided pots of the same height (Figure 7.5).

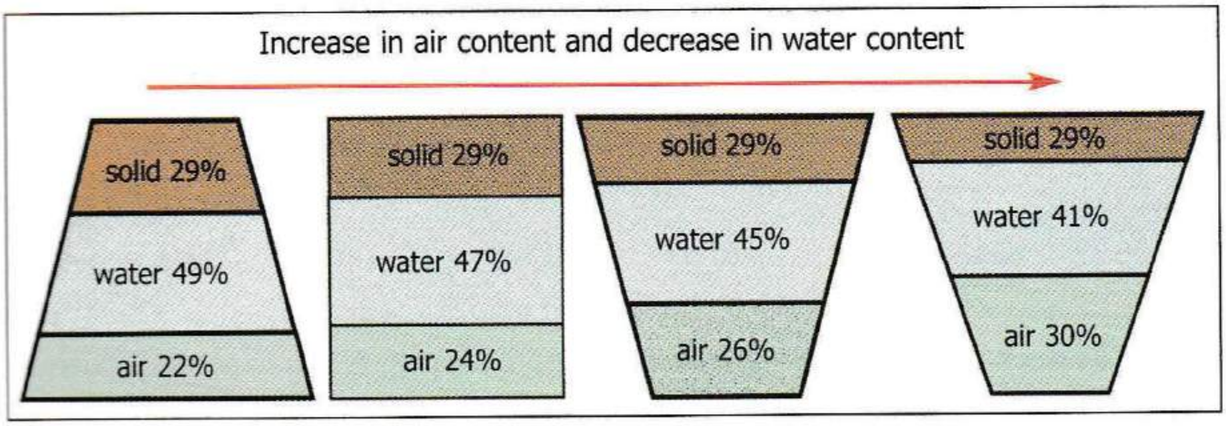


Figure 7.5. More tapered containers of the same height show an increase in air-filled pores and the water content decrease.

The proportion of water in just-drained medium in a typical nursery pot will be greater than the proportion in a similar depth of the medium if it formed the upper part of the natural soil of an area. In other words, container capacity is always greater than field capacity for the same medium. This means that if we put a soil having 35% water at field capacity into a container, we could find that its container capacity is nearer to 40-45%. That would leave very little space for air. Only in very tall containers (perhaps more than 0.8-1 m tall) is the container capacity much the same as field capacity.

Note: Media for use in containers must have a higher proportion of large pores than natural soils do if the roots of plants in pots are to get enough oxygen.

7.5 KIND AND SIZE OF CONTAINERS OR POTS FOR CLIVIA

Containers made of plastic, terra cotta, ceramics, fibre cement, etc. are suitable as planters for clivia. Be wary of cement containers as alkali may leach out into the growing medium affecting the pH. The growing medium may also be covered with a mulch of bark chips, nutshells, moss or stones.

The size of the container should be in relation to the size of the plant. The overall impression of the exhibit should be balanced and pleasing to the eye.

The plant grows constantly from a seedling to a mature plant. Pot size suitable for a seedling may hamper the mature plant and *vice versa*. In cool climates it is more difficult to keep the centre of a large pot warm enough for a seedling, resulting in slow growth. A large plant in a small pot may suffer from a lack of nutritient supply and growth will be inhibited. Growth and reproduction status of the plant determines the proper size of the pot to be chosen. Table 7.1 shows the proper pot sizes for clivia.

Table 7.1 Suggested relation between pot size and leaf number of plant (Wen-Chang, 2002).

No. of leaves	Size (inch)	Height (cm)	Size of the pot Top diameter (cm)	Bottom diameter (cm)	Number of plants planted per pot	Note Note
1	4-5	13-15	15-16	11-12	10	
2-3	4-5	13-15	15-16	11-12	2	
3-5	4	13	15	11	1	
5-8	5	15	16	12	1	
8-10	6	16	20	13	1	
10-15	7	20	22	15	1	
15-20	8	22	26	18	1	
20-25	10-12	26-28	30-34	20-22	1	Depending on the growing condition

Bossie de Kock plants all seedlings sown in August to September over in pots in January to February the following year. Be careful not to remove the endosperm still attached to the seedling. Because of space problems he planted half of the seedlings in 12.5 cm and the rest in 17.5 cm pots. 90 % planted in the bigger pots flowered the 3rd year whilst all the ones in the smaller pots flowered only after 4 to 5 years.

7.6 GROWING MEDIA MIXES (SUBSTRATE) IN USE FOR CLIVIA

All clivia growers have their own preferences when it comes to growing medium as the following examples demonstrate.

The Chinese recommends the following mixes:

Growing mix 1: 70-80% old horse manure (at least 3 months old) with 20-30% sand.

Growing mix 2: 60% broad leaf compost with 20% sand and 20% needle leaf compost.

Growing mix 3: Mix 15% grass compost (neutral or little acidic) with 20% sand, 50% broad leaf compost and 15% needle leaf compost.

Growing mix 4: Mix 40% broad leaf compost with 40% of old horse manure and 20% sand.

Gideon Botha: To composted pine bark mix adds half a cup of Bounce Back™ for each 20 cm pot.

André Calitz: This mix he uses for one year old to mature plants. 70 % fine bark, 10 % river sand (coarse like swimming pool filter sand), 15 % potting soil and 5 % consists of bone meal/ peat moss/ vermiculite/ Bounce Back™. This is a very loose mixture.

Willie le Roux: He uses one part compost to three parts fine bark.

Norman Weitz: 3 bags good potting soil, 1 bag cattle manure, 10 ℓ horse manure, 10 ℓ river sand, 0,4 kg dolomite and 0,7 kg Bounce Back™.

Frikkie Potgieter: To one wheelbarrow Fern Nursery clivia mix adds 4 ℓ Bounce Back™ (chicken manure).

Bossie de Kock: He uses equal parts loam soil, acid compost (peatmos) and fine bark. On 20 ℓ a cup of kraal manure and bonemeal is added.

The ratio of solid fraction to water to air in the growing medium mix is determined by particle size of the solid fraction. Various inorganic and organic materials are suitable for use as the solid fraction. In general, avoid granitic sand, beware of nematode (eelworm) contamination in river sand (rather use crusher sand, particle size > 0,25 mm) and steer clear of mushroom compost as it decomposes quickly and becomes too dense. The temperature during compost making should reach 60 °C for sterilization purposes. When in doubt, rather sterilize the solid fraction with heat, (steam for 1 - 1,5 hours), 1 % potassium permanganate ($KMnO_4$) solution, 1 % hydrogen peroxide (H_2O_2) solution or fungicides. Used containers should also be sterilized.

7.7 WHEN TO POT ON

The growth rate of seedlings determines the frequency of transplanting (See Table 7.1). In China the advised practice is to transplant seedlings 2-3 times during the first year, twice the second year and once the third year.

For mature plants the frequency is determined by factors such as whether the

- plant is pot-bound,
- growing medium still provides adequate nutrients and
- pot size and plant size are still in balance.

For *C. miniata* seedlings the best time to transplant is during the vigorous growth stage (spring to autumn) except for mature plants; they should not undergo soil and pot replacement during January to February; southern hemisphere, (June to August; northern hemisphere) and avoid soil replacement during June to August, southern hemisphere (December to February; northern hemisphere) as this will adversely affect the seed harvest and the germination of the inflorescence.

Gideon Botha, Port Elizabeth, transplants his plants only when the plant is clearly too pot bound. Transplanting is done from November to January (June to July; northern hemisphere) by choice, normally after the fruit are properly formed, if the plant has fruit. The plant is less likely to flower the next year if you transplant it too late.

André Calitz tries to replant his clivias every third year when he has to remove suckers from the adult plants. He normally repots during February and March (August to September; northern hemisphere).

Willie le Roux says re-potting and dividing during November to December (June to July; northern hemisphere) works well for him. He prefers to do this during waxing (growing) of the moon and not waning (reducing). He only repots when it is absolutely necessary, for instance when the roots are climbing out of the pot and begging him to be repotted or when the mixture has reached it's life span and is breaking up. He prefers to use smaller pots. Size range from 15 - 25 cm is sufficient for him.

Bossie de Kock transplants bigger plants only if and when necessary. He divides his plants in July to August (January to February; northern hemisphere). At this time the inflorescence has already formed and the plant will flower. Being cold, there is a minimum chance of bacterial infection. Treat the cut wounds and immediately plant them.

All plants repotted are treated in the following way: Take a large open container (20 ℓ capacity) and fill it with water. In a jug first mix according to the recommendations of the manufacturer Captan and Virikop with a small volume of water and then pour the mixture in the container. Also add Garden Ripcord™ and Supranure™ [3:2:1 (22)]. Supranure™ contains growth stimulants minimising the trauma to the plant.

Place two slats across the tub, place the pots on them and thoroughly drench the leaves and potting mixture. This method save chemicals by re-using the mixture till the tub is empty.

7.8 HINTS WHEN REPLACING SOIL OR CHANGING CLIVIAS TO BIGGER POTS

Do not water the plants to be transplanted for a couple of days before you transplant. This will avoid too wet soil damaging the roots, by reducing the friction between the soil and the pot.

Turn the pot on its side, be careful not to damage any leaves, and tap the pot gently on the side, so as to loosen the plant inside. Do the same on the opposite side of the pot. Now place the stem of the plant between the second and third fingers of your right hand, palm facing the pot, and turn the pot upside down. Remove the pot with your left hand. If it is a large plant, ask a second person to help, thereby minimizing possible damage to the leaves.

Use sterilized cutting tools and cut off any yellow leaves and spoiled roots before transplanting. Also cut away some roots if they are too dense or aged. Use water to clean the roots and treat the roots with a fungicide to prevent any infection.

Ensure that your soil mixture is dry as it is easier to get it in between the roots when planting. Once planted, water the plant well.

It is important to wash previously used pots completely inside and outside and to sterilize them well in advance before use so that any chemical could evaporate or break down. Then sterilize them by soaking in 2 % copper sulphate solution or a strong solution of dishwasher solution (Sunlight liquid) for 1-2 hours. Diluted household bleach (3,5% sodium hypochlorite, NaOCl) - 25 mℓ diluted to 10 ℓ - is an excellent sterilizing agent for pots and equipment used for your clivias. A plastic pot is porous and must also be treated. The soaking time for a ceramic pot, depending on the thickness, will be that much longer. Wait until completely dry (sun dried if possible) before use.

Inspect the bottom of the pot before potting. If the middle part is concave, it will accumulate water, that will become stale and a perfect breeding ground for diseases. Add extra holes on the outer rim for drainage if this is the case. Never use pebbles in the bottom of the pot as they are an ideal hiding place for hibernating snails/slugs and is condusive to poor drainage.

When you are planting the plant in it's new pot, check the roots. If the roots are too long you can roll them together, but ensure that you put some of your mixture in the middle of the roots.

After setting the plant in the pot, fill it half full with your mixture. Gently lift your plant to get your mixture into the root system. This is very important because if the nutrient does not reach the roots, it will result in spoiled roots.

Once you have filled the pot, gently tap the pot so that the growing mix can get closely to the roots and add more growing mix if necessary.

Norman Weitz adds to a 10 ℓ pot a hand full of bone meal to the bottom quarter of growing mix, mixes it well, puts a layer of growing mix on it so that the roots are not in direct contact with the bone meal and then carries on planting.

7.9 HOW TO GROW CLIVIA IN THE GARDEN

Plant 50-60 cm apart in slightly acidic soil enriched with plenty of compost and a handful of bone meal.

When planting clivias from nursery bags or replanting newly divided plants, it is important to ensure that they are planted at the same level as that at which they were growing previously, since planting too deeply can cause the leaf bases to rot (Figure 7.6).

Figure 7.6 Seedling planted too deep and the leaf base started to rot.

Clivias will not grow in clay soil rather plant them in pure compost.

Clivias are fairly hardy and can be grown in cold areas, provided they are protected from heavy frost and cold winds.

In summer rainfall areas, clivias are very water wise and only need watering once a month during the dry winter. Once the scape has reached 15 cm during August, water more frequently until the summer rains start.

In winter rainfall areas, water every week during summer and make sure your clivias are in well-drained soil during winter as they loathe wet clay soil.

Mulch the plants with well-rotted compost in spring.

7.10 TAKING CARE OF CLIVIA

The cultural practices (Table 7.2) Bing Wiese employs is a good guide how to take care of your clivia.

Table 7.2. The Clivia Calendar. Shaded cells represent months when a certain activity is conducted.

Activity	Southern Hemisphere											
Month	J	F	M	A	M	J	J	A	S	O	N	D
Harvesting seed				■	■	■	■					
Germinating seed					■	■	■	■	■			
Planting seed						■	■	■	■	■		
Planting out seedlings	■	■									■	■
Potting-on									■	■	■	
Dividing and transplanting	■	■								■	■	■
Feeding	■	■	■							■	■	■
Look out for pests	■	■	■	■						■	■	■
Month	J	A	S	O	N	D	J	F	M	A	M	J
	Northern Hemisphere											

CHAPTER 8

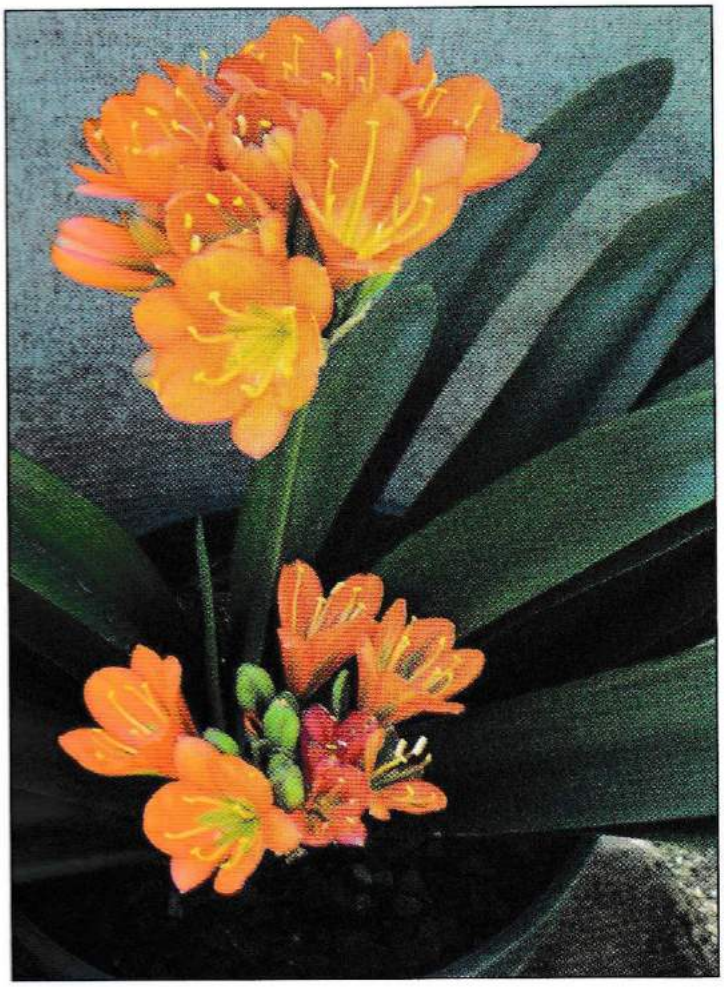
Temperature and daylight requirements for the cultivation of clivia

8.1 THE INFLUENCE OF TEMPERATURE ON THE CULTIVATION OF CLIVIA

Clivia grows on the indigenous forest floor where it is cool in summer and warm in winter. We should try to imitate these conditions in our back yard for the cultivation of clivia. We should strive to accomplish the ideal temperature conditions (Table 8.1).

Mori and Sakanishi (1974) found that if a plant was kept above 20 °C continuously, the plant failed to flower. Cold treatment at 10 °C for at least 45 days normal scape elongation and normal flowering were observed, while insufficient chilling either by imperfect degree or duration of cold resulted in anthesis – the scape do not elongate and the umbel is surrounded by foliage leaves.

Long days created by supplemental lighting after shifting to warm temperature do compensate for insufficient chilling.



Kept at 10 °C for 60 days and then kept at 20 °C emergence of inflorescence was observed after 18 days and the flowers open after 36 days with a mean 31 cm scape length.

De Smedt, van Huylenbroeck and Debergh (1996) found that leaf number of *C. miniata* increased significantly with higher temperature (20 °C compared with 16 °C and 7 °C). Supplementary lighting to reach a photoperiod of 16 h during wintertime had no effect on leaf number, but promoted leaf elongation. Regardless of temperature and light treatment, the first flower bud was initiated after 12 - 13 leaves were formed and subsequent flower buds after each 4 - 5 leaves. Higher temperature hastens flower bud development, but result in insufficient scape elongation, whilst lighting hastened scape elongation.

Table 8.1* The influence of temperature (T) on the growth, the flower and respiration of clivia.

TEMPERATURE (°C)	INFLUENCE ON GROWTH OF CLIVIA
0	The lowest/ minimum temperature clivia could survive at for a short period (max 2 hours), but succumbs if it stays cold for longer
8	Growth stops
10	Growth is retarded, immaterial whether seedlings or full grown plants
15-25	Most suitable temperature for cultivation and flowering
18-35	Most suitable temperature for germination of seed
> 25 °C + high humidity	Leaves become thinner and faded
> 25 °C + low humidity	Leaves become yellow, tips die back, withers and dies
> 28	Leaves become long and easily get infected with bacteria and fungi and sun scorched
38	The highest / maximum temperature clivia could survive
Best T	Where clivia grows the fastest, but this is not necessary the temperature the cultivator wants, because if clivias grow too fast the leaves become long, thin and weak, making the plant unattractive and disease prone. Therefore clivias are cultivated at a temperature where the appearance the cultivator prefers is obtained.
	INFLUENCE OF TEMPERATURE ON THE FLOWERING OF CLIVIA
At high summer T	Flowering period is 10 - 20 days. The fruit will drop after pollination or be much smaller than those formed in winter or at a lower temperature
At lower winter/ spring T	Flowering period is 30 - 40 days and colourful flowers are obtained
< 10	Colour of the flower is lighter and the flowering period will be longer
	INFLUENCE OF TEMPERATURE ON RESPIRATION
10 - 30	Normal respiration. At higher temperature respiration is faster and at lower temperature respiration is slower
0	Lowest temperature for respiration
40	Highest temperature for respiration. If this temperature is exceeded, respiration will stop and the plant will soon die

*Compiled from information in Xue, Zhong, & Ming (1999), Wen-Chang (2002) and Van Rensburg, paper delivered at NCC May 2003.

Temperature also influence the flowering period and the colour of the florets (Table 8.2)

Table 8.2 Influence of Temperature (T) on flowering period of clivia

T (°C)	Duration of flowering period (Days)	Remarks
6-12	60-70	Light coloured flower
12-15	40-50	Bright coloured flower
15-20	30-40	Bright coloured flower
25-30	20-30	Brilliant coloured flower

8.2 THE RELATIONSHIP BETWEEN TEMPERATURE AND METABOLISM OF CLIVIA

8.2.1 Respiration (Table 8.1)

By controlling temperature, metabolism of clivia is controlled. Temperature also influences the accumulation and use of organic compounds (Figure 8.1) in the plant and thus the growing and development of clivia. If respiration rate is faster than photosynthetic rate, the plant experience starvation and dies (Handreck *et.al.* 2002).

8.2.2 Photosynthesis

Photosynthesis (Van Rensburg, 2003) is the basis of accumulation of organic compounds and energy of the plant. Temperature directly influences photosynthesis by clivias. From figure 8.1 follows:

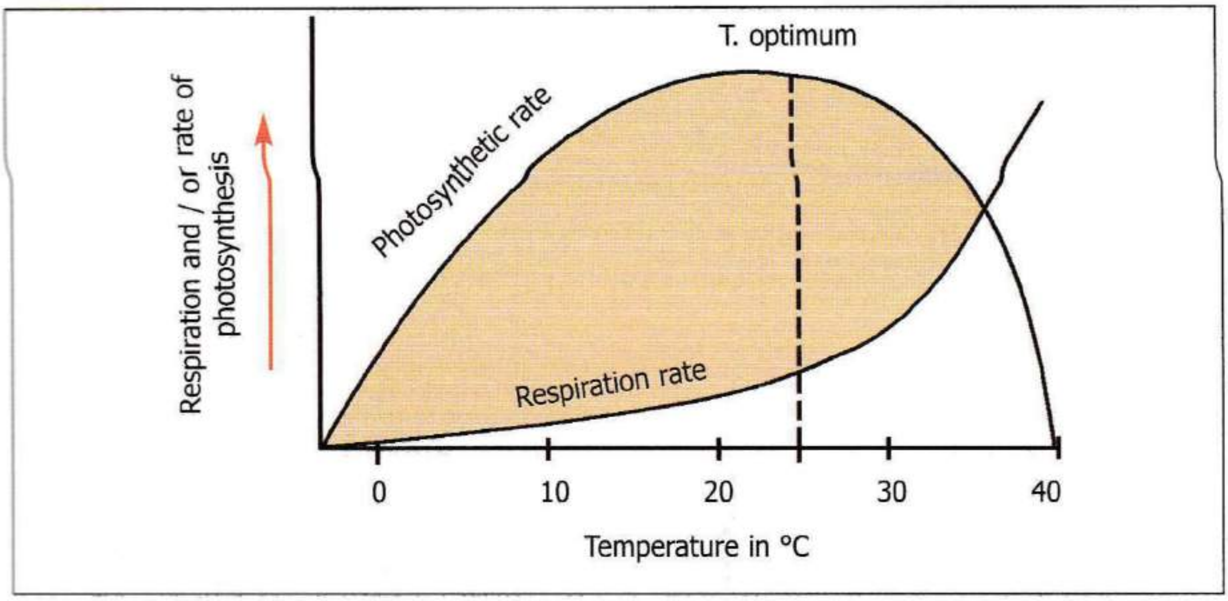


Figure 8.1 Influence of temperature on photosynthesis of plants in general (Van Rensburg, 2003).

T ≈ -5 °C:	Photosynthesis stops totally
T ≈ 10°C:	Poor photosynthesis takes place in clivia
T = 15 - 25 °C:	Active photosynthesis and clivia grows strongly/ luxuriant
T ≈ 30 °C:	Photosynthesis decreases rapidly
T ≈ 40 °C:	Photosynthesis stops.

Thus, when summer T > 30 °C, we must lower the temperature by cooling and avoiding direct sunlight to allow the plant to recuperate. Keep clivia warm in the winter and increase the amount of light to promote growth, flower and fruit formation of the plant.

8.3. INFLUENCE OF DAY AND NIGHT TEMPERATURE ON GROWTH OF CLIVIA

We have to create a difference in day and night temperature (Xue *et. al.* 1999. and Wen-Chang, 2002) for clivia to grow well. Suitable temperature differences (Table 8.3) ensure that the leaves will grow long, wide, thick, strong, straight and the development of the inflorescence and flowering is also promoted.

Table 8.3. Suitable day and night temperatures for clivia during different seasons (Wen-Chang, 2002)

Season	Spring	Summer	Autumn	Winter
Day T (°C)	15-20	20-25	18-20	15-20
Night T (°C)	10-15	15-20	12-15	10-12

If the temperature difference is small, inflorescence and flower development is retarded and the plant may not even flower.

Reason: If the temperature is high during the day the photosynthesis rate is high and large amounts of organic compounds are formed. If the temperature drops during the night the metabolism slows down, respiration and evaporation are slow and the use of nutrients and energy is low. Thus a larger amount of nutrients, produced during the day, can be stored so that sufficient nutrients will be available for the differentiation and development of reproductive organs and the plant will produce more flowers and fruit.

Day and Night temperature ≈ 20 °C: Although the ideal temperature for growth, the plant will grow poorly. Nutrients produced during the day will be used up at night and there will not be sufficient for the growth and development stage of the flowers.

High night temperature (> 25 °C): Means high respiration that uses up most of the nutrients, leaving the plant to grow poorly and produce no flowers or fruit – even after four to five years.

We must ensure a certain temperature difference between day and night temperatures.

8.4 SAFE WINTERING OF CLIVIA

Suitable soil temperature is 12-15 °C:

At this temperature nutrient decomposition by micro-organisms in the ground as well as lifespan and absorption of rootlet is optimized.

8.5 TEMPERATURE CONTROL IN SUMMER

Temperature lowering is important during hot summers. A cool ventilated environment can be created as follows:

- Erect a shade house with at least 50 % shade, depending on latitude.
- A vine bower or the shade of a tree lowers the temperature with 5 - 10 °C and has good ventilation.
- Water:
    1. If T > 25 °C, spray water on the walls and floor around the pots. This increases the humidity and lowers temperature or
    2. Build a shallow pool, place a wooden plank over it and place the pots on the plank or
    3. Provide a layer of damp sand or sawdust on the floor.

8.6 INFLUENCE OF LIGHT ON THE GROWTH OF CLIVIA

For normal growth clivias do not need a fixed length of daylight per day (De Smedt, *et. al.*, 1996). At a suitable temperature clivia will flower normally immaterial of the length of daylight received per day. The short winter and spring daylight is suitable for flowering. Sufficient daylight ensures larger and more colourful flowers. If the light is insufficient the leaves will become thinner, lusterless, flowering is retarded and the result is a lighter coloured flower.

Like other green plants, the clivias are also phototropic. If the plant is placed facing the same direction for a long time, the leaves will get distorted by growing towards the light. It is necessary therefore, to face the plant towards the sunlight and turn it 180° every 7 - 10 days to allow the leaves to grow evenly.

8.7 LIGHT REQUIREMENTS

The light requirement of clivias (Xue *et. al.* 1999) varies with the growing stages

Seed germinating: No light required

Seedlings: About six hours daylight per day

Full-grown plants: About eight hours daylight in the spring, autumn and winter and in the summer two to three hours daylight per day will be sufficient.

Too much light influences the development of the inflorescence. After appearance of the inflorescence clivia may be exposed to more light. In flower, one to two hours of light ensures that the flower lasts longer.

If placed in a too dark room for clivia, light may be compensated for by using a lamp with a 25 W red globe or a daylight globe, 0,3 - 0,7 m away from the plant or make use of grow lux tubes.

CHAPTER 9

The nutrition of clivia

9.1 TRANSPIRATION AND NUTRITION

Transpiration is the process of water loss in the form of water vapor through the stomata. The rate of transpiration by the leaves is directly related to the rate water and nutrients flow from the roots to the leaves and the opening (aperture size) of the stomata. Factors affecting transpiration rate and the opening of stomata are water content of the guard cells, relative humidity of the surrounding air, light, temperature and wind. Due to transpiration or water loss through the stomata during the day when stomata are open, there is a flow of water from the soil water solution, through the roots to the leaves then through the stomata to the atmosphere. This water flow, known as the 'transpiration stream', is also responsible for transporting the nutrient ions from the substrate to the leaves. The two processes transpiration and photosynthesis and their relation with stomatal function, are crucial for the nutrition of clivia plants.

Plant cells are live units and need oxygen to respire or 'breathe'. Leaves obtain their oxygen through the stomata (Figure 9.1) whilst roots get their oxygen from the substrate, either directly from the air-filled pores in the substrate or from the soil water containing dissolved oxygen. Roots, therefore, need a well-aerated growing medium to function optimally and even more so in the case of clivia plants having roots with a velamen (an external layer of absorbent cells).

9.2 FOLIAR FEEDING

Except for the uptake of nutrients by the roots, plants can also take up nutrients through the leaf cuticle, which is much thinner on the underside of the leaf than on the top surface (Figure 9.1). In younger leaves the cuticles are relatively thin, and nutrients applied as a leaf spray, can be taken up more readily than in older leaves with much thicker cuticles. Like any other living organism, leaves have a limited life span and if they are getting too old, the stomata, which are found on the underside only, are covered (blocked) by the thickening cuticle resulting in loss of function, followed by senescence and death.

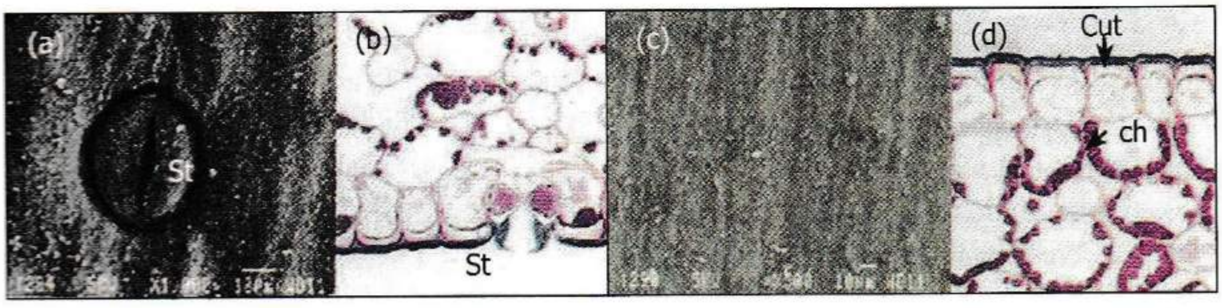


Figure 9.1 (a): Surface view of lower epidermis of clivia leaf showing stomatal ledge (St) of sunken stoma. (b): A sub axial cross section of the lower (absial) part of the leaf showing thick cuticle, structure of stoma and intercellular spaces between mesophyll cells. (c): Surface view and (d): cross section of upper surface of clivia leaf, showing absence of stoma, thick cuticle (cut) and mesophyll cells packed with chloroplasts (ch).

9.3 APPLICATION OF FERTILIZERS IN THE CULTIVATION OF CLIVIA

The production of any harvest is based on changing radiation energy from the sun into usable chemical energy such as sugars and starch. Photosynthesis is the primary process in the plant by which this is accomplished. During photosynthesis the green chlorophyll pigment in the plant absorbs radiation energy that is then used to let carbon dioxide from the air react with water to form simple sugars. The elements carbon, (C), hydrogen, (H), and oxygen, (O), make up 90 - 95 % of the dried mass of plants. Although indispensable, nitrogen, (N), phosphorous, (P), potassium, (K) and other macro- and microelements contribute only about 5 - 10 % to the plant mass.

In essence, we manage the photosynthesis process with nutrients. The growth results under certain conditions depend on

- Size of the leaf factory;
- production time, and efficiency of the factory.

These properties are measurable and manipulable in practice. All practices aim to optimise these properties.

9.4 PLANT NUTRIENT UPTAKE

To be absorbed, plant nutrients in the soil must be in direct contact with the roots.

9.4.1 Plant nutrient movement

The following mechanisms through which nutrients could reach the plant roots exist:

Contact uptake, when roots are in direct contact with nutrient elements dissolved in water.

Mass flow occurs when nutrient substances in solution move to the root. The uptake of water causes a lowering in soil moisture in the region of the root. This causes a continuous replacement of the water in the direction of the plant root. The movement of dissolved nutrients to the root in this stream is known as mass flow.

Diffusion causes, as the plant takes up the nutrients, a concentration gradient and the nutrients move from a higher to a lower concentration region and thus towards the root zone. Bear in mind that roots occupy a very small volume of the total soil volume and therefore roots come in contact with only a small portion of the nutrients. Roots are to an extend chemothropic, but mass flow and diffusion play an important role in the up take of nutrients.

9.4.2 Mechanism for the uptake of nutrients

There are two principle mechanisms for the absorption of nutrients namely:

Passive uptake: Where nutrients in the soil solution move into the root by diffusion. This process requires no metabolic energy.

Active uptake or absorption comprises the absorption of nutrients at a concentration gradient. Ions couple outside the cell membrane to "carriers". The two then move together through the semi permeable cell membrane. The carrier and ion separate inside the cell membrane and the carrier moves back to the outside of the cell membrane where it will again couple to an ion and the process is repeated. Metabolic energy is needed for this process. Some carriers are ion specific.

9.5 PLANT NUTRIENT ELEMENTS

The "structural elements" carbon, hydrogen and oxygen are the building blocs of numerous organic compounds existing in plants and contribute to a large extent to the biomass and life and growth processes of the plant.

The mineral elements present in smaller quantities are essential for many of the functions of the organic compounds as part of the structure or have a specific stimulating or regulating role in the plant's processes.

Table 9.1 Function and symptoms of deficiency of some macro and micro nutrient elements in plants.

DEFICIENT NUTRIENT	FUNCTIONS OF ELEMENT	SYMPTOMS OF DEFICIENCY
	Macro elements	
Nitrogen N	Present in most substances of cells.	Plants grow poorly and are light green in colour. The older leaves turn yellow or light brown and the stems are short and slender.
Phosphorus P	Present in DNA, RNA, phospholipids (membranes), ADP, ATP, etc.	Plants grow poorly and the leaves are bluish-green with purple tints. Older leaves sometimes turn light bronze with purple or brown spots. Shoots are short and thin, upright, and spindly.
Potassium K	Acts as a catalyst of many reactions.	Plants have thin shoots, which in severe cases show dieback. Older leaves show chlorosis with browning of the tips, scorching of the margins, and many brown spots usually near the margins. Fleshy tissues show end necrosis.
Magnesium Mg	Present in chlorophyll and is part of many enzymes	First the older, then the younger leaves become mottled or chlorotic, then reddish. Sometimes necrotic spots appear. The tips and margins of leaves may turn upward and the leaves appear cupped. Leaves may drop off.
Calcium Ca	Regulates the permeability of membranes. Forms salts with pectins. Affects activity of many enzymes.	Young leaves become distorted, with their tips hooked back and the margins curled. Leaves may be irregular in shape and ragged with brown scorching or spotting. Terminal buds finally die. The plants have poor bare root systems. Causes blossom end rot of many fruits, especially tomatoes.
Sulfur S	Present in some amino acids and coenzymes.	Young leaves are pale green or light yellow without any spots. The symptoms resemble those of nitrogen deficiency.

Table 9.1 *continued*

DEFICIENT NUTRIENT	FUNCTIONS OF ELEMENT	SYMPTOMS OF DEFICIENCY
	Micro elements	
Boron B	Affects translocation of sugars and utilization of calcium in cell wall formation. **Essential for pollen tube growth.**	The bases of young leaves of terminal buds become light green and finally break down. Stems and leaves become distorted. Plants are stunted. Fruit, fleshy roots or stems, etc., may crack on the surface and/or rot in the center. Causes many plant diseases, e.g., heart rot of sugar beets, brown heart of turnips, browning or hollow stem of cauliflower, cracked stem of celery, corky spot, dieback and rosette of apples, hard fruit of citrus, top sickness of tobacco. **Poor fruit and seed set in clivia.**
Iron Fe	Is a catalyst of chlorophyll synthesis; part of many enzymes.	Young leaves become severely chlorotic, but their main veins remain characteristically green. Sometimes brown spots develop. Part of or entire leaves may dry. Leaves may be shed.
Zinc Zn	Is part of enzymes involved in auxin synthesis and in oxidation of sugars.	Leaves show interveinal chlorosis. Later they become necrotic and show purple pigmentation. Leaves are few and small, internodes are short and shoots form rosettes, and fruit production is low. Leaves are shed progressively from base to tip.
Copper Cu	Is part of many oxidative enzymes.	Tips of young leaves of cereals wither and their margins become chlorotic. Leaves may fail to unroll and tend to appear wilted. Heading is reduced and the heads are dwarfed and distorted. Citrus, pome, and stone fruits show dieback of twigs in the summer, burning of leaf margins, chlorosis, rosetting, etc. Vegetable crops fail to grow.
Manganese Mn	Is part of many enzymes of respiration, photosynthesis, and nitrogen utilization.	Leaves become chlorotic but their smallest veins remain green and produce a checked effect. Necrotic spots may appear scattered on the leaf. Severely affected leaves turn brown and wither.
Molybdenum Mo	Is an essential component of the nitrate reductase enzyme.	Melons, and probably other plants, exhibit severe yellowing and stunting and they fail to set fruit.

9.6 ACIDITY AND ALKALINITY

Soils are acid, neutral or alkaline. This has a bearing on the hydrogen ion concentration in the soil and is measured as pH. The pH scale ranges from 1 (extremely acid) to 14 (extremely alkaline) and a value of 7 is neutral. The pH range of garden soil is 5.5 to 7.

Very low and very high pH damage plant roots while slightly less low or high pH can also decrease plant growth through effects on

- absorption and availability of nutrients to plants (Figure 9.2);
- amounts of nutrients held in soils;
- toxicities by nutrients and
- microorganisms.

The optimum pH range for organic potting media is something like 0.5 to 1 pH units lower than for soils (Figure 9.2). The availability of the trace element iron to plants in organic media decreases markedly as pH is increased, until it is very low at pH 9.5.

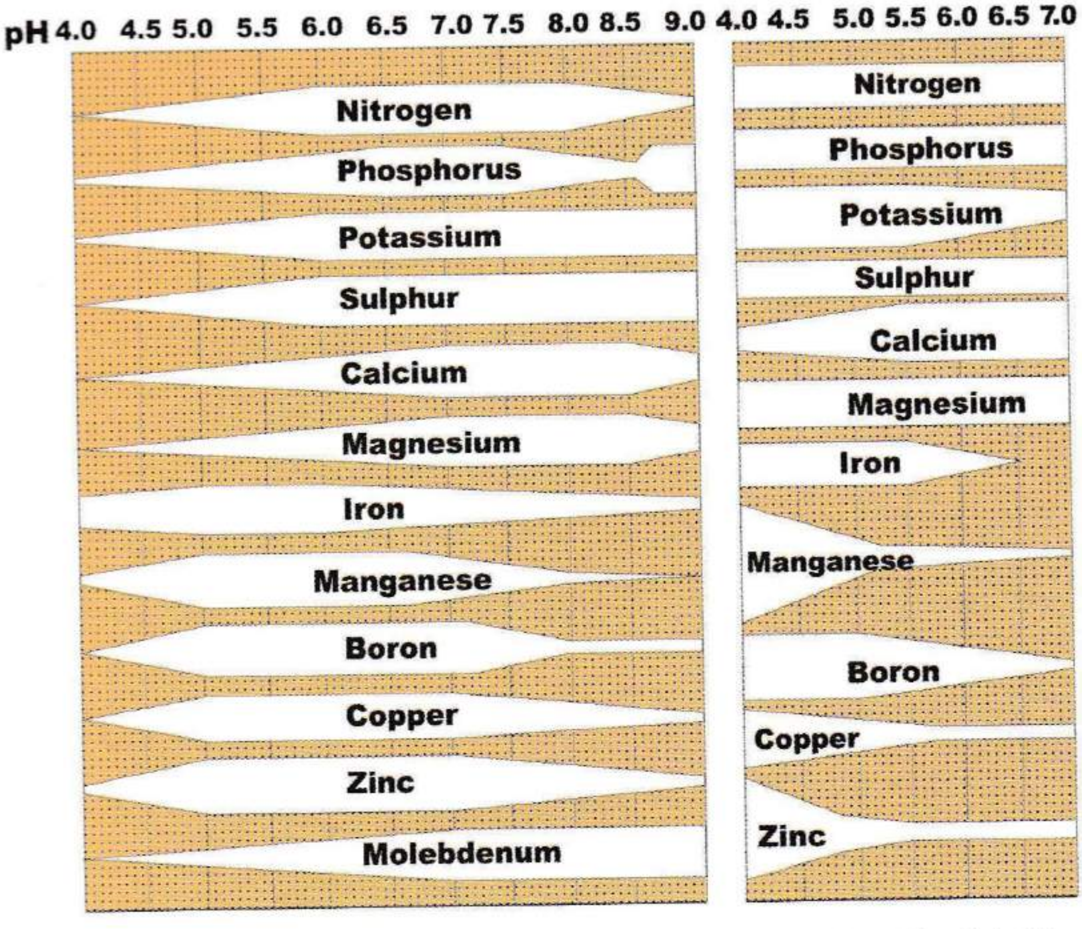


Figure 9.2 Left: The availability to plants of nutrient elements varies with pH in this manner in mineral soils. The wider the white bar, the greater the availability. Right: The availability to plants of nutrient elements in organic potting mixes varies with pH in this manner (Handreck and Black, 2002).

In organic media the pH may become very low resulting in the likeliness of manganese and iron becoming available in toxic amounts. If the pH gets too high manganese and iron will not be available to the plant resulting in the emergence of white young leaves, because of the inability of the plant to synthesize chlorophyll in the absence of these elements (Figure 9.3). By treating the young plants with a foliar spray consisting of 10 g iron chelate plus 2,0 g manganese chelate dissolved in 10 ℓ water the white leaves may turn green or any new leaves formed will be green again. Rectify the pH of the growing medium.

Figure 9.3 Absence of chlorophyll possibly due to iron and manganese deficiency.

If the water used contains more than 0.5 $mg\ell^{-1}$ boron, boron toxicity may be produced by use of fertilizers containing boron. Deficiency in boron result in poor fruit and seed set in clivia.

Irrigation with water caught on a galvanized roof or water stored in galvanized tanks can produce zinc toxicity if the pH drops to 5 and below.

All beneficial as well as pathogenic micro-organisms have a pH range in which they survive and grow best. Diseases cannot be controlled by pH.

The pH of growing medium can be altered through certain factors and actions as listed in Table 9.2.

Table 9.2 Factors that can change the pH of a growing medium

Factors that make it more alkaline	Factors that make it more acid
Watering with hard alkaline water.	Repeated use of fertilizer rich in ammonium salts.
Drift of lime rich dust.	Heavy acid fallout in urban/ industrial areas.
Builders leaving mortar residue behind.	Overwatering and excessive leaching with soft water especially in hot areas.
Watering with laundry effluent or septic tank effluent containing laundry detergent residues.	Repeated use of the same fertilizers (makes it either more acid or no change).
Disposal of ash and incinerator ash on garden soils	Repeated removal of plants tops (leaves, etc.).
	Applying mud from the bottom of lakes and dams.

9.7 MEASURING THE pH OF GROWING MEDIA

The more accurate measurement of pH is by means of a pH-meter following a standardized sampling technique of the growing mix. The clivia grower can conduct a simple test to get an indication of the pH of the growing mix by following the following procedure.

Pour-through technique for mix in pots

This technique (Handreck and Black, 2002) is widely used as a quick and non-destructive method of determining the pH of mix in pots. It is less accurate but is good enough for many practical situations.

Two hours after a normal irrigation, select several pots from a batch for testing.

Suspend each pot over a saucer or dish of a diameter that is a little larger than that of the base of the pot.

Pour onto the surface of the pot a volume of water that gives about 50 mℓ of drainage. Do this slowly, so as to allow time for the added water to move through the mix to displace some of the water already there.

Remove the pot and determine the pH of the drainage water with the aid of a pH meter or dyes such as those used to determine the pH of your swimming pool.

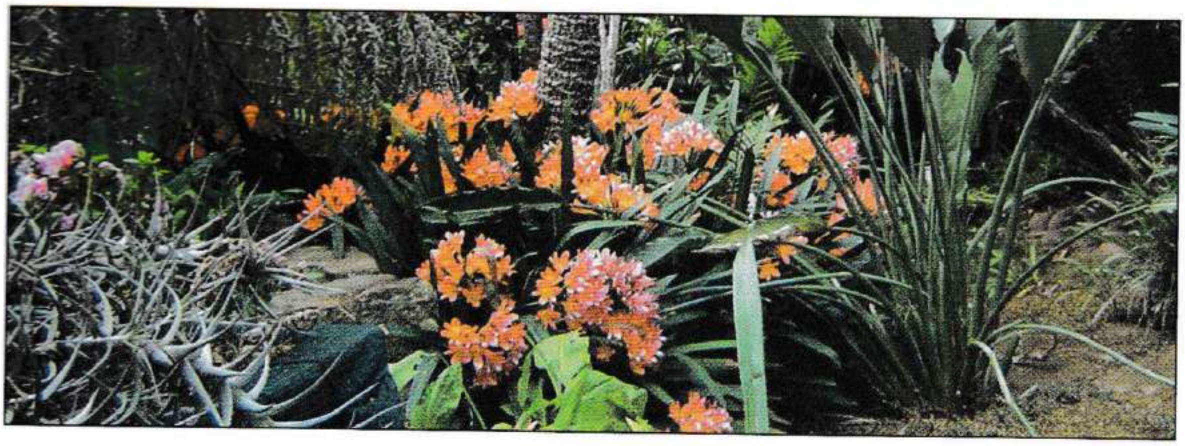
9.8 FERTILIZER REQUIREMENTS OF CLIVIA

A clivia plant (one stem) produces about 100 g dry matter per year as old leaves, inflorescence and seed. This means the plant looses about 3,3 g inorganic elements (expressed as nitrogen phosphorus and potassium) at a ratio of 7:1:5 per year. To replenish this loss nitrogen application can be divided into three as it leaches out easily and if applied in a single application will burn the roots. Fertilize with 3 g (0,5 teaspoon) of a 3:1:5 fertilizer per year per plant (stem) and then followed up twice a year with 3 g ammonium sulphate to supply extra nitrogen. Phosphate does not leach out easily, but because of the regular watering of pot plants a 1 g potassium nitrate application twice a year to replenish leached out potassium, should be applied.

Clivia may be planted in an inert growing medium without any nutrients. A commercially available balanced nutrient solution should then be used. You may try out the so-called "Hoagland" solution (Table 9.2). Six stock solutions are prepared of which aliquots are used to prepare a dilute solution with which the plants are then watered.

Table 9.2. Hoagland's Nutrients solution

Stock solution no	Inorganic salt	Number of gram per litre water	Aliquot solution (mℓ) of each to be combined and diluted to one litre with water and use on plants
	A. Macro elements		
1	Potassiumdihydrogen phosphate KH_2PO_4	139.1	1
2	Potassium nitrate KNO_3	101.1	5
3	Calcium nitrate $Ca(NO_3)_2$	239.2	5
4	Magnesium sulphate $MgSO_4.7H_2O$	149.5	2
5	**B. Micro-elements (prepare only one litre stock solution containing all five salts)**		1 (of solution no 5)
	Boric acid H_3BO_3	2.36	
	Manganese chloride $MnCl_2.4H_2O$	1.18	
	Zinc sulphate $ZnSO_4.7H_2O$	0.22	
	Copper sulphate $CuSO_4.5H_2O$	0.08	
	Molybdic acid $H_2MoO_4.2H_2O$	0.02	
6	**C. Chelated Iron FeEDTA**	5% solution	1

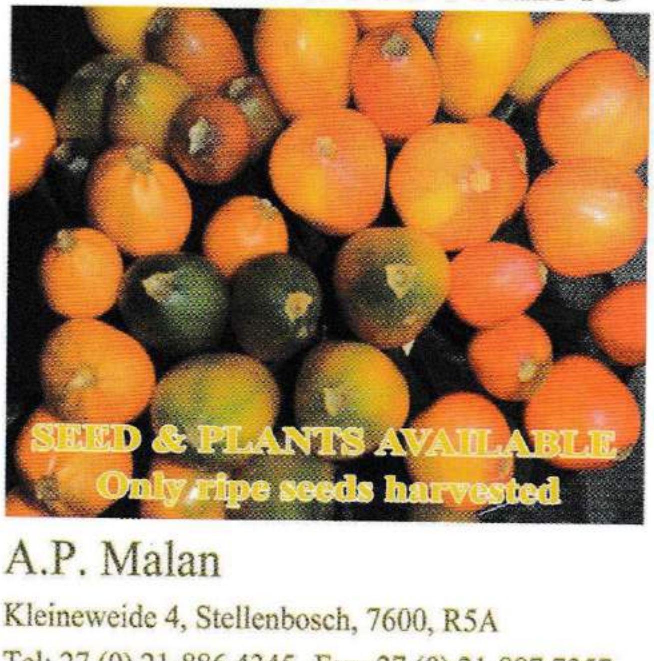


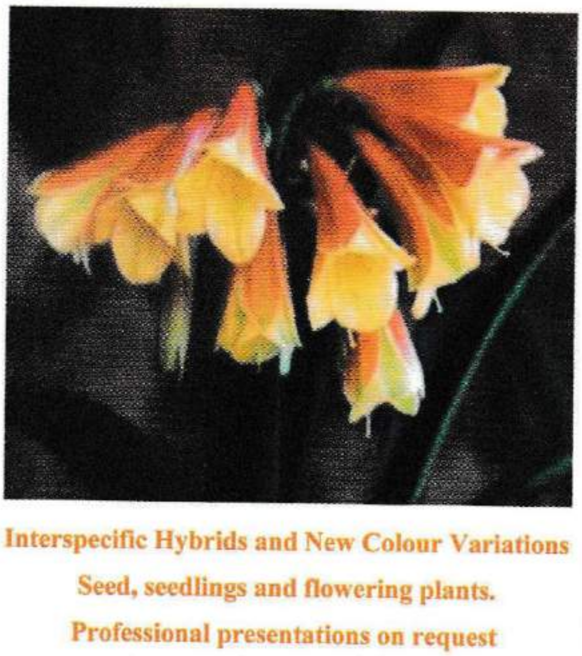
9.9 FERTILIZER PROGAMMES

Pat Gore fertilizes his plants twice a year with Osmocote or Plant Cote. He applies about half a teaspoon per plant in October (April; northern hemisphere) and again in April (October, northern hemisphere). He also applies foliar feed monthly - Nitrosol or Multi Feed or Kelp.

Norman Weitz fertilizes his plants monthly. October to December (April to June; northern hemisphere) with 3:2:1 (3 parts nitrogen, 2 parts phosphorus and one part potassium), January to March (July to September; northern hemisphere) with 2:3:2 and March to April (September to October; northern hemisphere) with 3:1:5. If a liquid mixture is used spray it on the leaves as well as on the roots.

André Calitz feeds his clivias once a month either through the root system or the leaves.





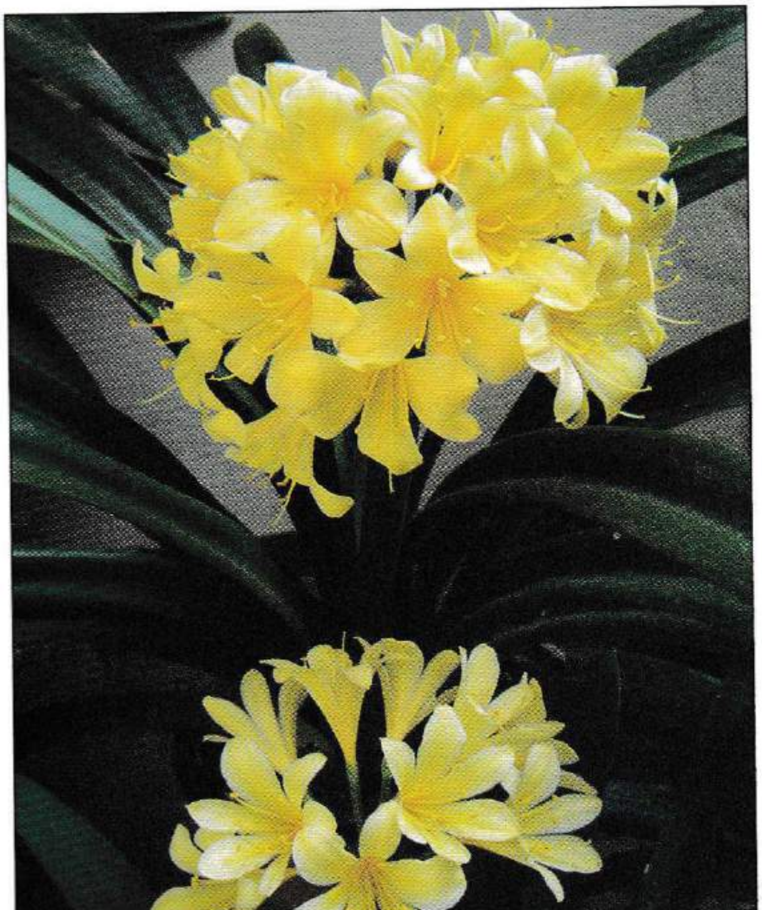
CHAPTER 10

Watering

Water losses from a medium in which plants are growing is partly by evaporation from the surface of the medium and partly by transpiration from the leaves of the plants and are often grouped together as evapotranspiration.

In warm to hot weather, water is unable to travel fast enough from roots to leaves to keep up with the transpiration rate. This happens even when the growing medium has ample water in it. After a while the plants begin to protect themselves by beginning to shut their stomata. Being drought tolerant clivia has an excellent ability to keep the rate of water loss at the same level as the rate of arrival from below.

As plants continue to remove water from a medium, the rate of flow of water to roots decreases, further limiting the amount of water available for transpiration. The total amount of water transpired by a plant is somewhere between 250 and 1000 g per g of dry matter produced. A poorly fed or diseased plant uses water less efficiently than does a healthy, adequately fed plant under the same conditions.



10.1 GROWTH AND WATER SUPPLY

Poor water supply result in closing of stomata in the leaves and thereby restricting or completely shutting off the exit of water through the stomata so as to bring losses more in line with the ability of the plant to extract water from the medium. Photosynthesis decreases, and with it growth, because carbon dioxide is unable to move into the plant. Those who want rapid production of tall or wide leaves must ensure that their plants are never short of water.

The plant experiences water stress when the rate of movement of water into the roots is too low to keep pace with transpiration. A small amount of water stress can be beneficial to plants. Hardier plants can be produced if water and nutrients are carefully limited to a little below the amounts needed to produce lush growth, while plants grown with an abundance of all their requirements will be soft, perhaps lax, and will lack an ability to withstand environmental stress.

There are some critical stages of growth at which water stress has especially severe effects on plant growth. Water stress at any time reduces leaf size and number, and therefore quality of the foliage of the plants. Plants must be well watered during bud initiation and at flowering.

10.2 SOME BENEFITS OF WATER STRESS

Plants utilize their energy very efficiently. Hence they take water first from those parts of the growing medium from which it can be extracted with least effort. As these parts are dried, other parts are exploited. If the top part of the soil profile is always the wettest part – because of frequent shallow watering – it is the part from which the plant will get most of its water. That will also be the part in which most of its roots will be concentrated. If, on the other hand, water is applied deeply but infrequently, the roots will be forced to grow into and extract water from deeper in the profile.

Slight water stress may help to induce flowering. For example, many fruit trees need a short period of stress to enable them to produce flower buds. But continued water stress once the buds start developing will reduce yields.

10.3 USING WATER WISELY

Water is used wisely when the amount applied matches the needs of the plants being grown. If vigorous growth is needed, large amounts of water are needed; if growth can be minimal, little water need be applied. Precious water is wasted when more is applied than is needed to achieve the required growth rate. On the other hand, we defeat our aims if the amount of water applied is less than that needed to give the desired growth.

10.4 GENERAL COMMENTS

Match water applications to the level of growth needed.

Water infrequently and deeply. If the water is very saline, you will have to water frequently enough to maintain the salinity of the main root zone low enough to keep growth rate adequate.

Avoid using sprinklers in the heat of the day. Losses by evaporation and the cooling effect are high then. Also avoid watering in the evening in areas of high humidity. Allowing the leaves to remain wet overnight encourages attack by fungi. Rather, when ever possible, water early in the morning.

Reduce evaporation by mulching wherever possible.

This is for those who want maximum plant growth from minimum amounts of water. Plants receiving a balanced supply of nutrients produce more growth per unit of water applied than those that are less well fed. They may also use a little more water, but for each litre of water used they may produce as much as twice as much growth. There is a limit. If extra fertilizer does not increase growth, it will not increase the efficiency of water use. There is little point in irrigating plants that are supposed to grow fast if they lack nutrients.

On the other hand, fertilizing plants that do not need to grow much will only increase the amount of water they use. They will become tolerant of dry conditions.

Work out some likely watering frequencies based on

- the readily available water content of the mix;
- pot size; and
- a range of evaporation rates.

Apply only enough water to fill the reservoir of the pot and to give a small amount for leaching. The amount of leaching water will usually be 5-10% of total water applied, but could be a little more if the water used has a high electrical conductivity.

Group plants according to their water requirements. In other words, do not have plants and pots of different sizes in the one group.

When watering by hand, use a water breaker so that mix is not splashed out of the pot. Direct the water onto the mix, not over the foliage.

Losses of water by evaporation from the mix itself vary considerably from mix to mix. Mulching can save water.

Check automatic-watering systems frequently. Adjust them to suit changes in weather and plant needs.

Irrigating via capillary beds, drippers or by hand onto each pot is less wasteful of water than overhead sprinkling. Losses of nutrients from soluble fertilizer applied in the irrigation water will be less.

The fleshy roots of clivias can store a certain amount of water giving a strong capacity for resisting dry conditions. For example when we move a clivia from one place to another it will still be fine in 2-3 days even without soil. If under suitable management the time can be prolonged to a month or even longer.

Well or borehole water with high electrical conductivity or pH is unsuitable for watering clivia. If the temperature of the water is below 5 °C it will adversely influence root growth. Rather collect the water in a container and store it for 2 days before watering the plants so that the temperature of the water is closer to that of the pot soil and allow certain compounds of magnesium, iron and calcium to precipitate and settle to the bottom of the container and use the clear water for the plants.

10.5 WAYS TO DETERMINE GROWING MEDIUM WETNESS IN A POT

Look: To check if the soil in a pot is dry or not we can use our hands to dig into the top layer of soil. If it is still dry 1/3 down from the top of the soil, it means that the soil is dry. If only 1/5 of the top layer is dry, there is no need to irrigate. Withered leaves may not be caused by lack of water.

Knock: Use your fingers or any other hard object to gently knock on the side of the pot. A clear sound means that the soil is dry. A dull sound means that the soil is still wet enough.

Weight: We can use our hands to judge the weight of the pot. If it is lighter than it was the time after watering, it means that the soil lacks water. This method requires experience.

André Calitz applies the principle that "the thicker the root the less water the plant needs". He waters his clivias every second week and sprays their leaves with water on "hot" days.

CHAPTER 11

Pests and diseases affecting clivia

Clivia (Henriette Stroh in Clivia Four, 2002) is regarded mostly as resilient, semi-hardy and drought resistant plants. They thrive under a variety of conditions, but eventually some will fall victim to a disfiguring or even fatal pest or disease. We need speedy and accurate identification of these pests and diseases in order to minimise severe setbacks in our growing program or even the tragic loss of a rare or unusual cultivar.

11.1 GENERAL REMARKS

As many growers are in need of both nursery and agricultural chemicals, only the active ingredients will be mentioned in Tables 11.1 and 11.2. Read, as well as comprehend, the instruction leaflets included with all the chemicals. By not applying chemicals during the heat of the day and not mixing different chemicals you can avoid the very real danger of burning your plants. Henriette does not recommend 'cocktails' because the different chemical substances in the formulations might have a reaction and cause damage to plants or have no effect at all e.g. the particles of a wettable powder form an emulsion that precipitates, if mixed with a liquid chemical. Chemicals may only be mixed if the label indicates compatibility with certain other chemicals. The use of any other chemicals after a copper containing spray has been administered should not be attempted before at least 7 to 10 days have passed.

Be aware of the dangers of chemicals – most are toxic. The toxicity of a chemical is expressed as its LD_{50} value. (Lethal Dosage is the amount of chemical needed in $mg.kg^{-1}$ body mass, which will kill off 50% of a population of test animals). The smaller the LD_{50} value the more toxic the chemical. Take note of the colour-coded labels indicating toxicity of the content.

11.2 PESTS

A pest is an animal that causes damage to plants. The smallest (nematodes) to the biggest (mammals) contribute at least a few pests, but the insects as a group outweighs all others in importance (Table 11.1).

11.2.1 Rodents

Clivia fruit are a delicacy to rodents and although they do not eat the seed, they have no qualms about carrying the berry away for later consumption and thereby hiding your precious seed forever. Use rodent bait as a control in late winter when the normal food source of rodents is low. This is normally the time for berries to ripen as well.

11.2.2 Insects

Insects can be identified by the naked eye and controlled in time to prevent devastation. Of all the different insects only the few that are troublesome, as pests on plants, have to be controlled in a corrective manner by treating affected plants with visible damage. The whole garden should not be sprayed because a lot of beneficial insects will also die in the process.

Insect pests are divided into biting, sucking and chewing insects, whereas the insecticides are divided into stomach, contact and systemic insecticides. The choice of the correct insecticide will depend on the size and eating habits (sucking or biting or chewing) of the insect, which needs to be controlled. Insects, which are controlled by means of a contact or stomach insecticide, will have to come in contact with the insecticide before they are controlled. A systemic insecticide is absorbed by the plant and transported to all plant tissues and will poison the sucking and chewing insect wherever it may start to feed.

Remember that systemic insecticides are more concentrated than contact insecticides and only a small portion of the plant has to be sprayed not the whole plant.

11.2.3 Nematodes

Plant-parasitic nematodes are small 300 - 1000 µm organisms that feed on the sap contained within plant roots. All parts of the affected plants suffer to some extent if infested with nematodes showing signs of water and nutrition deficiency as well as lesions of entry or knobs were they habour. An association between nematodes and certain pathogens (Agios, 1997) may develop resulting in a combined pathogenic potential far greater than the sum of the damage either of the pathogens can produce individually. Nematode-fungus disease complexes are *Fusarium* wilt, *Pythium* damping off, *Rhizoctonia* and *Phytophthora* root rot. Better known are the interrelationships between nematodes and viruses. After feeding on virus-infected plants nematodes remain infective for periods of 2 - 4 months and sometimes even longer. The *Pratylenchus* species of nematodes is fairly common and is a large group of plant root parasites with a wide range of host plants. The water source (Sean Chubb in Clivia Four, 2002) and the sand/ soil mixed with the bark may be the origin of nematodes in growing media. Make sure that water used for irrigation is nematode free.

Table 11.1 Summary of pests affecting clivia

Pests	Plant symptoms	Notes	Control Active Ingredient
Lily borer, Amaryllis caterpillar, *Brithys pancratii*, Australian *Brithys crini*	Young yellow and black (or white and black) transverse striped larvae feed in groups and tunnel into the leaves. The larger larvae move to the base of the leaves and may feed on the meristem. Most active during the months of October to April, the summer growing season.	Squashed by hand. Indicator plants are *Crinum, Nerine,* etc. Use a systemic stomach pesticide	Cypermethrin Deltamethrin Trichlorfon Bifenthrin
Young Loopers Lily Caterpillar, *Spodoptera pieta*	Larvae are greenish caterpillars with pale longitudinal stripes, which skeletonize the leaves from the uppersides.	Squashed by hand. Use a systemic stomach pesticide	Cypermethrin Deltamethrin Trichlorfon

Table 11.1 *continued*

Leaf miners	The larvae of several species of small flies and moths tunnel between the upper and lower leaf surfaces (epidermis), disfiguring the leaves with their trails of blotches of dead tissue.	Squashed by hand. Use a systemic stomach pesticide.	Dichlorvos Omethoate Bifinthrin
Flies sciarid flies (fungus gnats) and other unidentified flies.	Their larvae cause damage to the soft new inner and unexposed leaves. Fungi and bacteria causing severe secondary infection can enter wounds caused by larvae. Fungus gnats flying or their small reddish-brown pupae on plants are attracted by rotting organic material but do not do serious harm to the plant itself but are secondary after being attracted by decay already present.	Use a contact insecticide	Mercaptothion Chlorpyrifos
Whiteflies (Blackflies)	The adults are 1-3 mm long sap-feeding insects covered in a white waxy powder. Some species have a dark gray covering - blackflies. Eggs are laid on the underside of leaves. The immature resemble tiny scale insects. Swarm when disturbed.	Troublesome in sheltered places and are often found attacking fuchsia plants. Suck sap, causing retarded growth, leaves turn yellow and drop. The holes pierced may lead to fungus attack. Destroy plant debris promptly. Apply as full cover spray when noticed, especially the underside of leaves; repeat every 3-4 days to break the life cycle.	Bifenthrin Cyfluthrin Cypermethrin Deltamethrin Permethrin
Snout Beetle	A disfiguring lacy effect of circular lesions on clivia leaves, flowers and fruit. The beetle is brown to charcoal, 10-25 mm in size with the head elongated to form a distinct snout and feeds at night. They promptly drop off the leaf at the slightest threat.	Biocontrol in the form of the little golden creeper mole or seeking it out with a strong hand-held light. Spraying late afternoon with a contact insecticide.	Mercaptothion Chlorpyrifos Fenitrothion Beta-cyfluthrin Dimethoate

Table 11.1 *continued*

Pests	Plant symptoms	Notes	Control Active Ingredient
Mealy Bug, Root Mealy Bug	These are small 3 mm, flat and oval shaped insects, adorned with a flock of waxy, white, powder-like threads. Closer examination reveals filaments around the edge of the body, with two distinct filaments at the rear of the body. They excrete honeydew and are therefore betrayed by the presence of ants. Mealy bugs cause severe damage during the warm summer months, targeting the tender new leaves. They will also gather in masses like cotton wool underneath the leaves and into the upper roots if left unchecked.	They transmit serious viral diseases or cause wounds for fungi and bacteria to enter. Indicator plants are the *Agapanthus* species. Root Mealy Bug is more resistant. The pot will need to be submerged in a solution of proprietary insecticide and to soak it for at least 10 minutes. Several treatments may be necessary at intervals of 7 to 14 days. Indoor plants: use methylated spirits and hand picking for control. Control ants.	Chlorpyrifos Mercaptothion Bifenthrin Cyfluthrin Cypermethrin Fenitrothion
Red spider mite	Red spider is not an entirely successful pest on clivia in South Africa, but may causes problems when the atmosphere is excessively hot and dry. They spin a fine silk web, in which they live, on the undersides of leaves.	Spray thoroughly using a systemic insecticide at 10 to 14 day intervals. Regular sponging of the leaves - particularly the undersides, will prevent recurrence.	Amitraz Chlorpyrifos Mercaptothion Oxydemeton-methyl Phenothrin/ Tetramethrin
Scale	Scale is a circular shape, 1-2 mm in diameter, reddish brown and easily observed. The nymphs are white. It attacks all parts of the host plant and its toxic saliva causes leaves to turn yellow and drop prematurely.	Scale is fairly resistant to many insecticides.	Chlorpyrifos Light mineral oil Mercaptothion Prothiofos Phenothrin / Tetramethrin
Slugs and snails	Love plants in well-watered areas. They rasp away from the underside of the leaves, leaving only some upper skin remaining, unlike the young loopers, which eat the leaf from above and find the buds on your show plants irresistible.	Slugs and snails may be lured out of hiding with a yeast-containing liquid such as beer.	Carbaryl and Metaldehyde

Table 11.1 *continued*

Grasshoppers	Grasshoppers eat the edges of the leaf. When they eat at the sides of new growth it causes deformities as the plant grows and can cause the plant to fan only to one side if it was eaten on that side. It takes the plant several seasons to recover to a good-looking plant again.	Catch them	Carbaryl
Nematodes Eelworms	Microscopic slender transparent worms in the soil. Attack roots causing lesions that make them susceptible to bacterial or fungus attack	Sterilize sand used in growing medium. Let contaminated water stand for two days to settle out eggs and worms.	Fenamifos Cadusafos

11.3 DISEASES

A disease is an impairment of normal function brought about as a result of infection of the tissues by a micro-organism – fungus, bacterium, virus, etc. – which is readily visible under a light microscope or other higher-magnification microscopy. Any organism that causes disease is called a pathogen.

Fungi, bacteria or viruses cause plant-disease by invading living plant tissue and damaging it. As it is very difficult to identify, only a plant pathologist in a well-equipped laboratory can make exact and reliable identification of the type of pathogen, because the symptoms differ from plant to plant under different environmental conditions. In contrast to insect pests, fungus/bacterial infections are best controlled preventatively. This means that plants should be sprayed as soon as environmental conditions are favourable for disease development.

Unlike single applications for the control of insect pests, spraying for fungal/bacterial diseases follows a program. The reason for the spraying program is to chemically cover any new growth as well as replenishing chemical levels on older leaves, which may have washed off. If it rains within 3 days of spraying you will have to spray again, especially if the plants have waxy leaves, as in clivia. Contact fungicides/bactericides are usually sprayed every 7 to 10 days, whereas systemic chemicals are sprayed every 14 days.

11.3.1 Fungi

A fungus (Buczacki, 2000) is a parasitic or non-parasitic organism, feeding heterotrophically, reproducing by sexual or asexual spores and usually forming hyphae. Feeding heterotrophically means that fungi cannot manufacture their own food, as plants do, by photosynthesis. They feed on existing organic matter alive or dead. A biotrophic (living cells as food source) fungus may under different circumstances be necrotrophic (kills living cells and use the dead tissue as food) or saprotrophic (uses dead organic matter as food source). Fungus infected plants debris should not lie around in the garden or greenhouse, but should be collected in plastic bags and discarded in a save way – do not put them on the compost heap - to prevent spreading their spores.

Moisture, optimum temperature and a nutritional environment are always necessary for fungal growth. Moisture is highly significant for all fungi, because their food are digested and absorbed in aqueous solution and it influences the availability of oxygen and carbon dioxide. Optimum temperature range is mostly between 15 - 30 °C. Relatively few disease-causing fungi are active during very hot and dry summers.

Fungi typically produce circular colonies as they spread out radially from a germinating spore as seen in "fairy rings" of toadstools.

11.3.2 Bacteria

Each bacterium (Buczacki, 2000) normally comprises a single microscopic cell, about 1 µm in diameter and bounded by a cell wall. All plant pathogenic forms are rod-shaped. Bacteria reproduce by dividing themselves in two and can multiply under warm conditions with incredible rapidity. Most bacteria are heterotrophic, live only on dead organic matter and are important organisms for bringing about decomposition and recycling. The few that feed on living tissues and cause plant diseases have the disadvantage that they are vulnerable to extremes of heat, cold and dryness. Bacteria are more significant as plant pathogens in warm, moist climates such as those found in the humid tropics. Bacteria are intensely destructive rot-causing pathogens. Prof. Mark Laing's guide in Clivia Yearbook 2 (2000) on how to deal with them is to be well heeded.

11.3.3 Viruses

Viruses are the most highly specialized of all pathogens, and they display the two extremes: a considerable number of viruses only affect one type of host plant while others, most notably cucumber mosaic virus, infect almost everything. Viruses are total parasites; they cannot survive permanently away from the living cells of their hosts. While in a cell, viruses usurp some of its functions resulting in distinct symptoms unlikely to be confused with effects of fungi, bacteria or pests. The overall effect of many virus diseases isn't a discrete symptom of any sort, but rather a slow and general debilitation, apparent to gardeners by a decline in plant performance. Viruses spread through the sap as it moves from one part of a plant to another.

Viruses spread by first, the systemic contamination of the host's tissues and the frequent passage of the contamination from parent to offspring means that the virus doesn't necessarily need to travel anywhere. If the parent is contaminated, the virus will probably already be present inside every plant 'from birth' and so any vegetative propagation will be a serious candidate for virus problems.

Secondly, some fungi and bacteria act as transmission vectors. Any creature in contact with infected plant sap will automatically collect virus. Virus infected sap-feeding insects, flying (or wind-blown) may spread virus fast. Spreading virus through the soil, which is rather slow and of short range, comes from nematodes.

The third method by which viruses can be transmitted originate from the handling or use of tools on virus-infected plants means that contaminated sap will unavoidably be picked up on fingers, secateurs or other implements. If these are brought in contact with the sap of healthy plants, transmission is unavoidable. Any commercial brand cigarettes (Buczacki, 2000) are contaminated with virus and smokers who then handle plants would be able to infect the plants with disease. The need for cleanliness and hygiene is clearly paramount in avoiding the spreading of viruses.

Table 11.2 Summary of diseases affecting clivia*

Disease causing organism	Plant symptoms	Notes	Control
		Fungi	
Rusts	Rusts caused by many different fungi account for reddish-brown or yellow pustules on the upper and lower sides of the leaves. They begin slowly, but multiply rapidly during favourable weather conditions.	They do reduce active growing area and thus photosynthesis. The weakened plant could be susceptible to aggressive rot-causing fungi and bacteria setting in as secondary and tertiary infections. At present rust-causing fungi are not well identified and preventative control measures are the best defense against them. In short, spray regularly.	Mancozeb Triforine Chlorothalonil Triazoles** Diphenoconazole (triazole) Dithiocarbamate
Leaf and stalk spot *Stagnospora curtisii*	These form visible, bright red to brown, sunken lesions on members of the *Amaryllis* family	This fungus has been suspected on clivia during extremely humid conditions. Do not confuse this with the tearing effect due to potassium deficiency.	Diphenoconazole (triazole)
Leaf dieback *Macrophoma agapanthii*	The leaves die back from the tips leaving pale brown, parchment-like and scalloped remains. The whole leaf eventually dies down to the plant base if untreated.	Apart from clivia others affected are *Haemanthus* and *Veltheimia* spp. The suggested action is to cut affected leaves back, well beyond the translucent area of infection. The wound must then be sealed using one of the fungicides	Flowers of sulphur Mancozeb Chlorothalonil Dithiocarbamate It is convenient to use Mycota™ foot powder and spray or Merthiolate™ spray.
Damp-off disease *Phytophthora, Pythium, Fusarium* and *Rhizoctonia*	These are the most aggressive fungi for the clivia grower that cause rot and 'dieback', and can lead to the loss of entire mature plants as well as seedlings. *Phytophthora* and *Pythium* are amongst the fastest and most destructive fungi known.	All four of these pathogens have been positively identified during an extremely wet and hot growing season. They are soil-borne but can also spread via contaminated water through splashing when watering	See individual fungus

Table 11.2 *continued*

Disease causing organism	Plant symptoms	Notes	Control
Pythium	*Pythium* is very troublesome in clivia seed and seedling trays. Infection starts initially slightly below the soil surface	Prevention is by sterilizing the seed, seedlings and growing medium with appropriate protective chemicals. Use systemic fungicides.	Mancozeb, Dicarboximide, Chlorothalonil Copper oxychloride Furalaxyl Propamocarb Phosphorous acid
Phytophthora	*Phytophthora* root rot is a slightly slower killer in adult plants. The leaves show slight symptoms of drought and starvation. Leaves turn a yellow green on outer leaves first in clivia and then the plant falls over. The roots are all soft due to root rot.	*Phytophthora* is active in warm wet conditions and favours badly drained growth medium and poor aeration. In this case the affected plant tissue is cut away and the clean surfaces treated with neat chlorothalonil. If what is left of the plant is then planted in clean sterilized filter sand new roots will soon emerge, resulting in a healthy plant again. Avoid planting in leaf mould collected under avocado trees. Open standing irrigation water could also be infected. Use systemic fungicides.	Furalaxyl Propamocarb Chlorothalonil Phosphorous acid
Rhizoctonia	*Rhizoctonia*-infected plant tissue has a watery appearance with tan to reddish brown lesions that will finally girdle the stem and cause young plants to fall over. Roots can still be firm. Although some visible symptoms could lead to confusion with the bacterial infection *Erwinia* it is not as fast, soft and mushy and lacks the characteristic foul odour.	It is often found among newly transplanted plants. Avoid over-potting, over-fertilizing, a wet, heavy medium or an incompletely decomposed medium can all contribute to heavy plant loss	Preventative treatment: Mancozeb Chlorothalonil Curative treatment: Benomyl Pencycuron Thiophanate methyl (benzimidazole) Carbendazim

Table 11.2 *continued*

Fusarium	*Fusarium* is a soil-borne pathogen causing root and basal stem rot in lilies. It is often recognised by its wilting effect, mainly in newly transplanted plants. It enters plants through wounds on injured roots or leaf bases.	Avoid contaminated growing medium, soil compaction, and excessive soil water because this is almost impossible to cure.	Only slightly curative chemical: Benomyl Preventative treatment: Dithiocarbamate Quaternary ammonium compounds
Sclerotium rolfsii (Collar rot)	*Sclerotium rolfsii*, referred to as collar rot, has been identified in China and locally. This is a very serious infection with almost no control. It is spread by water and infected growing medium.	High humidity and extremely high temperatures are preferred by this pathogen, which attacks plants near the soil level. The same treatment can be followed as that for *Phytophthora* root rot	Pencycuron** Cyprodinil/ fludioxonil Tolelofos methyl Dichlorophen
		Bacteria	
Erwinia carotovora	*Erwinia carotovora* is mostly secondary or tertiary in its occurrence and enters mostly through wounds or stomata – it is responsible for most crown and soft rots. The smell of putrefaction is rather obvious upon close examination.	The grower must remember that general fungicides have no remedial effect on bacterial infections. Good sanitation practice and sterilization is important.	Copper hydroxide Tetracycline
Pseudomonas Bacterial Blight	Pseudomonas causes bacterial leaf spot.	Good sanitation practice and sterilization is important	Copper hydroxide Tetracycline

* It is very important that a plant with a detected fungal or bacterial problem is kept dry during treatment.

** Do not use continually – not more than three consecutive applications.

Table 11.3 Chemicals registered for the control and combat of pests and diseases mentioned in this chapter

Active ingredients marked with (*) are systemic pesticides and marked with (#) are considered to be relative harmless to bees. All systemic fungicides inhibit growth (pencycuron is not so severe). Triazoles should not be administered on more than three consecutive times – distorted leaves result.

Active ingredient	Trade name	Manufacturer	Pests/ Diseases
Insects			
Amitraz*	Mitec Red Spidersprey Apivar	Aventis Wonder Szyndra	Red spider myte
Beta-cyfluthrin	Bullock	Bayer	Snout Beetle
Bifenthrin	Telstar Brigade	FMC FMC	Lily borer, Mealy Bug, Root Mealy Bug, White fly
Cadusafos	Rugby	FMC	Nematodes Eelworms
Carbaryl	Karbadust Stalkborer granules Carbasol	Dow, Efekto Kombat Efekto	Grasshoppers
Carbaryl and Metaldehyde	Slaklokaas Sluggem Pellets Snailban Snailflo	Kombat Orchard Suppliers Dow Efekto	Slugs and snails
Chlorpyrifos	Dursban Dursban 2E Chlorpyrifos Lirifos	Efekto Dow Efekto, Combat & Dow Plaaschem	Flies sciarid flies (fungus gnats). Snout Beetle, Mealy Bug, Root Mealy Bug, Red spider mite, Scale.
Cyfluthrin	Baysol Contact SpraBaysol RFU Baythroid	Bayer Bayer Bayer	Mealy Bug, Root Mealy Bug, White fly
Cypermethrin	Garden Ripcord Cypermethrin Polythrin Ripcord Sherpa	Efekto Argopharm, Dow Villa BASF Aventis	Lily borer, White fly, Mealy bug Root mealy bug
Deltamethrin	Deltamethrin Decis Forte Blue Death- garden and Home Insect Killer Garden Pests	Hyper, Almond Aventis Robertsons Home Care Kombat	Lily borer, Young loopers White fly

Table 11.3 *continued*

Dimethoate*	Insecticide granules Dimethoate Fetron	Efekto Combat, Hyper & Wenchem Plaaschem.	Snout Beetle
Fenamifos*	Nemacur	Bayer	Nematodes Eelworms
Fenitrothion	Fenitrothion Folithion Liquid Tracker Garden Insecticide	Dow Bayer Bayer	Snout Beetle, Mealy Bug, Root Mealy Bug
Light mineral oil	Oleum	Efekto	Scale
Mercaptothion	Avi-mercaptothion Kopthion Malathion Aviguard Datathion Garden Insects Malasol	Avima Dow Efekto Avima Kynoch Combat Efekto	Flies sciarid flies (fungus gnats), Snout Beetle, Mealy Bug, Root Mealy Bug, Red spider mite, Scale
Oxydemeton-methyl*	Metasystox R	Bayer	Red spider mite
Permethrin	Bio-Kill Garden Spray Coopex	Environmental Products Aventis	White fly
Phenothrin/ Tetramethrin	Garden Gun	Efekto	Red spider mite, Scale
Prothiofos#	Tokuthion	Bayer	Scale
Trichlorfon*	Dipterex Trichlorfon	Bayer Almond, Hyper & Dow	Lily borer, Young loopers
	Fungi		
Benomyl*#	Benlate	Du Pont	*Rhizoctonia* (curative), *Fusarium* (slightly curative)
Bithertanol (triazole)*	Baycor 300 EC	Bayer	Rusts
Calcium phosphonite (phosphorous acid)	Phytex 200 SL	Horticura cc	*Pythium, Phytophthora*
Carbendazim			*Rhizoctonia*
Chlorothalonil#	Bravo	Efekto	Rusts, leaf die back *Macrophoma agapanthii* *Pytium, Phytophthera* *Rhizoctonia* (preventative)

Table 11.3 *continued*

Active ingredient	Trade name	Manufacturer	Pests/ Diseases
Fungi			
Copper oxychloride	Kocide 2000 Virikop Copperoxychloride WP	Gouws & Scheepers Efekto Universal Crop Protection	*Pythium*
Cyprodinil/ Fludioxonil*	Switch	Novartis	*Botrytis* rot, most of the aggresive fungi
Dicarboximide	Captan	Agricura	*Pythium*
Dithiocarbamate	Zineb	Universal Crop Protection	Rusts, leaf die back *Fusarium* (preventative)
Dichlorophen	Xanbac D	Gouws & Scheepers	*Sclerotium rolfsii* Plant fall over
Diphenoconazole (triazole)*	Score 500 EC	Novartis	Rusts, leaf and stem rot *Stagnospora curtsii*
Flowers of sulphur	Wettable sulphur		Leaf dieback *Macrophoma agapanthii*
Furalaxyl*	Fongarid	Ciba-Geigy	*Pythium, Phytophthora*
Mancozeb#	Dithane Penncozeb Mancozeb Sancozeb	Efekto Aventis Cropchem & Kombat Dow	Rusts, leaf die back *Macrophoma agapanthii* *Pytium, Rhizoctonia* (preventative)
Methalaxyl (phenylamide)*#	Apron 35 SD	Novartis	*Pythium, Phytophthora* (seed treatment)
Pencycuron*	Monceren	Bayer	*Sclerotium rolfsii* (plant fall over) and most of the other aggressive fungi
Propamocarb*	Previcur N	AgrEvo South Africa	*Pythium,* *Phytophthora*
Quaternary ammonium Compounds	Spore Kill	Hygrotech, BHS Du Pont	*Fusarium*, and general agricultural disinfectant on surfaces
Tolelofos methyl	Rysolex		*Rhizoctonia* (curative), *Sclerotium rolfsii*

Table 11.3 *continued*

Thiophanate methyl (benzimidazole)	Applied Topsin Flo	Kynoch Agrochemicals	*Rhizoctonia* (curative) *Sclerotium rolfsii*
Triforine*#	Funginex	Efekto	Rusts
Zinc undecenoate/ Undecenoic acid	Mycota™ foot powder and spray or Methiolate™ spray	R & C Pharmaceuticals	Leaf dieback *Macrophoma agapanthii*
Bacteria			
Copper hydroxide#	Kocide 2000 Virikop Copperoxychloride WP	Gouws & Scheepers Efekto Universal Crop Protection	*Erwinia carotovora,* Pseudomonas Bacterial Blight
Tetracycline			*Erwinia carotovora, Pseudomonas* Bacterial Blight

11.4 PREVENTION

Accurate fungal and bacterial identification can only be achieved if a live sample is sent to a plant pathology laboratory. Knowledge of the exact pathogen responsible is very important for without this the marketing personnel and manufacturers of chemicals cannot give you accurate and cost-effective solutions to the cause of your nightmares. Clivia growers must be observant and sensitive to the slightest disorder amongst their plants when trying to decipher the code in the many symptoms. Try to photograph diseased plants in order to extend the database of visible symptoms, as reliable laboratory results could take up to two months. In the meantime, do take your control measures and counter measures.

Other factors involved in the control and prevention strategy are problems with growing conditions and culture disorders that can perpetuate bacteria and fungi situation.

Henriette Stroh recommends the following preventative measures in Clivia Four (2002):

Increasing the light intensity in order to grow stronger and more resistant plants.

A decrease in nitrogen fertilizer and an increase of potassium, magnesium and calcium results in more balanced plant growth.

Air movement is important – reducing air movement causes heat build-up e.g. 80% shade cloth is not conducive to good air movement if totally enclosed.

Another factor is the general tendency to find a convenient sheltered spot between the house and boundary wall or between outbuildings etc., where the air can be quite stagnant. Above all don't overcrowd plants. Benching with air below is better than on the floor.

Greenhouse hygiene is important: remove diseased plants immediately as well as dead leaves, as far away as possible is the rule, not outside the door or onto the compost heap.

Isolate infected debris in plastic bags and place it in your municipal waste bin to let it have a honourable burial away from your growing area.

Ensure that compost purchased is well 'composted' and aerated and be certain that it drains well enough. Sterilization before you purchase is imperative. Raw sawdust and bark should be avoided. To speed up the composting process, add a handful of calcium carbonate (lime) or dolomite and a handful of ammonium nitrate a year in advance. In this way essential calcium is also supplied. Unsuitable and raw medium is a major factor in plant loss.

Avoid adding too much fertilizer to new medium. Fresh bone meal when transplanting can be disastrous.

Avoid over-potting, the enormous effort of one more transplant is worth your while, as the large pot is only conducive to more moisture.

Avoid 'water drip' from one plant above another.

Environmentally stressful conditions to your plants should be avoided.

Protect your plants against changes in their ideal growing environment brought about by weather conditions – for example, use quaternary ammonium compounds (Spore Kill™) to protect them against fungi and bacteria in hot and humid conditions; use sharply draining potting media which do not retain water if they are exposed to rain.

Isolate all plants, which are being treated for fungal or bacterial infections and keep them very dry. This will accelerate their recovery from those infections, whereas it is very difficult to kill a clivia by giving it too little water!

Isolate newly acquired plants and treat with a quaternary ammonium compounds before placing in main growing area.

The practice followed by Ammie Grobler of dipping all plants during transplantation in a quaternary ammonium compounds solution and leaving them to dry off before replanting in a new growing medium and pot can save a lot of tears later.

All cuts made during the dividing process must be sealed with preventative chemicals.

11.5 GENERAL

Prepared pesticides should never be stored for longer than a day, after which they start breaking down and losing their efficacy.

Pesticides should never be discarded down drains as they cannot be removed from wastewater at wastewater plants and can cause serious pollution. Rather dig a hole in your backyard and pour it in there. The bacteria in the soil will break the chemicals down within six weeks.

It is worthwhile investing in a good pressure sprayer.

Jeyes Fluid™ is not recommended for use on plants. It is a general disinfectant containing a number of chemical substances, which are harmful to plants. The Jeyes Fluid used in the horticultural industry in the UK has a different chemical composition to that sold in South Africa.

Only use chemicals, which are marketed for the home gardener if living in an area demarcated as urban, this includes smallholdings within an urban area as well. Insecticides and fungicides for the agricultural sphere are more concentrated and will damage plants if not correctly diluted. It is also illegal to buy and use these in an urban area.

11.6 LETHAL FACTOR – ALBINISM

Although not a disease, the occurrence of the so-called lethal factor, which is a complete lack of chlorophyll and which results in the early death of seedlings among yellow and variegated *Clivia miniata*, is escalating and is now also reported from seedlings with pigmented bases. This is a genetic weakness. Some times, in the case of not true albinism, a higher survival rate is experienced after a treatment with $2g^{-1}$ magnesium sulphate solution applied weekly for a few weeks, because magnesium sulphate lowers the pH of the growing medium and is necessary for chlorophyll synthesis. Too high a pH (Figure 9.2) causes iron and manganese deficiencies, which may also lead to a deficiency of chlorophyll (paragraph 9.6) and be taken for albinism.

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Notes

CULTIVATION OF CLIVIAS

Ook in Afrikaans beskikbaar as KWEEK VAN CLIVIAS