CLIVIA

FOUR

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Mature flowerhead of *Clivia mirabilis*

EDITORS

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EDITORIAL

In Clivia 3 we alluded to the discovery of *Clivia mirabilis,* which is the mainspring of this Yearbook. We have all experienced *Clivia's* toughness, its 'never say die' approach to life, which the D.N.A. research has shown would have been inherited from this grandmother of all the *Clivia* species. So the already remarkable genetic diversity and versatility of *Clivia* and its horticultural potential have suddenly expanded beyond belief. The Nature Conservation authorities have taken the steps necessary to protect this new species vigorously, but arrangements are being made by them to ensure that the public will be able to obtain seed and / or seedlings, so that the ideal of 'conservation by propagation' may be realised.

All of us must surely also want to know how it came to be that the other species which evolved from this species now grow over *800km* away in climatic conditions which are dramatically different. Why are they not found in the wild within that *800km* vacuum, say at Knysna where the climate and forest environment are ideal? And why is there so little overlap between C. *caulescens* and C. *nobilis* with C. *gardenii* and C. *miniata* where there is no dramatic difference in the environment in which all of these four species grow in nature?

The research by the National Botanical Institute at Kirstenbosch up to now shows how C. *mirabilis* and the other species evolved on the *Clivia* family tree. That research is continuing, to date the evolution of each of the five species. We expect that to be established before the next Yearbook is published so that it can include an article by a paleobotanist, which will deal with these intriguing questions.

Further research will include investigation into the increasing number of variations being discovered within the C. *gardenii* complex. Most populations which have been visited grow in wet or swamp like conditions. That probably also holds true for the type specimen which Major Garden sent to Kew and which bares his name. The starting point for a proper understanding of the relationship between the various forms must be to fingerprint that type specimen which is now in the Herbarium at Kew.

We also mentioned in Clivia 3 that the Cape Clivia Club had contributed financially to that research. We have seen in this Yearbook how rewarding that research has been. We urge the Clivia Society and all its constituent Clubs to contribute generously to that research so that its momentum will be maintained.

In an article written in the 1930's and republished in Clivia 2, the late Gladys Blackbeard, who is the doyenne of *Clivia* growing in South Africa, advises on nutrition of *Clivia* that '[t]he secret of flowering is to rather starve your plants than overfeed ...when buds show, sprinkle round each plant a little well-decayed horse or cow manure'. Modern experience has shown however that *Clivia* respond well to more sophisticated nutrition and growing media. Consequently we have included a number of articles to guide *Clivia* enthusiasts on nutrients and potting mediums.

Many of us grow *Clivia* in conditions which may encourage pests and diseases. Valuable plants have been lost as a result, and Henriette Stroh has taken a lot of care to obtain good illustrations of these problems and valuable guidance on how to deal with them. What must be emphasized however is that new problems, especially with fungi and bacteria, arise continuously, and safer and more effective or natural means of combating problems are being found every year. Henriette has emphasized therefore that hers is an open-ended invitation to all *Clivia* growers to make available continuously for publication in the Yearbooks illustrations of new problems and how they have been solved. This should include good illustrations of virus infections on which an article is planned for the next Yearbook.

Bill Morris has guided us on the origins of peaches and pastels. Mendel has helped us to plan breeding programs, which will have predictably reliable results such as broad leaves or short leaves. However if, as we understand, it has been established that colour is inherited from genes found only in the pod parent, but that these genes can only express or show their colour under the control of nuclear genes inherited from both the pod and the pollen parent, how do we choose the right parents to produce the new colours we are all inspired to breed? We can select the broad-leaved plants which we planned to breed from year-old seelings, but is there any physical characteristic on which we can rely to predict the flower colour of year-old seedlings? For example, we now know that green stems can indicate not only yellow but also peach flower colour. And is there any relationship between the intensity of stem pigment and the flower colour as an indicator of pastel flower colour?

If colour is inherited from the pod parent, can we rely on this role of the pod parent to produce, for example, pink flowered offspring from a red flowered mother with a white throat if we use the right pollen? Are we wasting our time using red flowered pollen to produce red flowered offspring from an orange flowered pod parent? And why does a Group II Yellow such as 'Natal Yellow' pass on its yellow flower colour when crossed with 'Butter Yellow', but orange flower colour when crossed with virtually all other yellows? How does Mendel apply to the regulation of the colour genes inherited from the mother, which are not nuclear genes?

Most of us probably follow a hit and miss approach when breeding for colour and have to wait five years after pollination only to be disappointed too often by the flower colours produced. But we are sure that there are a few amongst us who can advise us on what guidelines to follow to be able to predict flower colours more reliably from our breeding. Won't they please come forward in the next Yearbook?

It is most appropriate that this Yearbook should deal primarily with the discovery of a new *Clivia* species just ten years after Nick Primich sought out those who shared his enthusiasm for *Clivia* and brought them together to found the Clivia Club. He stimulated a new interest in *Clivia*, particularly in South Africa. All of us who have benefited hugely from that initiative salute and thank him again. And we would also add our profound appreciation to the other honorary member of the Society, Yoshikazu Nakamura, for his most generous donations of seed, information and advice over these past ten years and in doing so, for opening our eyes to the potential of *Clivia*.

Finally we must thank all who have taken the time and trouble to prepare the articles which have made this publication possible. Please let no member feel that his or her contribution would be too small, so that we will have a wealth of knowledge and experience relating to *Clivia* for publication in the next Yearbook for the benefit of all of us.

An article on an old population of a C. m*iniata* x C. *caulescens* hybrid, found in the wild, has been deferred until next year for further research.

Cape Town, June 2002

The following abbreviations have been used, particularly in the captions to the photographs:

CC Cape Clivia Club
KZN KwaZulu-Natal Clivia Club
NC Northern Clivia Club

THE MIRACULOUS CLIVIA,

an astonishing new species from the arid Northern Cape

John Rourke

Dr Rourke is the Curator of the Compton Herbarium at Kirstenbosch National Botanical Garden.

Summary

The article discusses a new species of *Clivia* unlike any of the existing summer rainfall taxa in that it is a sun hardy winter growing species from the Northern Cape Province adapted to an arid mediterranean climate. It's tubular bicoloured flowers, orange and green tipped at first, becoming orange-red and yellow tipped later, are borne out on shiny orange-red pedicels. These coloured pedicels enhance the scape at flowering but abruptly change to green after pollination. The leaves have a prominent median white stripe on the upper surface.

Johannes Afrika, game guard at Oorlogskloof Nature Reserve who first drew attention to populations of C. *mirabilis* in the reserve.

Introduction

'John, you're interested in the systematics of Clivia, so I think you had better have a careful look at this/ said Dr Dee Snijman, a colleague of mine as she laid a pressed dried plant specimen on my lab workbench, one hot afternoon in January 2001. It was what appeared to be (and indeed was), a tubular-flowered *Clivia* but the locality given on the field ticket, 'Oorlogskloof, Nieuwoudtville', in the Northern Cape seemed totally absurd. We had become used to receiving unusual plant material for identification from Wessel Pretorius, Officer-in-Charge of the Oorlogskloof Nature Reserve, yet here was a specimen that defied logic. *Clivia* simply did not grow in the Northern Cape! Was this a diabolical hoax or a sensational discovery? To our delight the latter proved to be the

I showed the specimen to an equally dumbfounded John Winter, who has been building up a fine collection of wild-sourced Clivia material at Kirstenbosch. We both agreed: a personal site visit to view the plants *in situ* was essential, so as to establish the veracity of this record. By now it was February and even if the plants were in fruit and not yet in flower, we simply had to see them in their natural habitat.

After receiving a permit from the Northern Cape Department of Nature Conservation, to collect a few live specimens, we set off to meet Wessel Pretorius at Nieuwoudtville, popularly known as 'the bulb capital of the world'. February is not the best time to visit this delightful platteland dorp perched on the Bokkeveld escarpment between Van Rhynsdorp and Calvinia, renowned for the world's most spectacularly speciose display of indigenous bulbs in late winter and spring. As we drove down the dusty main street, with the air temperature at about 35°C, the sun beating relentlessly on shimmering corrugated iron roofs, I could not help feeling that other than the centre of the Sahara desert there could hardly be a more unlikely place to find a new species of *Clivia*. But the environs of Nieuwoudtville contain such a mosaic of geological systems, such a diversity of landforms, habitats and sheltered refugia, that a huge range of plant species with different ecological requirements find niches for themselves in this area.

Nieuwoudtville by the now seasonal flow (May - November) of the Oorlogskloof River. About half a kilometre wide and 200m deep the canyon is edged by a resistant capping of Peninsula Formation Sandstone cliffs. Some 4700*ha* in extent, Oorlogskloof reserve was established as recently as 1983. There is no public vehicular access although an excellent network of hiking trails has recently opened this rugged stretch of countryside to keen hikers, some of whom in all probability must have seen *Clivia mirabilis* in previous years without realising that it had not been described in scientific literature.

Oorlogskloof canyon, natural habitat of C. *mirabilis*

Next morning, we were peering over the eastern rim of Oorlogskloof, one of these refugia that has enabled moisture-loving plants to survive in an otherwise hostile environment. Oorlogskloof is a spectacular canyon incised through the Bokkeveld escarpment just west of the town of

As the sandstone cliff faces have weathered and crumbled over the millenia, tallus screes have formed below them, creating a habitat for sparse patches of low, light woodland. It is here on the eastern margin of the canyon that *Clivia mirabilis* makes its home.

Wessel Pretorius with C. *mirabilis* in the natural habitat

Even as Wessel Pretorius guided us down the krans on the morning of 20th February 2001, I could see groups of *Clivia* plants among the huge boulders below. The first thing that struck me was that about half were in full sun, the remainder in very light shade under a sparse tree cover. Clearly this was not only a drought resistant species but one that could take a 6 month roasting under the brutal northern Cape sun with little if any sign of leaf damage.

The leaves of C. *mirabilis* showing median leaf striation and variation in range of leaf tips

The leaves were also unusual. Each possessed a prominent white stripe down the middle on the upper surface. (Some populations of *Clivia nobilis* also have a median white stripe on their leaves, but nothing as prominent as the Oorlogskloof plants). Moreover, the leaf bases were deeply pigmented in rich purple-carmine hues. Several plants bore fruiting heads. The berries were already turning from green through yellow to red, and would be ripe within a couple of weeks. Now there was no doubt in my mind. Although we had not yet seen flowering specimens, we were in the presence of a previously unknown species of *Clivia,* growing in a hitherto inaccessible almost virgin habitat, scarcely touched by the hand of man. Most surprising of all, nearly 800*km* of karroid semi-desert separated this species from its nearest relative in the Eastern Cape.

Later that year in mid-October we returned to Oorlogskloof to study flowering material, as well as collect a type specimen from which *Clivia mirabilis* was formally described (Rourke 2002). Its specific epithet *(astonishing, miraculous, to be wondered at),* reflects an enduring amazement at the apparently endless surprises nature still has in store for us in this part of South Africa.

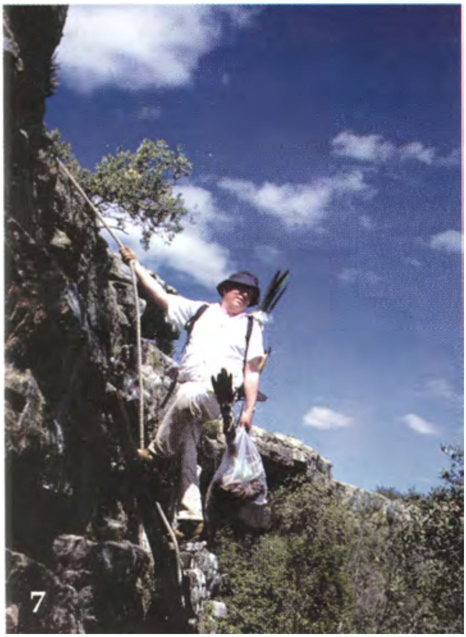
Diagnostic Characters

Clivia mirabilis is distinguished by its straight, actinomorphic, bicoloured (orange/yellow) tubular corolla, long drooping pedicels (25 to 40mm long) that are orange-red at flowering and green when fruiting; the distinctive single median white striation on the upper surface of the leaves which usually have smooth cartilaginous margins; and the irregularly shaped glebulose-gongyloid berries. The basal part of the leaves forming the leaf sheath is flushed a deep carmine maroon, unlike any other *Clivia* except C. *nobilis* which occasionally produces similarly coloured leaf bases. The orange-red colouration of the pedicels and ovaries in this species during flowering is a unique character in the genus *Clivia.*

Distribution and Habitat

Clivia mirabilis is apparently confined to the Oorlogskloof Nature Reserve in the Northern Cape.

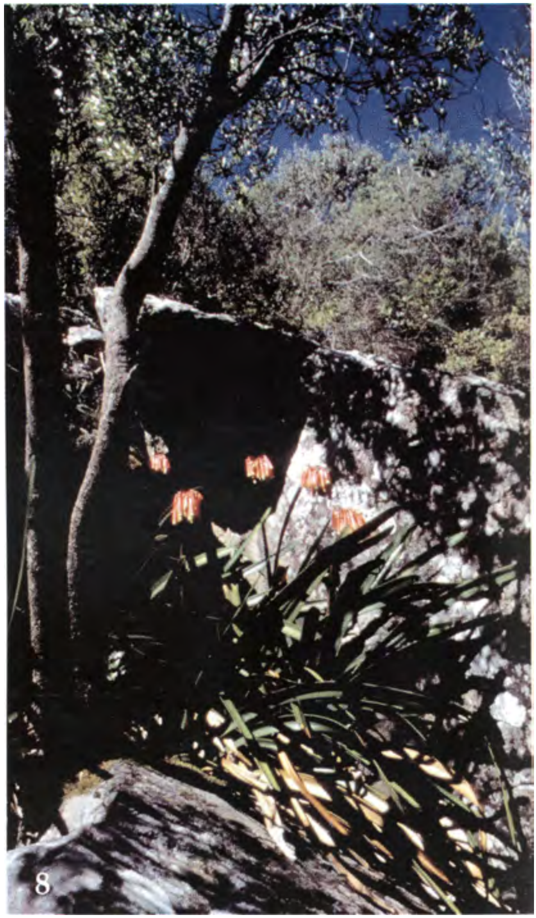
The margins of the Oorlogskloof canyon are capped with 30m cliffs of Peninsula Formation Sandstone. This has eroded to form coarse sandstone talus screes below the cliffs that are partly covered in a light woodland of relictual Afromontane evergreen forest elements, principally *Olea europaea* ssp. *africana, Maytenus acuminatus, Maytenus oleoides, Cassine schinoides, Halleria lucida* and *Podocarpus elongatus* with additional shade provided by outsize (4m tall) specimens of *Phylica oleoides.*



John Rourke climbing up the eastern wall of Oorlogskloof with the type plants of C. *mirabilis*

Small groups of *Olivia mirabilis* grow rooted in humus between cracks in the sandstone talus of the rock scree, either as solitary individuals or in small groups. Occasionally some clumps occur in full sun but these tend to have shorter leaves and often show signs of water stress (dried leaf tips). However, the remaining leaves show no signs of sunburn, despite the intense insolation experienced for several months each year.

The main population examined extends over several hectares and probably consists of well over 1,000 individuals. Due to the position of these two sites under the eastern cliffs of Oorlogskloof canyon, most plants experience shade until about midmorning after which they are in direct sun.



C. *mirabilis* in natural habitat amongst sandstone rocks

It is a matter of great surprise that a *Clivia* species is able to survive and thrive in the harsh climatic conditions prevailing in this part of the Northern Cape. The area is characterised by a semi-arid Mediterranean climate with a strictly winter rainfall regime - exactly the opposite climatic conditions experienced by the other four species in this genus. The mean annual rainfall at this site is 414*mm*, falling mainly between May and September. Vegetative growth is thus restricted to a brief winter growing period. Situated at an average elevation of between 850 and 900*m* some 100*km* inland from the coast, these populations are subject to brief but light frost in winter.

Root system of C. *mirabilis* with a 1 *metre* measuring tape

Root System

On excavating several plants in the habitat for cultivation at Kirstenbosch, the enormous root system characteristic of this species was revealed. Large adult plants have a mass of fleshy, succulent roots between half and three quarters of a metre in diameter radiating from the base of the rhizome. Individually these roots are an average 20mm in diameter. This disproportionally large volume of subterranean biomass gives mature plants an extensive water storage capacity, allowing them to survive the prolonged rainless summers of the Oorlogskloof environment.

Flower colour, development & pollination

Each flower-head bears between 20 and 48 flowers on a purple to carmine flushed peduncle. The general impression of a fully open scape is of bicoloured flowers, orange-red at the base, yellow towards the mouth and with orange-red pedicels. During the development of the flower both perianth and ovary progress through a series of well-marked colour changes.

Immature flowerhead of C. *mirabilis* about a week before opening

The unopened bud is yellowish but prominently green-tipped and the ovary is also pale green.

Mature flowerhead of *C. mirabilis*. Note red pedicels and ovaries

At flowering the green colouration slowly disappears from the tips of the tepals, which take on the same yellow tones as the basal half of the perianth. The pedicels, ovaries and upper half of the perianth are deep orange-red at this stage. After pollination the yellow colouration disappears and the whole perianth including the ovary takes on a uniform orange/red colour. As the perianth begins to wither, the ovary swells and undergoes an abrupt colour change from orange to bright green, as do the pedicels. No other *Clivia* has pedicels the same colour as the perianth when the flower is fully open.

The purpose of these colour changes is not yet understood but is probably related to pollinator cues. Pollination appears to be by sunbirds. A single sighting of a malachite sunbird probing the perianths was made at Oorlogskloof on 18 October 2001, suggesting that sunbirds could be involved in pollen transfer. However, like the other three tubular-flowered species, C. *mirabilis* may also be a 'selfer' as between 80 and 90% of the flowers in each umbel are pollinated and produce viable berries. Flowering extends over approximately six weeks, commencing in the first week of October, peaking in mid-October and continuing until about mid-November.

C. *mirabilis* immature berries

Fruiting

The berries mature more rapidly than in the other *Clivia* species. By the end of February, four months after flowering, the fully developed berries have begun to turn yellow and orange with a few having advanced to the final stages of ripeness in which the pericarp is pinkish and later red. Most berries contain two to three seeds, sometimes one. Occasionally a maximum of seven seeds per berry is produced. The berries have turned red by the end of March and are shed shortly thereafter, prior to the onset of the first winter rains in April/May. This rapid autumn maturation of berries is in sharp contrast to the summer rainfall area *Clivia* which mature slowly, usually 12 months for C.*miniata* and C. *gardenii*, about 9 months for C. *caulescens* and C. *nobilis* to coincide with the commencement of October / November summer rains.

Ripe berries of C. *mirabilis*. Note the green pedicels.

Seed Dispersal and Germination

Berries commence falling passively from the parent plant by late February. By early April the majority of berries have been shed. Germination appears to be rapid in response to the onset of autumn / early winter rains. At Kirstenbosch seeds sowed on 18 March 2001 had already developed a 10*mm* radicle by 10 April 2001.

On germinating, the primary root develops into a swollen, white, succulent cylinder up to 50*mm* long, 5 to 6*mm* thick. During the moist winter months (May to September), it swells, accumulating water in its succulent tissue. By October two short (5 to 10*mm* long) leaves have been produced where after further vegetative growth of the seedling slows or largely ceases with the onset of summer dormancy (November to April). This rainless phase persists for approximately six months, during which time the seedling survives on water reserves stored in the greatly enlarged primary root. Vegetative growth commences again in autumn. Thus the biology of a C. *mirabilis* seedling in its first year is much akin to a winter rainfall area geophyte, with the swollen primary root being functionally equivalent to a corm or bulb.

Five month old seedlings of C. *mirabilis*. Note the prominent carmine pigmentation on the cotyledons and at the bases of the first pair of leaves

The phenology of the germinating seed described above is clearly an adaptation to a semi-arid mediterranean climatic regime - exactly the reverse of the summer rainfall region *Clivia* species.

Within a few months of germinating, the plumular bud (cotyledon plus first true leaf), becomes densely pigmented with anthocyanins. This prominent development of anthocyanins at the base of the leaves is later evident in the leaf sheaths of adult plants, which are heavily suffused with purple-carmine pigments. Why the seedlings of C. *mirabilis* are so densely pigmented with anthocyanins is not clear but it may be a response to the intense levels of sunlight experienced in the natural habitat thereby providing effective screening during the seedlings' critical establishment phase.

Relationships

The distribution ranges of all four previously known *Clivia* species are contiguous or overlap, while at many localities different pairs of species occur sympatrically. (C. *nobilis* with *C. miniata; C. gardenii* with C. *miniata;* and C. *caulescens* with C. *miniata.)* Geographically, populations of C. *nobilis* in the Eastern Cape, though more than 800*km* distant, are the closest spatially to C. *mirabilis.* Moreover, C. *nobilis* also appears to be the closest relative to C. *mirabilis* on morphological grounds. Among these are the tough stiffly erect coriaceous leaves with a median pale striation on the upper surface (some populations of C. *nobilis* occasionally have a faint median striation), and the small seeds.

Breeding Potential

Obviously, *Clivia mirabilis* will be of huge interest to breeders on account of its unusual characters. Biologically, its tolerance of intense sunlight should introduce a degree of sun-hardiness to the leaves of its offspring. Coupled with this is its adaptation to an arid winter rainfall climate. Perhaps a line of sun-hardy *Clivia* will eventually be bred that will grow in full sun in mediterranean climates, able to forego watering in summer!

The floral characters, especially the richly coloured pedicels and ovaries also offer breeding potential in combination with other species. Speculating any further is an almost hopeless exercise but we may be sure future hybrids will result in character combinations few of us can even imagine at this stage.

Phylogeographic questions

To those of us who have always seen *Clivia* as belonging to densely forested subtropical environments experiencing a summer rainfall/dry winter climatic regime, *Clivia mirabilis* seems a complete contradiction. Remote and isolated in the arid Northern Cape its very presence in this most unlikely of habitats is a paradox. How did it get there, how long has it been there, and how has it survived? These are obvious questions that at once spring to mind.

The heavy fleshy berries are not dispersed by wind. They may be carried short distances by fruit eating birds but in general the seeds germinate within a metre or two of the parent plant. So, long-distance dispersal must be ruled out as a reasonable explanation.

It is more likely that *Clivia mirabilis* is relictual - a survivor of a past phase in the country's climatic history, when subtropical vegetation covered much of the interior of South Africa. From the Miocene period about 20 million years before the present, increasing aridification eliminated this vegetation type from much of central South Africa leaving survivors like the ancestors of C. *mirabilis* to adapt to the emergence of an increasingly dry climate in the western half of South Africa, as the 'proto' Benguela current brought a stream of cold water to the west coast of Africa which ultimately led to the development of a mediterranean type climate (Axelrod & Raven, 1978).

The afromontane forest elements in Oorlogskloof are, like *Clivia mirabilis,* only just surviving in the sheltered microclimate provided by this amazing protected habitat. At best we can only speculate on the past history of these plants, but one thing is certain: they are survivors and as such must command our profound admiration.

Conservation

There will inevitably be a demand from growers and breeders to obtain plants or seeds of *Clivia mirabilis.* At present all populations of this species that are currently known occur in a nature reserve controlled by Northern Cape Nature Conservation.

Collecting in Oorlogskloof is strictly controlled. In order to obtain a permit to collect live specimens the National Botanical Institute signed a memorandum of agreement with Northern Cape Conservation, which states 'The applicant may not transfer the material or any progeny or derivatives thereof to any third party without the prior informed consent in writing of the Director'. This places a responsibility on the NBI not to distribute any live material or seeds at this stage. Due to unprecedented public interested Northern Cape Nature Conservation has temporarily closed the Oorlogskloof Nature Reserve until it has formulated a policy on the distribution of plant material. In the mean time representations have been made to them to allow the distribution of seed through properly regulated channels.

Acknowledgements

I would like to acknowledge the invaluable field assistance of the staff of the Oorlogskloof Nature Reserve, especially Johannes Afrika who first noticed this species, and also Wessel Pretorius whose well-prepared herbarium specimens alerted us to the existence of *C. mirabilis.*

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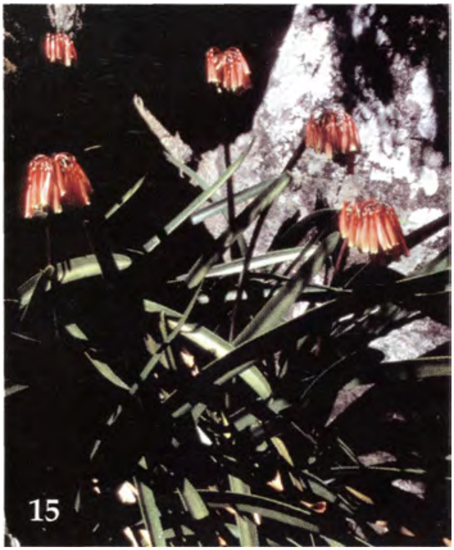


Clivia mirabilis in the natural habitat

GROWING AND PROPAGATING CLIVIA MIRABILIS

John Winter

The first *Clivia mirabilis* collected by Johannes Africa, a Senior Ranger in Oorlogskloof Nature Reserve, was sent for identification to Dr John Rourke, Curator of the Compton Herbarium at the National Botanical Institute, Kirstenbosch. This alerted Dr Rourke to this new species. For the purpose of describing and researching this *Clivia* a permit to collect a limited number of plants and seed was granted by the Department of Nature Conservation of the Northern Cape to Dr Rourke. The tremendous interest shown in this unexpected discovery in the Northern Cape has raised concern for the safety of the population of C. *mirabilis* and as a result the reserve has been closed.

The first impression I had of *Clivia mirabilis,* the latest addition to the genus *Clivia,* was its resemblance to *Clivia nobilis.* The thick rigid upright leaves resemble a C. *nobilis* growing in an exposed situation. However, the leaf has a pale green stripe running down the mid-rib. The seed is small and also similar in size to C. *nobilis.* C. *mirabilis* flowers in November and the berries are ready for harvesting four months later in March. It is unusual for *Clivia* seed to ripen so rapidly, the four other species all taking approximately seven to eight months before their berries are ready for harvesting.

The known population of C. *mirabilis* occurs in the Oorlogskloof Nature Reserve where they are protected. This reserve is situated in the Bokkeveld Mountains of the Northern Cape where the climate is Mediterranean with winter rainfall of only about 415*mm* per annum. Winter temperatures can fall to nearly 0°C. In summer the temperatures can rise to over 40°C and it is very dry but coastal mists relieve these conditions at times.

They have extensive thick *(*20*mm)* roots that penetrate the rocky scree and anchor the plant securely making it very difficult to remove a plant. More importantly the roots serve as a storage organ providing moisture and nutrients to the plant during the dry summer months, supplemented by moisture collected by the leaves from the sea mist. They grow in partial shade and also in full sun without any sign of sun damage to their leaves - some leaf die-back was noted but this had been caused by stress arising from lack of moisture. Leaf litter provides nutrients.

As with all *Clivia* species, C. m*irabilis* can be grown in a range of media from simply coarse sand to a mixture of well-matured compost, coarse sand and milled bark.

In their natural habitat their roots live in well-aerated rocky screes with leaf-mould, providing adequate oxygen, moisture and nutrient for the plants. To provide a similar growing medium I chose instead of coarse sand to use mainly seven parts of milled composted pine bark mixed with three parts of milled composted pine needles and one part organic fertilizer (Neutrog Bounce Back™).

Initially the plants were kept fairly dry taking into account that they are accustomed to a dry environment particularly in the summer. Under these conditions no growth occurred until watering was increased and the growing medium kept fairly moist. The plants responded immediately and have since produced steady growth, apparently faster than in the habitat and certainly a lot faster than C. *nobilis*! Seedlings grown in a coarse sand medium have not responded as well.

One-year old seedlings grown from seed in composted medium

As mentioned earlier the seed of C. *mirabilis* is ready for sowing in March. Two methods of sowing were used. One method was to remove the seed from the berry and wash in water that had a liquid soap added. This acts as a fungicide and also helps to remove the membrane that covers the seed. Finally the seed was washed in clean water and placed in a clean transparent plastic bag, sealed and kept in a warm place. Germination occurred in three to four weeks. As the seeds germinated they were removed from the plastic bag and planted in 15*cm* pots containing a medium similar to that used for the larger plants. The other method of sowing the seed is the conventional way of placing cleaned seed in the growing medium at a depth of one and a half times the size of the seed and keeping it moist. The root develops first followed by a narrow leaf. This method turned out to be just as effective as using the sealed plastic bag.

The plants of C. *mirabilis* have been grown in a tunnel with a wet wall at the one end and an extractor fan at the other. The young seedlings have been placed close to the wet wall that keeps them perpetually moist but this does not appear to have a negative effect on the seedlings. The tunnel is shaded but this also does not appear to have an adverse effect on the plants. If grown in a conventional *Clivia* shade house I imagine C. *mirabilis* will do just as well although the growth rate will probably be slower. The young seedlings produce long thin leaves but as the plants develop each new leaf is broader than the previous one.

Although C. *mirabilis* is not the most spectacular species within the genus *Clivia* it offers many opportunities to those interested in breeding new cultivars by making use of the unusual characteristics the new species offers - for example, the red coloured pedicels and ovaries, sun hardiness, tolerance of hot summers, cold winters, flowering in November and a faster growth rate than C. *nobilis.*

In conclusion it appears that C. *mirabilis,* although originating from an arid winter rainfall region, responds well to the same growing methods used for the four summer rainfall species. It will be interesting to observe when they will flower and produce suckers.

Clivia nobilis from Olifantskop, the most westerly recorder population, 800*km* from Oorlogskloof
Grower: Michael Jeans

CLIVIA MINIATA WITH GREEN THROATS

Above: Multipetal. Breeder and grower: Norman Weitz

Above, right: 'Mine'. Breeder and grower: Christo Lotter

Right: Grower: Clivia Unlimited

Below, left: Grower: Hein Grebe

Below, right: Winner any other colour Class NC 2001. Grower: Elda de Witt

THE STORY BEHIND THE COVER PICTURE

John van der Linde

The botanical convention is that a scientifically accurate line drawing, or better still, a watercolour painting should form part of the official description of any new plant species. The picture, in the form of a Botanical Plate, together with dried plant material and the full written description, is then stored under controlled conditions in an internationally recognized Herbarium.

The description, including the picture and any additional line drawings, is also published in an appropriate botanical journal, and the name then given to the new species becomes its official, name.

Why a painting and not a photograph? The work is done mainly for scientific purposes, so fine detail is important. Also special features can be highlighted; when comparing plants paintings are more useful for showing up distinctive identifying characteristics. Finally, surprising as it may seem, colours can be reproduced more accurately.

For the name of a new plant species to be validly published under the International Code of Botanical Nomenclature it must be accompanied by a Latin diagnosis or description or both. This is because Latin is the international common language of botany. The correct Latin name for a plant is the primary reference base for the storage, retrieval and use of the botanical knowledge. The description of *Olivia mirabilis* begins

> *'Clivia mirabilis. Rourke, sp. nov., a speciebus affinibus, corollis actinomorphis rectis tubularibus bicoloribus (miniatis/luteis); '.*

The name 'Rourke' appears because Dr John Rourke is the author of the new species, and published the name and official description in Vol. 32,1 of *Bothalia,* the principal botanical journal of the National Botanical Institute of South Africa. The plant material, botanical plates and description are kept in the Compton Herbarium at Kirstenbosch National Botanical Garden, Cape Town, together with similar records for many hundreds of previously recorded South African plant species. The type specimen on which the original description was based is like the title deed of a species name.

The Botanical Plate of C. m*irabilis* was painted by Auriol Batten, and is reproduced with her kind permission. Auriol Batten is one of South Africa's best-known botanical artists, with artwork represented at the National Botanical Institute in Cape Town and Pretoria, the Royal Botanic Garden, Edinburgh and in numerous private collections. She has designed seven sets of South African postage stamps.

Her published artwork includes : *Wild Flowers of the Eastern Cape Province* (C.T. 1966); *Flowers of South Africa* (Sandton 1986). She painted illustrations for well-known books on *Dierama* and the *Gladiolus* species, and for *Curtis' Botanical Magazine,* which is an official publication of the world-famous Royal Botanic Garden, Kew.

The Clivia Society is greatly privileged to be allowed to use Auriol Batten's definitive Botanical Plate of this truly amazing new species, aptly named *Clivia mirabilis.*

Ciivia mirabilis

A LAYMAN'S COMMENTARY ON THE NEXT ARTICLE

Molecular systematics of the Genus Clivia

John van der Linde

When scientists publish their research they give full details of their methods, so that other scientists, working independently, can verify their results. The following article by Ferozah Conrad and Gail Reeves is written in that vein. Although these details are likely to be beyond most of us, this article is published here because of the importance of their results and conclusions. The purpose of this commentary is therefore to summarise, in everyday language, the processes that were followed.

Simply put, the authors had three aims : To confirm, by DNA analysis, the identification already made by other means, of *Clivia mirabilis* as a species in the genus *Clivia;* to investigate the relationship with the other species; and finally and most exciting to most of us *Clivia* lovers, to deduce a *Clivia* '*fa*mily tree', showing how the genus *Clivia* developed to the present time, from the most recent common ancestors that existed millions of years ago.

The authors began by taking tiny samples of leaf tissues from plants collected from the wild. These plants are from the Living Plant Collection of the National Botanical Institute, maintained at Kirstenbosch National Botanical Garden in Cape Town.

Besides a sample from C. *mirabilis,* samples were taken from one plant each of C. nobilis, C. *gardenii, C. miniata* and C. *caulescens. A* sample was also taken from a *Cryptostephanus vansonii,* an amaryllid from Eastern Zimbabwe known to be closely related to the genus *Clivia* (and to *Tulbaghia,* incidentally).

Each one of these individual plants carries a message from its ancestors. That message is in the DNA, the genetic material in every cell, handed down from generation to generation. That DNA carries not only the histories of these six plants, but also the whole history of their ancestry. The authors, in matter-of-fact and unemotional prose, have now revealed the most likely version of that history to us - a fascinating DNA detective story.

They began by treating each sample with chemicals, to 'unzip' and then unwind the two strands of DNA from their normal double helix format. In a throw-away phrase, they casually mention that the amount of genetic material extracted varied in weight from twenty to fifty nanograms in each case. To the layman these figures are mind-boggling, because do you know what a nanogram is? A nanogram is one thousand-millionth of a gram! Heavy stuff!

Having applied further chemicals and several thermal cycles, the end result was, for each sample, a much magnified specifically targeted stretch of DNA, called a sequence. Each sequence is rather like an identifying bar-code which can be 'read' by special equipment, and which is directly comparable with the sequences similarly isolated from the samples from the other plants.

An important point is that the DNA in question was extracted from the genes from the chloroplast regions of the cells in each leaf sample. The significance of this is that, unlike genes in the nucleus of the cell - which are inherited from both pod and pollen parents, chloroplast genes are inherited from the mother plant only. This means that the ancestors referred to above are the mother plants of the mother plants of the mother plants.... and so on, back generation by generation, tracing the maternal line from the present time, back into the long distant past - in effect, to the Great Grandmother of them all.

Because there is no genetic contribution from the pollen parent to the chloroplast genes to 'cloud the picture', the only source of change to genes inherited maternally can be mutations. These occur due to random errors in copying this particular genetic information.

For this reason the scientists focus on the chloroplast DNA sequences, and in particular on the differences between them, because they show the unclouded effects of the mutations accumulated over the millennia as the 'family tree' split into its various branches.

The number of differences presently observed is a measure of how far back the ancestors (or more correctly, the most recent common ancestors) of these six plants - now alive and flourishing at Kirstenbosch as you read this article - diverged from each other. For example, if there are few differences between the sequences for two plants, then their most recent common ancestor must have existed fewer years ago than if there were significantly more differences between the two DNA sequences.

The next step was to feed the sequence data into a computer, which then examined all the possible 'family trees' that could have given rise to the differences in sequences that were observed.

The computer, using an extremely sophisticated software program, then picked out the most likely 'family tree' from the range of 954 possible alternatives.

This 'tree', called a cladogram, is shown on page 21. The varying lengths of the branches of the cladogram illustrate the point mentioned above : If two plants have more similar DNA sequences, then they have a common ancestor which lived more recently in the past, and so are joined by shorter branches on the diagram. Plants with more differences in their DNA sequences share a more remote common ancestor, and are therefore linked by longer branches.

Once the scientists have estimated the rate at which chloroplast DNA changes with time, they can apply that rate to the number of observed changes in order to estimate how long ago the various branches diverged, and even the approximate date when the more recent common ancestor of the six plants must have existed. The authors have not made these calculations yet.

At this point I refer the reader to the Section 'Results and Conclusions' in the next article. This section makes for easier reading than the earlier, more technical sections. The conclusions are fascinating!

The work that the authors of that article have done is of major significance and they deserve to be recognized for their contribution to our knowledge of the genus *Clivia*. Their work was made possible by the generous donation by Mr Leslie Hill of the funds needed to equip the Molecular Systematics Laboratory at Kirstenbosch that has been named after him. The Cape Clivia Club contributed to the cost of the chemicals that were used.

Cryptostephanus vansonii

MOLECULAR SYSTEMATICS OF THE GENUS CLIVIA

Ferozah Conrad and Gail Reeves

Leslie Hill Molecular Systematics Laboratory, Kirstenbosch

INTRODUCTION

The genus *Clivia* (Amaryllidaceae) comprises five species of which C. *caulescens,* C. *miniata, C. gardenii* and C. *nobilis* are better known. The recent discovery of a fifth *Clivia* species - *Clivia mirabilis* (Rourke, 2002) in the Northern Cape has prompted questions regarding the relationship of this taxa to the other four *Clivia* species. Interesting questions also pertain to biogeography of the genus since the distributions of the other *Clivia* species are restricted to the east coast of South Africa, from the Eastern Cape northwards.

The most modern approach to phylogeny reconstruction involves the use of DNA sequence data as a source of phylogenetic information - a field of study known as molecular systematics. This involves the collection of DNA sequence data from targeted gene regions for all taxa of interest and the evaluation of this data to determine the extent to which nucleotide variation occurs among taxa. Other sources of characters for phylogenetic studies have been based in fields such as anatomy, cytology, palynology and morphology but DNA sequence data have become a valuable source of characters in recent years. In this study we utilised four non-coding chloroplast regions as a source of phylogenetic information: the rpoB-trnC intergenic spacer, the trnL intron, the trnL-F intergenic spacer, and the rps16 intron.

MATERIALS AND METHODS

DNA isolation and polymerase chain reaction (PCR)

Total genomic DNA was extracted from 1.0g fresh leaf using the 2X CTAB method of Doyle and Doyle (1987). Twenty to fifty nanograms of total genomic DNA were used as a template for Taq mediated amplification. One hundred microlitre reactions contained Promega magnesium free thermophilic buffer (50mM KC1, 10mM Tris-HCI, 01% Triton X100), 3mM MgC12, 0.004% BSA, 0.2mM each dNTP, 100ng of each primer and 2.5U Taq polymerase. Thirty cycles of DNA amplification were carried out in a Gene Amp PCR System 9700 (Applied Biosystems Inc) using the following programme for the rpoB-trnC spacer region: denaturation: 94°C for one minute; annealing: 52°C for one minute; extension: 72°C for one minute - five cycles and then the next 25 cycles: denaturation: 94°C for one minute; annealing: 48°C for one minute; extension: 72°C for one minute. For the trnL-F region and rpsl6 intron the following programme was used: denaturation: 94°C for one minute; annealing: 48°C for one minute; extension: 72°C for one minute. Presence of PCR products was verified on a one percent agarose gel.

Amplification of the rpoB-trnC intergenic spacer region was achieved using primers rpoB5' and trnC5' (Ohsaka and Ohnishi, 2000). Primers rpsl6F and rpsl62R (Oxelman et al., 1997) were used to amplify and sequence the rps16 intron. Primers 'c' and 'f' (Taberlet et al., 1991) were used to amplify the adjacent trnL intron and trnL-F intergenic spacer between the trnL and trnF exons. For each of the above regions amplification primers were then used as sequencing primers.

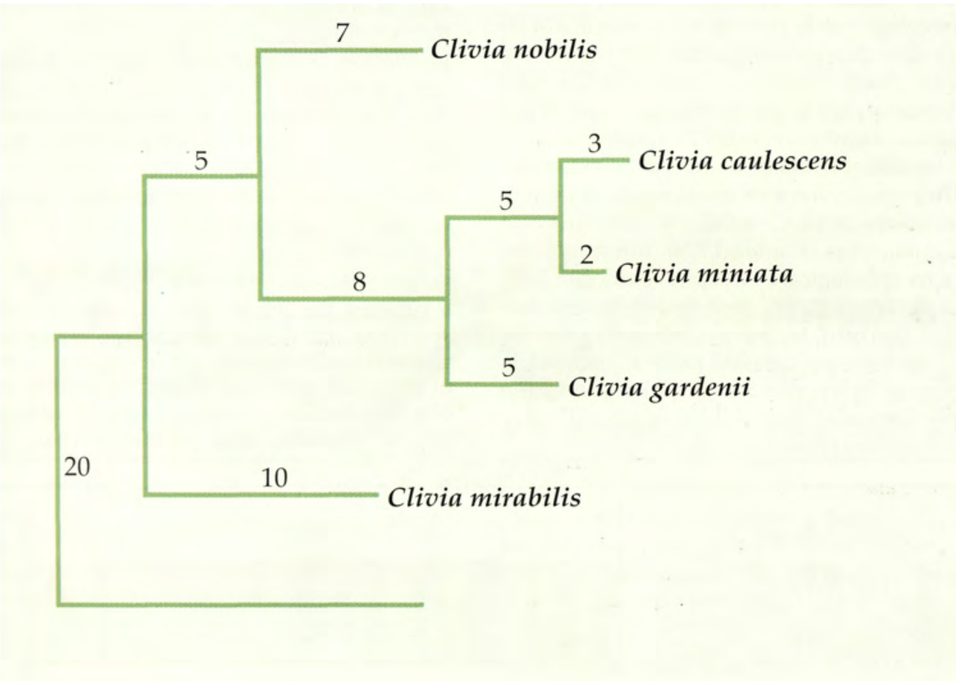
DNA SEQUENCING AND SEQUENCE ALIGNMENT

Amplification products were purified using Qiaquick (Qiagen) spin columns according to manufacturer's instructions and directly sequenced on an ABI 377 automated sequencer using standard dye-terminator chemistry following manufacturer's protocols (Applied Biosystems Inc). For assembly and editing of the complementary strands Sequencher (Gene Codes) was used.

A combined cladistic analysis of the four non-coding DNA regions was performed using the parsimony algorithm of the software package PAUP* for Macintosh (phylogenetic analysis using parsimony v.4.0b Swofford, 2001). Cryptostephanus vansonii was designated as the outgroup taxon based upon results of a larger analysis of DNA sequence data for the Amaryllidaceae (Meerow et al., 1999).

RESULTS AND DISCUSSION

Of the 2897 characters included in the combined analysis 17 were potentially parsimony informative. Branch and bound parsimony analysis gave a single tree with length 65, consistency index (CI) of 0.97, and retention index (RI) of 0.92.



Branch lengths are proportional to the number of nucleotide changes

Figure 1: The most parsimonious tree found from combined analysis of all four DNA sequence matrices

In the single most parsimonious tree shown in figure 1, *Clivia mirabilis* is placed as sister to a clade comprising the other four *Clivia* species. C. *nobilis* is placed as sister to the clade comprising C. *gardenii,* C. *miniata* and C. *caulescens,* and C. *gardenii* is in turn placed as a sister to the terminal clade comprising *C. miniata* and C. *caulescens.* This would therefore imply that *Clivia mirabilis* is representative of the most primitive lineage of the genus, and the terminal taxa, C. *miniata* and C. *caulescens,* are the most derived taxa.

In terms of biogeography this would imply an expansion of the lineage from the western Cape eastwards. *Clivia* mirabilis is the only species in this genus to be found in the winter rainfall region of South Africa (Rourke, 2002), and it is placed here as the sister to the remainder of the genus. *Clivia nobilis* is found in the Eastern Cape where its distribution overlaps with that of C. *gardenii. Clivia gardenii* then extends further north along the east coast. *Clivia caulescens* extends from Mpumalanga to the northern extreme of the genus' distribution in the Northern Province. The distribution of C. *miniata* is extensive throughout the east coast where its range overlaps with C. *nobilis, C. gardenii* and C. *caulescens* (Winter, 1999). Interpretation of morphological character evolution in light of the phylogenetic tree would suggest that the upright flowers demonstrated by C. *miniata* are derived since C. *miniata* is placed in the most terminal clade in the phylogenetic tree. All other taxa display pendulous flowers.

GLOSSARY

clade a group of organisms which include the most recent common ancestor of all its members and all the descendants of that most recent common ancestor

consistency index (CI) a measure of the amount of homeoplasy exhibited by a character or set of characters on a tree; defined as the sum of the minimum individual character ranges divided by the observed number of changes; if there is no homoplasy, these quantities will be equal, so that the consistency index achieves its maximum value of one

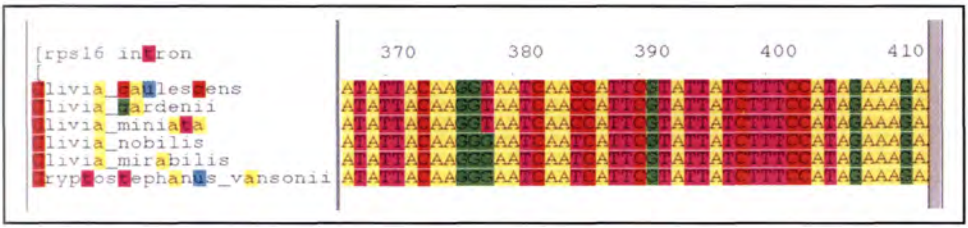
lineage any continuous line of descent; a series of organisms connected by reproduction by parent of offspring

outgroup one or more taxa used to help resolve the polarity of characters, and which is hypothesized to be less closely related to each taxa under consideration than any are to each other

parsimony refers to a rule used to choose among possible cladograms, which states that the cladogram implying the least number of changes in character states is the best

phylogeny the historical relationships among lineages of organisms or their parts (eg. genes)

polymerase chain reaction (PCR) a process for amplifying a target DNA sequence manyfold, in which a series of thermal cycles each result in denaturation of a double stranded target, annealing of oligonucleotide primers to the resulting single strands, and primer extention



A *Clivia* DNA string has approximately 2 800 characters in it. The above diagram is a snapshot of parts of some of those strings and shows two of the mutations.

catalyzed by a thermostable DNA polymerase

retention index(RI) the retention index measures the extent of character congruence at maximum parsimony

Taq polymerase a thermostable DNA polymerase from Thermus aquaticus, a thermophyllic bacterium; used for amplification of DNA via polymerase chain reaction.

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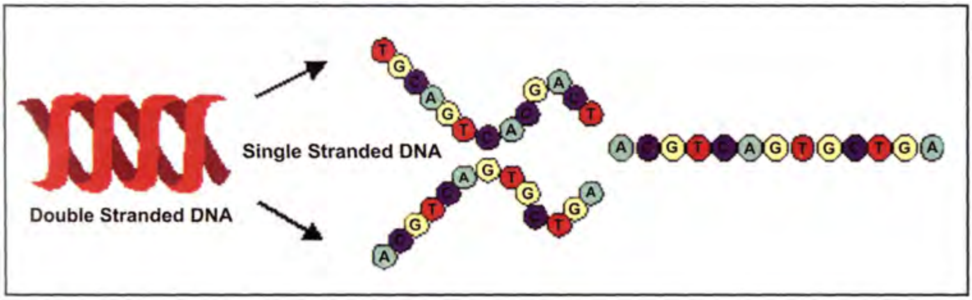

Reading DNA

Here you can see how the bases of a helix become a DNA sequence.

When you write a letter, you put together words using different letters of the alphabet. With twenty-six letters you can say anything you want. It is important that the letters go in the right order.

This sentence stops making sense when thaliekmviserhflker are in the wrong order.

When new cells are made, the organism is puttimg together different letters of the DNA alphabet. The order of the DNA bases is called the **sequence.** The DNA sequence codes for all the proteins that are ultimately made from DNA.

VEGETATIVE (ASEXUAL) PROPAGATION OF CLIVIA

Ammie Grobler and Lena van der Merwe

Clivia can be propagated in two ways:

Sexually: That is the conjugation of male and female sex cells after pollination. Pollination is the transfer of the pollen grain onto the female organ (pistil) so that fertilization can take place. Seed carrying the embryos then develop. (See detailed description in Clivia Yearbook 3.) Every one of these offspring inherits characteristics from each parent so that none of them will be identical to either parent or to one another.

Asexually (vegetative): This is the ability of a plant to produce offspring through its vegetative parts such as leaves, stems and roots. In asexual propagation all of the offspring are genetically identical, i.e. are clones of the mother plant. In the case of *Clivia* the natural method of cloning is through the rhizome.

Vegetative propagation can be achieved artificially, but before we cover the different methods, we must first ask an important question: *Why do I want to propagate a specific* Clivia *vegetatively?*

Remember that unlike sexual propagation vegetative propagation results in the production of a number of genetically identical plants. It is therefore the only way in which one can obtain exact replicas of a highly desirable *Clivia.* Many *Clivia* multiply asexually by way of suckers and grow into large clumps. This has an adverse influence on the quality of their flowers that can be remedied by dividing the clumps into individual identical plants, which will flower properly However some *Clivia* do not sucker readily and, especially if they are exceptional specimens, artificial means can be used to encourage them to produce exact replicas of themselves vegetatively.

DIVISION OF CLUMPS

This should be done only after flowering and till late summer - that is from October to the end of January, as follows: Carefully unpot or lift the clump and wash away the soil until all the parts are clearly visible.

Cut off all the suckers (daughter plants), which are attached to the mother plant by stolons (underground runners) but only if they have independent roots.
Offsets, which are attached directly to the rhizome of the mother plant so that they share a root system with the mother plant, must be carefully cut from the mother plant ensuring the offset retains its part of the rhizome and the roots attached to it. Underground runners which have grown out of the rhizome of the mother plant, but which have not yet developed their own roots, must not be removed.
The rhizome, out of which the suckers and offsets grow, is clearly discernable from the roots. It is thick and has nodes (the axillary buds) out of which offsets or suckers develop.

Cut the long roots short to about 10cm and place the plants for 24 to 48 hours (depending on the temperature) in a warm shady place to dry out.

After the drying out period, place the plants for 30 minutes in a KicStart™ solution (50m/ in 10/ water).

In all cases use only a sharp knife which is sterilized before every cut using an antiseptic agent such as Sporekill™, or bleach or by heating in a flame.

Submerge the plants for 20 seconds in a disinfectant solution such as Sporekill™ *(2ml* in 10/ water) and then plant the plants in a suitable potting soil or into the open ground.

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

SCORING

Scoring refers to different types of cuts made on the rhizome to stimulate vegetative propagation. First a clear distinction between the pseudo stem (above the ground) and the true stem (mainly under the ground) has to be made. The true stem (rhizome) is usually underground, is hard and slightly woody in older plants. It contains the axillary buds out of which offsets or suckers will develop.

The pseudo-stem above ground consists of leaf-sheaths covering the terminal part of the true stem (delicious nutrition for the lily borer!).

Scoring must be made into the rhizome. It disturbs the hormonal balance in the rhizome resulting in the development of offsets or suckers from the axillary buds.

When to resort to scoring?

Scoring is a drastic step, which carries the risk of losing the plant. It is resorted to only to reproduce clones of an exceptional plant with exceptional flowers, which does not form suckers naturally, and is in high demand.

Methods of scoring

Wedge scoring method *(Figure 1)*

Do not remove the plant from the soil. Remove just enough soil to expose the top roots.

Make 3 to 4 wedge-shaped incisions about *5mm* deep into the stem with a sharp sterile knife. Sterilize the wounds and soil with Sporekill™ solution *(2ml* in 10/ water). Repeat the sterilizing during watering with KicStart™ solution (50m/ in 10/ water).

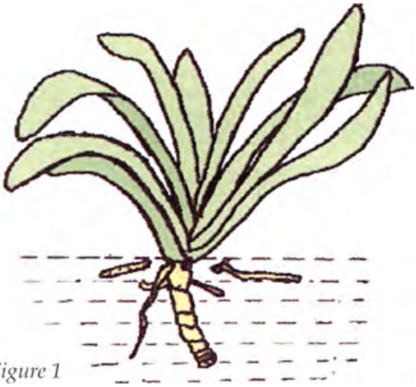
Figure 1

Heated small metal rod or metal knitting needle method *(Figure 2)*

Do not remove the plant from the soil. Take a *3.5mm* diameter metal knitting needle or metal rod and heat it in a flame. Press the hot needle right down the crown of the plant into the rhizome. The object is to destroy the growth point of the plant, thus stimulating auxiliary buds to sprout and form offsets.

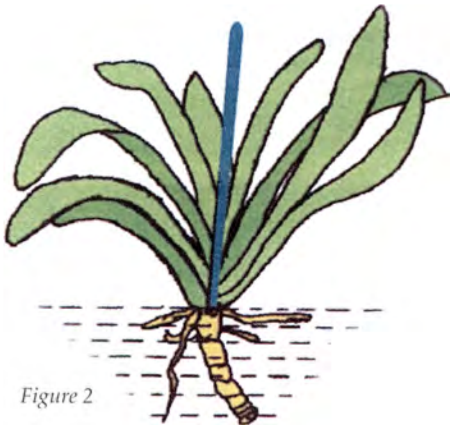
Figure 2

Scoring the rhizome *(Figure 3)*

This is a rather hazardous undertaking. Remove the plant from the soil. Wash the rhizome and roots clean. Prune the roots to about 10cm. Turn the plant upside down so that the bottom end of the rhizome points upwards. Make a cross incision about 3 to 4*mm* deep into the bottom end of the rhizome 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 KicStart™ solution and disinfect when watering.

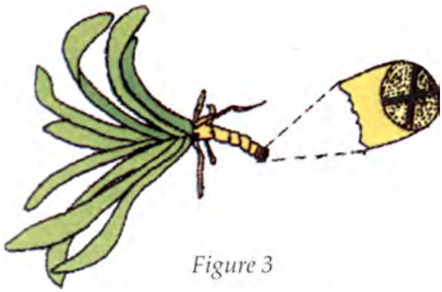

Figure 3

Removing a part of the rhizome *(Figure 4)*

Remove the plant from the soil. Wash the rhizome and roots until clean. Prune the roots to about 10cm.

Cut at a 45° angle about *5mm* deep into the rhizome and then vertically downwards to cut away about 1/4 of the width of the rhizome. Treat the cut surface with fungicide. Allow it to dry off and replant as above.

Figure 4

Plant on a stone (adopted from Hennie Koekemoer)

This is a very safe method and can be used with exceptional seedlings or young plants which need repotting. Place a golf ball sized stone directly under the plant when planting. According to Hennie, this is a very effective way of stimulating the production of offsets.

GENERAL

The success of the above artificial methods depend upon:

- The vigour of the plant
- Climatic conditions at the time. Cool, dry conditions are ideal.
- Proper treatment and preparation of the plant. Sterilize the tools and equipment used and always work very cleanly when you make any incisions in a plant. Before and after each incision, sterilize your knife, your hands and everything in contact with the wound to prevent contamination - that is not only bacteria or fungi (they are treatable) but virus infections which are untreatable and must be prevented. Take the right precautions and you will succeed!

Good luck with your vegetative propagation of *Clivia.*

Division soon after flowering will have an adverse effect on seed set and seed development. Some growers also believe that new flower bud formation starts soon after flowering and that division should be done in May to avoid abortion of nascent flower buds and to protect seed.

Pruning roots can result in those roots dying back but some growers have treated cut root ends with Bravo™ neat to stimulate root growth from the cut surface.

Some growers have found that divisions need not be dried off. The leaves of the sucker should be tied together to protect them before it is severed from the mother plant. Treat the cut surfaces with fungicide, do not prune the roots, replant the sucker right away and water it with **KicStart**™ *and* **Sporekill**™. *That will reduce the shock of surgery! Then keep the divisions dry and the leaves tied for about 2 to 3 weeks until they have settled down.*

The growing medium itself can stimulate growth from cut surfaces and avoid disease. Use Bravo™ on the cut surfaces and plant in clean, sterilized filter sand - compare Henriette Stroh's article on Pests and Diseases under the heading Phytophthora.

Year round use of the fertilizer Peters Professional™ has been found to stimulate the production of offsets but it does have a negative affect on flowering unless it is used less often. Eds

PEACH AND PASTEL CLIVIA and their origins

Bill Morris

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I am interested in the variety of peach and pastel *Clivia* flowers and their origin.

I believe they may be of various types and origins. The following is an outline of my interpretation.

The normal orange *Clivia* in the wild is a variable plant in most of its characteristics. These characteristics are under the control of numerous genes. Generally, each individual gene is part of a set called a metabolic pathway. This produces certain chemicals by step-wise chemical transformation from simple chemicals to more complex ones. These pathways are interconnected in many ways as a chemical produced by one may be used by another at different times. It is sometimes in competition for the chemical at the same time. Such interrelationships are the reason many genes are said to be multi-functional. Not that the gene can do many things, but that the gene's chemical product can be part of many pathways.

In the case of colour in *Clivia* flowers (and other plants) the pigments of various different pathways of which chlorophyll, carotenoids (mainly yellow) and flavonoids (white, red, blue and purple) are the main groups.

In the wild *Clivia miniata* colour can vary from red to various shades of orange, then salmon, to even paler pastels, peach and yellow. All of these can then have white, yellow or green throats or background colours. Thus, at least three metabolic pathways are involved. This spectrum of colours (ignoring the throat or background colours) from red to yellow can be due to inefficient genes in the metabolic pathway. So, at each step less than the usual amount of chemical is turned into the next chemical. Each step therefore acts as a partial bottleneck along the manufacturing process. These multiple bottlenecks mean that at the end of the line, varying lesser amounts of the final product (anthocyanin pigment) are produced.

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C. *miniata* pastel forms from the habitat (NBI)

C. *miniata* 'Ella van Zijl'.. Grower: Toy Jennings

Thus the whole series of colours from red to yellow can occur in what are really normal (orange) *C. miniata.* These inefficient genes are probably the product of different minor mutations, giving rise to various alleles (or forms) of each gene which are present in the wild population of *Clivia miniata.* It is the random or chance recombinations of these modified genes that give rise to the various colours. Because of these interconnections between all the metabolic pathways and the 'multiple functions' of the genes, the plants with very little colour in the flowers (peach and yellow) are very rare because most of them have other 'problems' in other pathways, due to the cumulative effects of inefficient genes. This makes them less vigorous or less fertile or their seeds less viable so they compete less well with other plants and only occasional ones are found.

Most of the yellow and peach variants that are known are not members of the continuous 'orange' spectrum caused by multiple ineffective genes. They are due to single gene mutation. In these plants a single gene has undergone a mutation which has made it totally ineffective, and this causes a total block of anthocyanin production giving a yellow flower. This is called a null mutation. In the case of peach flowers this null mutation can be described as 'leaky'. That is, just enough chemical is produced by the gene to give a trace of colour. It seems likely that some pastels could also be produced by a leaky 'null mutation'.

The important difference, however, is that one type of yellow, peach, pastel, etc. is produced by the cumulative effect of a number of genes, whereas the other type is produced by a major mutation (change) in just one gene.

Now, the question is, how can you differentiate between the two types? This is done by their different breeding behaviour.

C. *miniata* Peach. Grower: Clivia Unlimited

Lotter's Peach. Breeder and grower: Cristo Lotter

In the case of the multiple gene type, the plants when selfed or when two of the same type are crossed give varying results. Plants are obtained which can vary giving a wide spectrum of colours similar to the normal orange range but paler and there is no particular numerical relationship amongst the colours.

In the case of single gene mutations, crossing between the colours is predictable. That is, yellow x yellow gives yellow offspring, peach x peach gives peach, and so on. Also, in crossing these mutations with normal orange plants, the mutations are recessive, and in the second generation the mutations reappear in Mendelian ratios.

In cases where yellow x yellow or peach x peach give normal orange offspring, this is because the single gene, mutant plants are of two types (Group 1 and Group 2). These differ because a single gene null mutation has affected two different genes but each plant only has one affected gene (but present in a double dose).

The end result of this interpretation is that when a new yellow, peach, pastel, pink, etc. occurs, it may be a multiple gene type which will breed as an orange or it may be a single gene mutation which will breed according to Mendel.

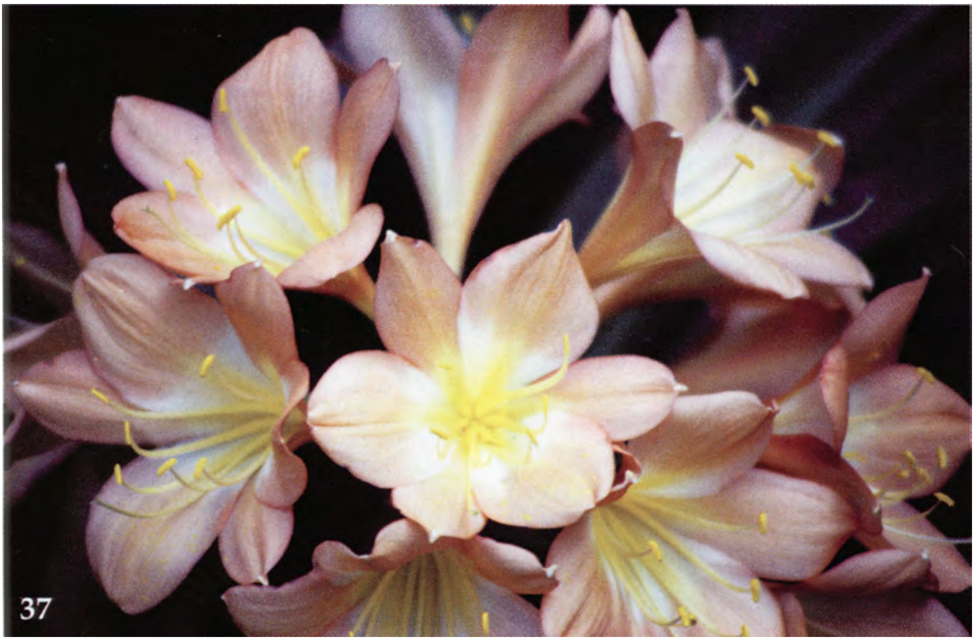
There is one other source of pastel, peach or pink flowers and this comes from crossing an orange (multiple gene control) with a single gene mutant yellow. When a normal orange is used, most of the offspring are paler than the orange parent. When a paler orange is used the same result occurs and even paler flowers can be obtained. Pastels or peach flowers can occur. These plants will again breed differently but will give Mendelian ratios when crossed with appropriate single gene yellows.

C. m*iniata 'Chubb Peach' m*ultipetal. Breeder and grower: Sean Chubb

C. *miniata '* pastel. *Grower:* Clivia Unlimited

Winner C. *miniata* peach/apricot class and third Best on Show NC 2001. Grower: Sarel Naude

Winner *C. miniata* pastel class CC 2001. Breeder and grower: John Winter



Winner *C. miniata* pastel class KZN Interest Group 2001. Breeder: Nick Primich. Grower: Louise Swanepoel

THE NUTRITION SYSTEM OF CLIVIA

Hannes Robbertse

Profesor Robbertse is a former Director of the Margaretha Mes Institute of Seed Research, University of Pretoria but joined the Department of Plant Production and Soil Science in 1994.

In this paper, I am going to focus on those parts of the *Clivia* plant that are involved in the nutrition process.

Plant roots are responsible for the uptake of mineral nutrients by root hairs.These nutrients are then transported through the xylem vessels to the stem and leaves where they are utilized in metabolic processes. The leaves are the carbohydrate (sugars and starch) factories of the plant through the process of photosynthesis. Carbohydrates produced by the leaves are loaded into the phloem tubes (cells) and translocated to the different parts of the plant where they are utilized for energy production or stored as sugars or starch. In order to get a better understanding of the functioning of roots and leaves, it is necessary to know something about the origin and structure of these organs.

The root

Origin and structure

Apart from the primary root deriving from the radicle of the embryo in the seed during seed germination, most *Clivia* roots derive from deep inside the stem. The first sign of root formation is a small group of dividing cells, organising themselves into a root tip meristem *{Figure 1).* Unless damaged, these meristem cells will function as the 'cell factory' of the root and will continuously provide new cells required for the root growth. The newly formed cells are immature and have to grow and differentiate (mature) into specific functioning tissues like the root cap protecting the delicate meristem cells, epidermis, ground tissue and vascular system *{Figure 1).* The maturing epidermis cells form outgrowths, called **root hairs** *{Figures 2 and* 4). In actively growing roots the root hairs closer to the root tip are alive and thin-walled. Further away from the root tip the root hairs develop striations and die, but remain intact as a velvety layer around the root *{Figure 2).*

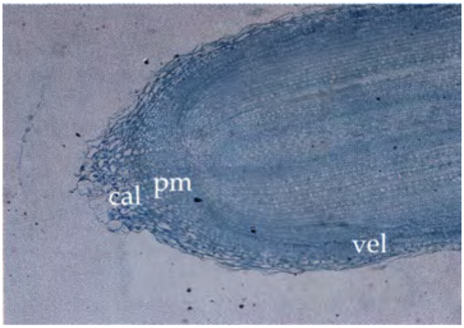


Figure 1. Longitudinal section of *Clivia* root tip. Cal = calyptra consisting of dead tissue, protecting the delicate promeristem (pm) cells. The promeristem cells initiates all other tissues of the root, including the velamen (vel)

Figure 2. Picture of *Clivia* root tip (rt) and outside of velamen (vel) covered with root hairs

Being a **semi-epiphyte** (a plant using another plant as a support to expose itself to the sunlight), the *Clivia* root structure also simulates epiphytic roots in the sense that it has a **velamen** *(Figures* 3 *and* 4), which is also formed by the root tip meristem as a separate tissue underlying the epidermis.

Closer to the tip of actively growing roots, all the cells, including the velamen cells are alive. The maturing velamen cells develop net-like striations on the inside of the cell walls before losing their protoplasts *(Figure* 4). The now dead velamen cells become filled with air that reflects light and gives the root an opaque or whitish colour. The first cell layer underneath the velamen is called the **exodermis** and consists of large cells *(Figure* 4) with thickened side (radial) walls impregnated with a corky substance (suberin) making them impenetrable to water, thus preventing water from moving through the cell wall from the velamen to the underlying cortex.

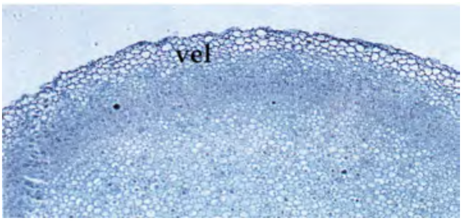


Figure 3. Cross section of *Clivia* root close to the root tip, showing young velamen cells

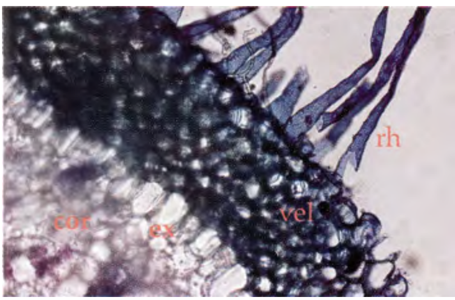


Figure 4. Cross section of *Clivia* root further away from the root tip, showing root hairs (rh), well differentiated velamen (vel), exodermis (ex) and cortex (cor)

Some of the exodermis cells, called **transfusion cells,** slightly intrude the velamen *(Figure* 5*)* and retain their dense cytoplasm in contrast to the surrounding ones that develop large vacuoles and die. Any solutes passing through the exodermis, therefore, have to pass through the cytoplasm of the transfusion cells. The outer walls of the transfusion cells are specially designed *(Figure* 5*)* for 'loading' substances into the cytoplasm of these cells for transfer to the cortex cells.

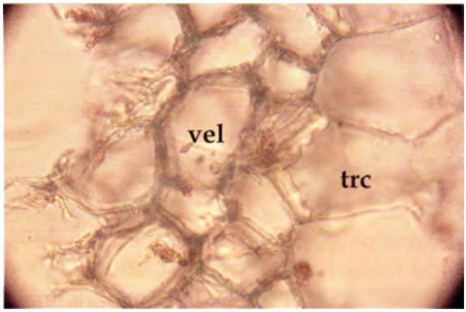


Figure 5. Section of *Clivia* root showing transfusion cell (trc) with thickened outer wall intruding into the velamen (vel)

Functioning of the root

The root hairs in the younger part of the root, closer to the root tip, are alive and responsible for the absorption of water and mineral nutrients from the growing medium. In the older part of the root, the root hairs and velamen cells have died *(Figure* 4). Water and nutrients now move into the root hairs and velamen cells by means of capillary action. The action of the velamen can be demonstrated by bringing the root in contact with a drop of stained water. The thick mass of dead root hairs together with the velamen act like blotting paper in absorbing the drop of water and staining the root hairs and velamen cell walls. Once in the walls of the velamen cells, the water and nutrients have to pass through the protoplasts (cell contents) of the transfusion cells to the cortex, due to the impermeability of the exodermis cell walls. Due to the semi-permeability of the cell membranes and the cytoplasm, the exodermis acts as a 'filter' in preventing certain unwanted ions from entering the root.

Although not yet proven, it is possible that the velamen cells may also absorb water in the form of water vapor either from the atmosphere where the plants grow as epiphytes or from soil water vapor.

The way in which water and nutrients are taken up by the living root hairs directly from the substrate or indirectly by the transfusion cells from the velamen, can be explained as follows:

Fertilizers consist of mixtures of mineral salts. When mineral salts dissolve in water, they dissociate into positive and negative ions. For example, if a salt like potassium nitrate, KNO_3, dissolves in water, positively charged potassium ions, K^+, and negatively charged nitrate, NO_3", ions are formed. The mineral salts in applied fertilizers dissolve (dissociate) in the soil water, or water in the growing medium. The water together with the ions is then absorbed by the roots as explained above and transported through the xylem (wood) vessels *(Figure* 6) to the leaves. The vascular cylinder of the root is ensheathed by an **endodermis** *(Figure* 6*)* with similar structure and function as the exodermis, also acting as a selective filter for certain ions.

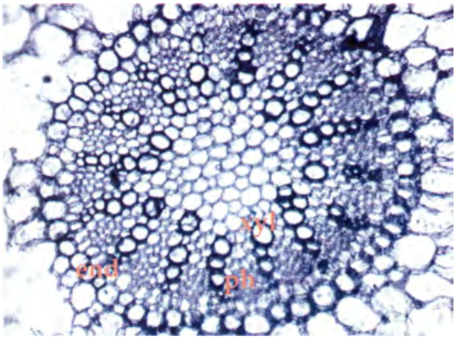


Figure 6. Cross section of *Clivia* root showing the central cylinder encircled by the endodermis (end) with alternating xylem (xyl) and phloem (ph) groups

Apart from its absorbing function, the velamen also has a protection function due to the layers of dead, air-filled cells surrounding the live cells of the cortex and vascular cylinder. *Clivia* roots are therefore more tolerant to desiccation than roots of most other plants. Due to their specific structure and functioning, *Clivia* roots will thrive best in a moist, but not wet, and well-aerated growing medium containing sufficient, but balanced amounts of all required mineral nutrients.

Figure 7. Longitudinal section of stem apex showing young inflorescence bud (inf), new apical meristem or bud (am) and leaf vascular tissue (lvt)

The leaf

Structure and function

Clivia leaves are produced by the apical meristem (bud) of the stem *(Figure* 7). Mature leaves are strap-like with parallel veins containing the vascular tissue responsible for transportation of water and nutrients to and from the leaves. In cross section *(Figure* 8a*)*, it can be seen that the outer layer of cells surrounding the leaf is the epidermis.

The outer cell walls of the epidermis cells are thick-walled and covered with a waxy layer, named the cuticle. The function of the cuticle is to prevent excessive water loss from the leaf surface.

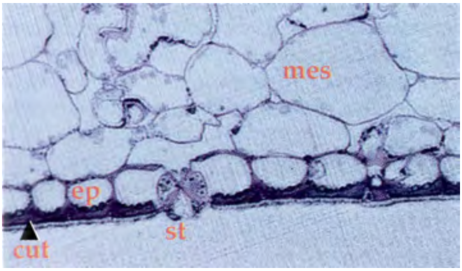


Figure 8a. Cross section of *Clivia* leaf showing cuticle (cut) covering the epidermis (ep), stomatal pore (st) surrounded by two guard cells and mesophyll cells (mes)

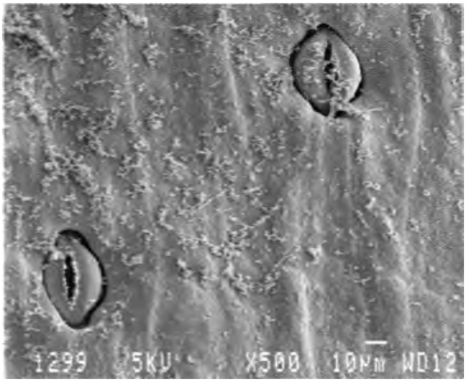


Figure 8b. Scanning electron micrograph of the lower epidermis of *Clivia miniata* leaf showing two stomata and wax deposits

Stomata occurring in the lower, but not in the upper epidermis, are small pores in the epidermis, each surrounded by two guard cells *(Figures* 8a *and* b*)*. Changes in the shape of the guard cells allow the stomatal pores to open or close, allowing gasses, like carbon dioxide and oxygen, to pass into or out of the leaf.

The space between the upper and lower epidermis and traversing vascular bundle is filled with thin-walled ground tissue (mesophyll) cells containing **chloroplasts** *(Figure* 8a*)*. The chloroplasts contain the green pigment, chlorophyll that can absorb the energy from sunlight and convert it into chemical energy. The latter is utilised by the leaf for synthesizing carbohydrates from carbon dioxide and water through the process of photosynthesis. Carbohydrates are the source of energy for the plant and are utilised for respiration, growth, flowering and fruiting. *Clivia* has a very effective photosynthetic system and can cope with relatively low light intensities.

Stomata play a major role in photosynthesis in the sense that if the stomata are closed, no carbon dioxide can move into the leaf, resulting in the cessation of photosynthesis.

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 of water and nutrient flow from the roots to the leaves, and to the opening status (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 substrate water solution, through the roots to the leaves and 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 of 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, but 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. This is particularly so in the case of *Clivia* plants having roots with a velamen.

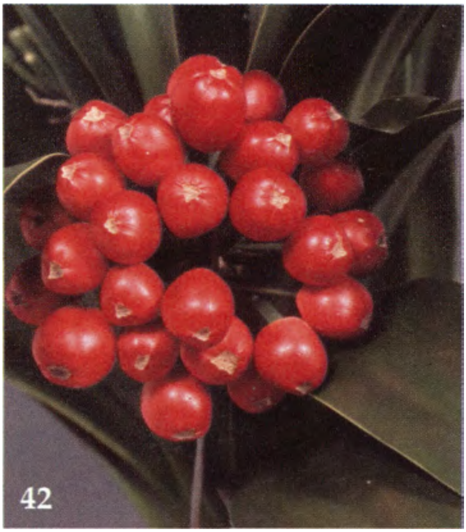
Foliar feeding

In addition to the uptake of nutrients by the roots, plants can also take up nutrients through the leaf cuticle. 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. As they become too old, the stomata are covered (blocked) by the thickening cuticle, resulting in loss of function, followed by senescence and death of the leaf.

[C. *miniata x C. gardenii*] x [C. *caulescens* x C. *gardenii*] 'Golden Sunset'. Breeder: Y. Nakamura. Grower: Mick Dower

C. *nobilis*. Grower: Norman Weitz

C. *miniata* winner first flower section and runner up - Best on Show CC 2001. Breeder: Pen Henry. Grower: Ian Brown



C. *miniata* with berries section winner NC 2001 Grower: Dawie van Heerden

C. *miniata* ' Nico's Dream' first flower.
Breeder: Neels Carstens. Grower: Johan Botha

C. miniata winner short, broad leaf with flower section and runner-up Best on Show NC 2001.
Grower: Pikkie Strumpher

C. miniata winner any other colour section CC 2001 Breeder: Y. Nakamura.
Grower: Charl Malan

C. *miniata* variegated yellow. Breeder: Christo Lotter. Grower: Norman Weitz

THE IDEAL pH AND NUTRITION FOR CLIVIA

Pierre de Coster, Belgium

The pH scale shows the acidity or alkalinity of the growing medium. The scale ranges from 0 to 14 with the neutral point at 7. The lower the number is below 7, the higher the acidity; conversely the higher the number is above 7, the higher the alkalinity.

Experience has taught us that Clivia can tolerate a wide scale of pH -let us say from 3.5 to 6.5.

Above 6 their growth becomes stunted and there is yellowing of their leaves.

I experienced that myself last year, and a fellow grower experienced major problems in the same year at 6.2.

It is important that the potting mix has the correct pH right from the inception of the plant's growth. Management of the pH is a problem because it is not easy to fix it for every individual pot.

We should aim for a pH of 4.3 to 5.5.

I estimate that for the average potting mix of pure peat and peat with pine needle compost 3.0 to 3.5 kg calcium carbonate is required per cubic metre of mix.

I no longer use pine needle compost but rather a mixture of coconut fibre and peat and compressed peat pieces.

Our calcium fertilizers in Belgium have varying compositions. They are all based on calcium carbonate but some contain in addition 3% to 30% of magnesium carbonate. These are to be preferred because not only do they provide essential magnesium, but magnesium carbonate is 5 to 6 times more soluble than calcium carbonate. Thus 1 kilogram of magnesium carbonate will neutralize more acid than 1 kilogram of calcium carbonate and is therefore more effective in raising the pH.

Nutrition

I referred the editors to the article written by Marc Vissers on the roles played by the various elements of nutrition in the life, growth and health of a plant, which was made available to them with his consent.

However, it has always been difficult to establish the ideal feeding program for *Clivia* because they respond slowly and not always clearly. My target figures are:

pH of H_2O 4.50 to 6.0
Conductivity 200 to 400

milligrams per litre potting mix	
N	30.00 to 140.00
P	min. 30.00
K	150.00 to 250.00
Ca	400.00 to 1200.00
Mg	150.00 to 250.00
Fe	min. 1.00

C. miniata 'Shaja Moja'. Winner - pot plant section NC 2001 Grower: Dawie van Heerden

BEST ON SHOW

Winner *C. miniata* yellow section and Best on Show CC 2001 Breeder: Y. Nakamura Grower: Charl Malan

Winner C. *miniata* yellow section and Best on Show KZN 2001 'Watkins Yellow: Golden Glow' Breeder and grower: Natal National Botanical Garden

BEST ON SHOW

Winner C. *miniata* broad petal yellow section and Best on Show NC 2001. Breeder: Y. Nakamura. Grower: Bertie Guillaume

C. *miniata* Metro Interest Group Best on Show 2001. Grower: Tino Ferero

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FROM THE HABITAT

C. miniata. Grower: Clivia Unlimited

Winner broad leaf variegated *Clivia minata* in flower class NC2001 Grower: Ammie Grobler

C. *miniata* Meier Green'. Winner most unusual flower section NC 2001, Breeder: Hermann Meier. Grower: Peter Grey

C. *miniata* 'Harlequin' Breeder and grower: Roly Strachan

C. miniata yellow 'Akebono' class winner Northern KZN Interest Group. Growers: James and Connie Abel

C. *miniata* yellow broad leaf
Breeder and grower: Hein Grebe

Clivia caulescens Grower: Loukie Viljoen

Clivia nobilis section winner
NC 2001 Grower: Annetjie Holtzhauzen

C. *miniata* 'Chiffon'
Breeder and grower: Roly Strachan

Clivia caulescens
Grower: Claude Felbert

THE ROLE PLAYED BY THE VARIOUS ELEMENTS OF NUTRITION IN THE LIFE, GROWTH AND HEALTH OF PLANTS

Marc Vissers, Belgium

[*This article is a summary by us of extracts from a more detailed technical paper, preparedly Marc Visserjor the Experimental Nursery Bloemisterij, Belguim, as the first part of a Manual for serious plant growers. We have left out the more advanced chemical and other technical data but a full copy of the translation of the paper into English is available on request. Readers who are not at all technically inclined will benefit particularly from the very handy and practical diagnostic tables setting out the symptoms of and a key to the recognition of nutritional problems. These will be found in sections four and five. In section six we have also added a key for the symbols of the chemical elements referred to. Eds.*]

CONTENTS:

1. INTRODUCTION

Many symptoms of stress are seen in pot plants. While problems may arise due to spray damage, sunburn, desiccation, cold or frost, physiological effects etc., the most common cause is a surplus or deficiency of a specific nutrient.

Some understanding of the underlying theory is necessary for one to gain a better insight into nutrition and the problems that arise from a surplus or deficiency in specific nutrients.

2. THEORETICAL BACKGROUND TO THE VARIOUS ELEMENTS

IMPORTANT PLANT MATTER, MOLECULES AND ELEMENTS

Plants consist of 90% water and 10% dry matter.

The dry matter can be divided into organic and inorganic materials.

The greatest portion consists of complicated organic compounds which are formed from only C, H and O. These elements make up together 94% of the dry matter in plants. They are synthesized from water, H_2O (from the soil) and carbon dioxide, CO_2 (from the air.)

All the organic compounds are synthesized via the sugars that are formed during photosynthesis. These sugars are very soluble and are transported from the green parts of the plant throughout the whole plant. In various parts of the plant they are used in the synthesis of various organic molecules (complex sugars, proteins, fats, chlorophyll, ...).

The inorganic materials make up only 6% of the dry matter. The most important element of these is N that occurs *inter alia* in the living plant material (proteins). Sulphur is also an essential constituent of proteins. But after these, also Mg and Fe (leaf formation), Ca and K (cell membranes) and P (energy storing and release) are absolutely essential for complete plant development. These are the major elements.

All these elements must either be present in the soil or must be supplied through fertilization.

In order to appreciate the functions of the various elements it is important to know the structures of the important plant molecules in which they are incorporated.

C. *miniata* 'Inspiration' Grower: Keith Rose

The following plant constituents are discussed:

- Protein molecules.
- Polysaccharides or sugar molecules.
- Fats.
- Chlorophyll or leaf pigment.
- ADP- and ATP-molecules.
- RNA- and DNA-molecules.
- Hormones.
- Enzyme activators and Coenzymes.
- Polyvalent elements.
- The most important element in the cell sap: K.
- The most important element in the cell structure: Ca.
- Summary of components and composition of plants.

Protein molecules

Importance:

The dry matter of the living part of every cell consists especially of proteins. These proteins are essential components of the living organism. **They determine to a large degree the cell structure** and also **control all chemical reactions** in the cell: enzymes are indeed also proteins.
Absorbed nitrate, sulphate and carbon are converted to form amino acids which are joined together to form peptides. Various polypeptide chains together form a protein. The promoting elements are Mn and Mo.

Polysaccharides

Importance:

Polysaccharides or sugars are firstly important energy sources for plants: they are produced during photosynthesis (trapping of photoenergy) and its consequence, all energy rich compounds which can be broken down (= oxidized) during respiration to make available chemical energy. This energy is necessary for all life processes in the plant, for heat production by the plant, for growth (mechanical energy: roots must thrust channels in the soil, leaves must develop from buds,. . . .).

Polysaccharides are essential to the plant for the construction of cell structures: cellulose chains give strength to cell membranes.

The sugar content of fruits is also determined by them.

Elements:

They are formed from C, H, and O and accordingly are also known as carbohydrates. The majority of sugars are very soluble and are thus readily distributed throughout the plant.

Promoting elements:

- Mg and Mn derive importance from being constituents of enzymes that regulate carbohydrate metabolism (eg. with Mn deficiency sugar deficiency occurs in roots).

- B not only is involved in sugar synthesis but also in phloem transport to the growth points, fruits and leaf nodes, ...

Since the formation of elementary sugars only takes place in the green parts of the plant, these must be transported throughout the plant to the non-green parts.

Fats

Importance:

Both fats (many single bonds) and oils (many unsaturated bonds, double bonds,. . . .) occur in the cytoplasm of plant cells. On one side they serve as an energy source when too few sugars are available while on the other they are important in cell walls as phospholipids.

Some lipids can also determine the colour of plant parts, e.g. carotenoids (the orange colour of carrots).

C.miniata Breeder and grower: Y. Nakamura

C. *miniata* variegated Breeder: Y. Nakamura

Chlorophyll, green leaf pigment

Importance:

This molecule belongs to the group of pigments and consequently results in the colour of plants; more specifically, **chlorophyll a** is responsible for the **green colour** of plants. Furthermore, chlorophyll is of crucial importance for photosynthesis. It can absorb light energy.

Composition:

The chlorophyll molecule is composed of C, H, O, N, and Mg. Mg is the central atom and a deficiency of Mg or N therefore manifests itself immediately as a lighter green plant colour.

Synthesis:

In the formation of chlorophyll, Fe is also important because Fe is a constituent of the enzymes that stimulate the formation of the pigment.

ADP- and ATP-molecules

Importance:

The molecule ATP is responsible for the trapping of light energy as chemical energy (photosynthesis) and for the energy transport in the plant (ATP is released during respiration). Without this molecule energy transport to the various parts of the plant would be endangered and the life processes and movements of the place could not take place.

Elements:

These molecules are composed of the elements C, H, O, N, and P and P plays a crucial role.

Synthesis:

ATP or adenosine triphosphate that is available for plant processes principally formed during respiration *(see p.* 50*)*. ATP is the molecule, which stores light energy in the form of chemical energy.

RNA- and DNA-molecules

= ribonucleic acid and desoxyribonucleic acid

Importance:

These molecules determine the genetic structure of every plant: every plant has a different DNA composition.

Elements:

There are five elements, C, H, O, N and P.

Promoting elements:

-Mg is a constituent of the enzyme RNA-polymerase that produces RNA.

-B is also important in the formation of nucleic acids.

C. *miniata.* Grower: Bertie Guillaume

Hormones

Importance

Various hormones function within the plant as growth and flowering regulators. They participate in various conversion processes within the plant such as protein synthesis, respiration, etc.

Elements:

Their elements are, C, H, O, N and CI.

Promoting elements:

-Zn is necessary for the formation of IAA (indoleacetic acid) and B drives the breakdown of IAA.

-Mo is necessary for the formation of ABA (abscisic acid)

Well known hormones:

N-containing:

-Indoleacetic acid (IAA) for the promotion of growth and root formation. Influence on cell stretching = auxine

N-free:

-Naphthylacetic acid (NAA): promotes root formation.

-Gibberellic acid (GA): promotes growth in height and flowering.

Interspecific *Clivia* 'Apricot Flush'. Breeder and grower: Brian Tarr

Interspecific *Clivia* 'Pink Sensation'. Breeder and grower: Wessel Lotter

Enzyme activators and Coenzymes

Activators: Many free metal ions (cations) can activate enzymes. Among these Mn^{++}, Co^{++}, Mg^{++}, Zn^{++}, Mo^{6+} and Ni^{++} fulfil this role.

Coenzymes: Many enzymes require for their activity the presence of coenzymes; these are mostly complicated organic compounds containing metal ions: Fe, Cu, Zn, Mo, ...

Polyvalent elements

In photosynthesis elements having many valency states are very important:

-iron: Fe^{2+} and Fe^{3+}
-copper: Cu^{+} and Cu^{2+}
-manganese: Mn^{2+},. Mn^{3+}, Mn^{4+}, Mn^{6+}, Mn^{7+}
-molybdenum: Mo^{2+}, Mo^{6+}

These have the capacity to oxidise or reduce and thus transport electrons to other compounds. This electron transport is necessary for photosynthesis.

The most important element in the cell sap: K = not incorporated in plant molecules

By far the most important element in this connection is K, which is present as the K^{+} -ion. The potassium ions remain in solution or occur adsorbed on specific plant structures. It thus accounts for a great deal of the salt concentration and consequently the osmotic pressure of the cell sap (together with the other ions in solution), and it is hereby very important amongst other things for the water balance of plants. Nitrates and chlorides also play a major role in osmoregulation.

The most important element in the cell wall: Ca

Ca strengthens the cell wall by making bridges between the phospholipids and other cell wall materials. Furthermore this element, together with K, determines the distribution of load on the cell wall and the porosity.

In addition the carbohydrates are also important in membrane formation; only water soluble sugars are suitable for this, namely cellulose chains (one talks of cell material), The cell wall must not be subject to degradation. In contrast to reserve sugar chains such as starch, cellulose is very stable (does not react easily with other materials, does not dissolve).

K, Mg, and B also play an important role in the formation of the cell wall.

Clivia miniata 'Ramona'. Breeder: Dave Conway Grower: Hugh Bollinger

Clivia miniata 'Quin's Moon'. Class winner KZN 2001. Breeder: Y. Nakamura Grower: Pat Quin

Summary of components and composition of plants

Table 1 below presents a collective summary of the different plant molecules or elements discussed.

Important components and molecules	**Constituent elements**	**Anabolic elements (promote formation)**
1. Proteins, Enzymes	C, H, O, N, S, (P)	Mn, Mo
2. Polysaccharides, Sugars	C,H,0	Mg, Mn, B
3. Fats, Oils, Lipids	C, H, O, P	Fe
4. Chlorophyll, Green leaf pigment	Mg, C, H, O, N	Polyvalent elements
5. ATP	C H, O, N, P	Mg,B
6. DNA	C H, O, N, P	Zn,Mo
7. Hormones	C, H, O, (N, Cl)	
8. Enzyme activators and Coenzymes	Mn^{++}, Co^{++}, Mg^{++}, Zn^{++},Mo^{6+},Ni^{++} Fe, Cu, Mn, Mo	
9. Polyvalent elements	Fe, Cu, Mn, Mo	
10. Most important ion(s) in cell sap	K^{+}, ($N0_3$", Cl")	
11. Most important element(s) in cell wall	Ca (P, C, H, O, Mg, B)	

From the summary the enormous importance of the elements C, H and O that occur in all plant molecules is apparent. N also occurs in most of the important molecules.

IMPORTANT LIFE PROCESSES IN THE PLANT

General

The plant uses solar energy to synthesize sugars from primary materials, water and CO_2 (photosynthesis = trapping of solar energy and sugar synthesis).

Everything that lives must respire, also the plant. The synthesized sugars serve this purpose. During respiration they are broken down and the plant gains energy for its activities, such as plant development, chemical reactions in the plant, heat maintenance, etc.

(respiration = breakdown of photosynthesised sugars with the release of chemical energy).

Note: both unsuitable simple sugars, also complex sugar molecules and even synthesized fats are employed in respiration; in emergency situations even proteins can be respired.

Not all sugars formed during photosynthesis are consumed in respiration. The surplus sugars (residual sugar) can be used for increasing dry material and thus growth. During growth the plant produces more sugar than it uses (growth = conversion of residual sugar to new plant molecules

[= new plant dry matter], with the energy derived from respiration).

During growth various materials are formed: complex sugars (sugar synthesis), also other carbohydrates including acids and fats (fat synthesis), and also proteins; the protein synthesis is similarly indirectly linked to the sugar cycle.

For rapid growth a great deal of photosynthesis (sugar formation) and respiration (sugar breakdown but energy production) must occur. Photosynthesis occurs only in the presence of light (thus during the day) and only in the green parts of the plant. Respiration processes take place day and night in the whole of the plant.

Growth = Photosynthesis - Respiration

Consequently, for growth to occur there must be more photosynthesis than respiration. It is therefore important to accelerate photosynthesis by providing higher temperatures during the day (primarily for photosynthesis) than in the night (for only respiration).

Summary of various life processes in the plant.

Photosynthesis: Conversion of light energy into chemical energy, sugar formation

Basic reaction: coupling of carbon dioxide and water to form simple sugars.

The importance of polyvalent elements in photosynthesis:

The presence of various polyvalent elements promotes the light reactions in photosynthesis, e.g. Fe, Mo, Cu and Mn *(see p. 48).* These function as intermediaries in the electron transport that takes place in the light reactions.

When and in what parts of the plant does photosynthesis occur:

Plants photosynthesise only by day or with artificial illumination.

Photosynthesis only occurs in the green parts of plants with large surfaces (especially leaves),

- to a lesser extent in green parts with a smaller surface (thick plant parts, or yellow / patchy leaves, growth points,. . . .)

- never in roots and other non-green parts: flowers.

Distribution of sugars to the roots and other non-green parts is consequently necessary.

Respiration:

Conversion of various energy rich compounds (sugars, fats, ...) to energy-poor compounds, with release chemical energy.

This energy can be used by the plant for:

chemical activity (reactions)

mechanical activity

heat regulation in the plant

When and in what parts does the plant respire:

Plants respire both by day and by night.

Respiration occurs in all parts of the plant. Both green and non-green sections use energy for their growth and consequently must respire (= energy release). Deficient sugar synthesis or transfer will result in much faster growth retardation or die-off in the non-green sections because, with disruption of the sugar reserves, these will not grow or life-critical proteins will be broken down.

Protein Synthesis:

That is conversion of absorbed nitrate/ sulphate / carbon to proteins, *(see p.*45*)*

Polysaccharide Synthesis:

Conversion of absorbed carbon / water to complex sugars, *(see p.* 45*)*

Fat Synthesis:

Conversion of simple sugars to fats, *(see p.* 46*)*

Clivia miniata runner up any other colour section CC 2001. Breeder: Y. Nakamura Grower: Charl Malan

Clivia miniata winner narrow variegated leaf in flower section NC 2001. Grower: Rory Niven

3. FUNCTIONS OF THE ELEMENTS (Table 2)

The majority of elements have multiple functions in the plant. Table 2 presents a condensed summary of the important functions by element.

ELEMENT	FUNCTION IN THE PLANT
Nitrogen (N)	quantitatively the most important element, especially important during the vegetative growth phase the most important constituent of living plant material, namely proteins and enzymes constituent of leaf green (chlorophyll molecule) and thereby responsible for the green plant colour and photosynthesis constituent of DNA (genetic material), vitamins, ATP (energy transport), ... Nitrates play a part in osmoregulation
Phosphorus (P)	especially important during rooting, also after flowering when more phosphorus is necessary P is a constituent of the most important energy transporter in the cell, namely the ATP molecule (without energy no life processes in the plant!) P forms strong bonds with C atoms (C-P-C bonds): these are important in the structure of the cell wall, and of the DNA molecules P is also a constituent of some proteins, and of importance for the formation of some enzymes
Potassium (K)	together with N quantitatively the most important element, especially important for flowering. K is the principal element that determines the strength and porosity of the cell wall, and gives resistance to adverse conditions K has a regulating function in maintenance of water balance: it controls the osmotic pressure of the cell sap and the opening and closing of the stomata K provides a better utilization of light energy during photosynthesis, and makes possible the transport of the synthesized sugars in the plant many enzymes function only in the presence of K

ELEMENT	FUNCTION IN THE PLANT
Magnesium (Mg)	Mg is the central atom in the chlorophyll molecule (leaf green), and thereby is essential for photosynthesis and therewith for the green leaf colour Mg is of importance for internal ion- and energy transport; it promotes the mobility of phosphates, so also that of the ATP molecule. Mg is part of enzymes acting as intermediaries in the carbohydrate cycle. A deficiency of Mg results in a sugar deficiency and this manifests itself in the non-green portions (such as roots and fruits, with consequent root inhibition)
Calcium (Ca)	Ca is very important for the structure and porosity of the cell walls Ca stimulates a limited number of enzymes, *inter alia* those functioning as intermediaries in respiration (= energy release)
Iron (Fe)	Fe stimulates some intermediary enzymes in the synthesis of chlorophyll, and is thereby indirectly of importance for photosynthesis Fe is one polyvalent ion that can switch valency (2^+ and 3^+). Thereby the element is involved in electron transport during photosynthesis Fe is important for root meristem growth
Manganese (Mn)	Mn is like Fe a polyvalent ion that can switch valency (2^+ and 3^+). Thereby it is involved in electron transport that occurs in photosynthesis Mn activates various intermediary enzymes in protein synthesis (it promotes nitrate reduction and the conversion of nitrites in amino acids Mn deficiency raises nitrate levels in the leaves just as Mg, Mn also forms part of enzymes that control carbohydrate metabolism; a Mn deficiency results in a sugar deficiency in the roots Mn also activates the enzyme that breaks down IAA

ELEMENT	FUNCTION IN THE PLANT
Boron (B)	B is directly involved in the synthesis of the enzyme that controls cell division, it inhibits the breakdown of the growth hormone IAA, and is thereby extremely important for root formation and the activity of the growth points B is essential for healthy cell walls; it stabilises cell wall structures, stimulates wood formation and thereby *inter alia* is responsible for increased resistance, e.g. frost resistance of fruit. B is responsible for starch as well as sugar synthesis in sugar transport (via phloem to the growth points *inter alia)',* thereby it increases the sugar content of fruits and tubers. B stimulates the growth of tubers, flower- and pollen production, promotes the fertility of pollen, B is also important in the synthesis of nucleic acids (RNA, DNA)
Molybdenum (Mo)	Mo activates 2 enzymes that are responsible for nitrate incorporation (- nitrate reduction) in amino acids (lowers the nitrate concentration in the plant, raises the protein concentration). Mo is also of importance in N fixation Mo is a polyvalent ion that can switch valency (2^+ to 6^+). Just as Fe is the element involved in photosynthesis. Mo is a catalyst for various enzymes, and is *inter alia* also necessary for the formation of the hormone ABA
Sulphur (S)	S is the least known major element and is important in the young plant stage It is a component of proteins (disulphide bridges bind amino acids together) and is thus very important for protein synthesis In S deficiency the starch concentration is raised because the carbohydrate metabolism is slowed down (less breakdown of starch reserve)
Zinc (Zn)	Zn is necessary for the formation of the growth hormone IAA, indoleacetic acid, that is responsible for the stretching of the side- and middle veins of leaves Zn activates some intermediary enzymes in protein synthesis (peptidase, proteinase, ... = breakdown of proteins)

ELEMENT	FUNCTION IN THE PLANT
Copper (Cu)	Cu is thanks to its polyvalency (just as Fe, Mn and Mo) important for reactions in electron transport as in photosynthesis. Cu is necessary for lignification of plant parts (wood formation) and thereby improves the strength of plants Cu also functions as intermediary in hormone maintenance (auxin formation) and thereby stimulates germination and growth. further, Cu is of importance in the synthesis of vitamins, and as intermediary in carbohydrate- and N metabolism
Sodium (Na)	Na is of importance in tissues with a special photosynthesis system (C4, CAM).
Chlorine (Cl)	Cl is of importance in osmoregulation and in the maintenance of cell electrical neutrality in the plant Cl also plays a part in photosynthesis, in particular in the oxygen production reaction Cl is also a component of specific hormones

Clivia miniata orange broad tepal section NC 2001. Grower: Bertie Guillaume

Clivia miniata Topaz Dream'. Grower: Keith Rose

Clivia miniata x *denii*. Breeder and grower: Norman Weitz

Interspecific *Clivia* 'Orange Belle'. Breeder and grower: Brian Tarr

4. SYMPTOMS OF DEFICENCY AND SURPLUS, + RISK FACTORS (Table 3)

For the cultivator it is in the first place interesting and important to know whether he has either a deficiency or a surplus problem. Therefore we compiled a summary in which we present per element how the nutrition problems are manifested and where on the plant they occur. Together with this the risk factors are presented.

A possible rule-of-thumb for deficiency effects is the following:

- the major component elements N, P, K en Mg are very mobile in the plant and appear first in the older leaves! This applies also to Mn^{+}.

- the trace element deficiency as well as the calcium deficiency are seen mostly in the younger leaves.

- surplus effects are seen mostly in younger leaves; this is accompanied by a secondary calcium-, iron- or magnesium deficiency. Occasional B, Cl, Mn surplus is seen mostly in older leaves.

	DEFICIENCY		SURPLUS	
ELEMENT	SYMPTOMS	RISK ENVIRONMENT	SYMPTOMS	RISK ENVIRONMENT
Nitrogen (N)	•light green colour old leaf; later whole plant •much root growth	•winter: little fertilization mixing of organic matter in the soil	•dark leaf •less rooting •excessive plant growth	•too intense N fertilization
Phosphorus (P)	•less rooting •red colour in old leaf (sometimes blue-green)	•high pH, excessive liming • after cold or drought •beginning of cultivation: greatest necessity	• dwarf growth (short stem, small leaf (=Zn deficiency)	•Uncommon, only in soil cultivation
Potassium (K)	•yellowing of old leaf edge • incomplete / slow flowering	•winter: little fertilization •high N, Ca, Mg-fertilization •end of cultivation: greatest necessity	•yellowing of old leaf (Mg deficiency) •yellowing of young leaf (Ca deficiency) • fewer leaves	•excessive K fertilization
Calcium (Ca)	•leaf edge necrosis to yellowing of young leaves (beginning at tip) •transparency in leaf • die-back at growth points	•dark, low humidity weather •much K, NH4	•yellowing of young leaf (Fe deficiency)	•pH too high
Iron (Fe)	•yellowing of young leaf between veins (over whole leaf)	•high pH •much Ca, Cu, Mn, Zn •wet cold soil	•red leaf edges and veins	• excessive foliar Fe fertilization

	DEFICIENCY		SURPLUS	
ELEMENT	SYMPTOMS	RISK ENVIRONMENT	SYMPTOMS	RISK ENVIRONMENT
Manganese (Mn)	•yellowing of old leaves between veins (locally in leaf) •less root growth	•high pH •much Ca, K •wet cold soil	•purple brown spots in old leaf (later in leaf edges) •later yellowing of young leaf (Fe deficiency) •bushy growth	•very low pH
Boron (B)	• non-developing growth point •malformed leaves beginning at base in young leaf	•high pH •high Ca values •boron free cultivation	• leaf tip necrosis in old leaf (leaf edge necrosis)	•low Ph, little Ca •bad irrigation water / fertilizers
Molybdenum (Mo)	•light green colouration of young / old leaf =N deficiency •long small leaves, rank form •inhibited rooting	•low pH = the acid sickness		•does not occur
Sulphur (S)	• complete yellowing of young leaf (veins more transparent than leaf pulp	• only in soil culture	•dark colour •less root growth causes marked pH decline	•bad fertilizers or irrigation water
Copper (Cu)	•rigid growth yellowing to dark blue-green colour & curling of young leaf • die-off of buds •meristem necrosis - bushy growth	•high pH •too much Ca	• dwarf growth; •reduced root growth •yellowing of young leaf (Fe deficiency)	•low pH
Sodium (Na)			• growth inhibition	•bad fertilizers or irrigation water
Chlorine (Cl)			•rooting inhibition •leaf edge necrosis in old leaf •dark colour	•bad fertilizers or irrigation water

5. KEY FOR RECOGNITION OF NUTRITION ABERRATIONS (Table 4)

To simplify diagnosis we have compiled a recognition key that depicts stepwise each nutrition problem that may be encountered. We start in the first instance with the whole effect one sees (leaf edges or total leaf colour), and look thereafter in which leaves the effect occurs (young or old). As a third direction indicator we take the potting soil pH in the event that it explains the possible cause and in the event that the pH can be measured by the cultivator himself.

One then has an indication of the possible cause pending the results of laboratory analysis of the leaf.

APPEARANCE	LOCATION	pH POTTING SOIL	CAUSE	COMMENT
Leaf edges Leaf tips	young leaf	low pH	-Ca(+K+Mg) -Zn	low pH = little Ca, mostly in dark periods leaf edge necrosis + yellowing
	old leaf	low pH	+B	necrosis of the lower leaves proceeding upward
		low + high pH	-K	chlorosis of the leaf edge
Leaf bleaching (yellowing or light green colour)	young leaf	low pH	(-Mg) -Ca(+K+Mg)	(yellowing from underneath leaf edge between veins transparency: light patches in leaves
		high pH	Fe (+Ca) (+Mn+Zn+Cu) -S	yellowing over whole leaf (between veins) complete yellowing of leaf + veins (similar to N deficiency
	middle young leaf	low pH	-Mg(+K)	yellowing from underneath the leaf edge (between veins)
	old leaf	low pH	(-Mg)	yellowing from underneath the leaf edge (between veins)
		high pH	-Mn(+Ca) (+Mn+K+Fe)	localised yellowing (between veins)
		low + high pH	-N	light green leaf colour, extensive root system
	young and old leaf	low pH	-Mo	light green leaf colour, poor roots
		low + high pH	(-N)	(light green leaf colour, extensive root system)

APPEARANCE	LOCATION	pH POTTING SOIL	CAUSE	COMMENT
Other colorations	old leaf	low pH	+Mn (-Ca)	purple brown patches
		high pH	-P (+Ca)	red colouration (sometimes blue-green) old leaf, less rooting immediately after cold period
	young and old leaves	low pH	-S	dark coloured leaf, fewer roots, growth inhibition
		low + high pH	+N	dark coloured leaf, fewer roots, growth inhibition, weak luxuriant growth
Other effects	growth point	low pH	-Ca (+K +Mg)	die-off of growth point
		high pH	-B (+Ca) - Cu (+Ca)	die-off of growth point meristem necrosis
	young leaf	high pH	- B (+Ca)	leaf malformation, starts from the base
	young + old leaves	low pH	- Mo (+NO3)	small irregular leaves
	whole plant	low pH	+ Mn (-Ca) + Cu (-Ca)	bushy growth dwarf growth
		high pH	- Cu (+Ca)	bushy growth, premature spiking
		low + high pH	- Zn, +P	dwarf growth
	flowering	high pH	- P (+Ca) - Cu (+Ca)	irregular flowering bud die-off
		low+ high pH	- K (+N)	incomplete delayed flowering

6 TABLE OF CHEMICAL ELEMENTS REFERRED TO IN THIS ARTICLE

B	Boron	K	Potassium	O	Oxygen
C	Carbon	Mg	Magnesium	P	Phosphorus
Ca	Calcium	Mn	Manganese	S	Sulphur
Cl	Chlorine	Mo	Molybdenum	Si	Silicon
Cu	Copper	N	Nitrogen	Zn	Zinc
Fe	Iron	Na	Sodium		
H	Hydrogen	Ni	Nickel		

THE ROLE OF LIGHT (OR RADIATION) ON THE GROWING OF PLANTS

Dénis van Rensburg

Professor van Rensburg has a doctorate in Chemistry and retired as the Rector of Pretoria Technikon

Green plants possess the amazing ability to manufacture their own food through the process of photosynthesis. It is this basic process upon which the entire world of living creatures depends for its own food, either directly by eating plants, or indirectly, by feeding on other organisms that have fed on green plants. The process of photosynthesis, or the manufacture of food using the energy of sunlight, is often expressed by this simple chemical equation:

PHOTOSYNTHESIS

Sunlight + $CO_2 + H_2O$ + Chlorophyll $\rightleftharpoons$ $C_6H_{12}O_6 + O_2$ (Glucose)+(Oxygen)

RESPIRATION

Green plants have the unique ability to utilize the gaseous carbon dioxide (CO_2) of the atmosphere, plus water (H_2O), in the presence of an energy source (sunlight) and chlorophyll (in the leaves of plants) to produce glucose ($C_6H_{12}O_6$), a kind of sugar that is a basic food for the plant) and give off oxygen (O_2) into the atmosphere as a by-product. The process of photosynthesis is much more complex than the equation would suggest, and a textbook published in 1992, telling the whole story required 21 pages to do so.

The important fact is that plants do not eat; we cannot 'feed' them. They **manufacture** their own food, beginning with the glucose produced during photosynthesis, and use the mineral salts in fertilizers (or the naturally occurring mineral salts in the environment) to complete the manufacture of food, to fabricate plant parts and to perform metabolic processes. A critical distinction between food and mineral nutrients, required by both plants and animals, is that food provides organisms with energy, minerals do not.

Carbon dioxide and water are the two **major** nutrients of plants and for plants to 'eat' or absorb these nutrients, **sunlight** (or the energy that is contained in sunlight) is absolutely necessary. But sunlight contains many different wavelengths or packets of energy. Just like a radio or TV set that only 'works' when it is tuned to a certain wavelength (or energy packet), so do plants only react to certain wavelengths and use that specific energy to manufacture food through photosynthesis. All the other light wavelengths are totally useless to the plant, and may even be harmful. In *Figure 1* all the wavelengths to be found in sunlight are shown. This wavelength range is commonly referred to as the 'electromagnetic spectrum'. From this figure it can be seen that the sunlight that reaches our plants or shade houses, apart from ordinary 'visible' light also contains X-rays, microwaves, radio waves, etc.

Because oxygen is produced when plants photosynthesise it is fairly easy to determine which wavelengths present in light are indeed preferred by the plant. All you need to do is to expose a plant to each different wavelength and measure the oxygen produced. If no oxygen is produced that specific wavelength has no effect on the chemistry of the plant. *Figure 2* shows such an oxygen versus wavelength graph for the Visible' light region.

Photosynthesis seems to be very high in the 'blue' and 'red' wavelength ranges and much less effective in the 'green' region, and absent in **all** the other wavelength regions.

This effect of light on photosynthesis or plant growth could have been deduced from the green colour of the leaves. The colour of an object arises when the object **reflects** those wavelengths present in visible light that it does not want or cannot use. If we pass light from the visible part of the electromagnetic spectrum through a prism we can 'see' all the coloured components of so called 'white light'. The red component has slightly less energy than the green, while the blue and violet components have the highest energy (lowest wavelengths) in 'white' light. *(See figure* 3.) Hence an object such as an apple will appear to our eyes as yellow because it absorbs all the other colours and only reflects the light it does not want - the yellow *(see figure* 4). An object appears red to our eyes because it absorbs or 'likes' all the other colours of the spectrum but 'hates' red and hence reflects it. A white object reflects **all** the colours and hence appears white, while a black object appears black because it absorbs **all** the colours. Hence, strictly speaking, black is not a colour! *(See figure* 5.) By the same argument green plants hate green light, therefore they reflect the green light and appear green to the human eye.

This brings an interesting aspect to the fore when it comes to the choice of shade cloth for your plants - green would not be the ideal choice but rather blue or red, when we consider the information in the 'production of oxygen' curve *(see figure* 2).

Due to the fact that the energy of radiation is inversely proportional to **wavelength,** UV-light will have more energy than white or visible light and causes much more damage to plastics, human skin and other substances. There is also more energy in 'blue' than red' light and blue light or shade cloth should in theory produce a little more heating in plants and the shade house than similar red shade cloth. Infrared light has low energy but the energy is sufficient to cause heating if absorbed. Due to their water content most plants are effective **reflectors** of infrared and are not greatly heated by it. Where shade cloth with a low percentage shade is used the colour of the cloth is not very important because more than adequate white light will reach the plants for photosynthesis - with high percentage shade the colour of the shade cloth does come into play.

Klein, Edsall and Gentile (1965) published an interesting paper on the effects of near UV and green light on plant growth. The conclusions reached are that the **near UV and green wavelengths** are capable of **suppressing** the growth of plants which otherwise receive adequate levels of those wavelengths necessary for photosynthesis and normal development. Conversely the selective **removal** of near UV and green wavelengths from white light gave enhanced growth. From these scientific experiments it is evident that green shade cloth should as a matter of routine not be used as a covering in shade houses. Due to the total reflectance of white shade cloth varieties a **higher than normal** shade percentage should be used when the shade cloth is white.

The amount of pure sunlight needed by plants to manufacture their food has always been an unknown factor usually obtained by trial and error. What we usually observe when a plant is receiving too little light is that it may compensate by producing more light absorbing pigment - hence the leaves go darker green. It may also grow thin and leggy, trying to find light. It will probably not produce flowers or the flowers may be of poor quality. Conversely, if a plant is receiving too much light, it may try to adapt by reducing the amount of pigment - the leaves grow paler. If the amount of light is really excessive, the leaf-tissue will be destroyed and leaves are scorched, especially in those areas where the leaf surface is at **right angles** to the incident light.

THE EFFECT OF TEMPERATURE ON PHOTOSYNTHESIS

The effect of **temperature** on **photosynthesis** is a very important consideration. Though the photochemical reaction is not dependent on temperature the rate of photosynthesis does increase with increasing temperature. *Figure* 6 shows this effect.

While gross photosynthesis rises with temperature so does respiration and whereas the photosynthetic rate tends to flatten at about 25°C respiration continues to rise rapidly above this temperature. Consequently the net photosynthesis (the production of energy compounds **minus** their use by respiration including photo respiration) must be considered continuously. It can be even better understood if we add a curve depicting respiration rate against temperature to the one shown in *figure* 6. (see *figure* 7.) Respiration increases strongly with temperature (same as with us humans) and at temperatures above about 35°C all the food manufactured is used to support respiration. At temperatures higher than 35°C plants therefore use more food than they produce to respirate, which leads to deterioration and ultimate death (if the condition is allowed to continue for too long, of course).

In their natural habitats plants are subjected to a day and night temperature differential, and it is important to imitate this as far as possible. Photosynthesis is affected by temperature as well as light intensity. As long as it does not become too hot, the rate of photosynthesis, and hence growth, increases with rising temperature, but only as long as there is sufficient light (and carbon dioxide). Not only is there no point in increasing the temperature of the greenhouse beyond 25°C if there is not sufficient light it is positively harmful as the rate of photosynthesis will, even at 25°C, fall below the rate of transpiration.

Technically speaking, when gains due to photosynthesis match losses due to respiration, this is termed the 'compensation point'. The practical value of appreciating this is that if night-time temperatures are too high, plants will gradually become depleted of their glucose and starch reserves, as losses due to respiration regularly exceed gains due to photosynthesis during the day.

DIFFUSE RADIATION AND ALBEDO VALUES

Diffuse or sky radiation is that radiation which reaches the earth's surface after being scattered from the direct beam by molecules in the atmosphere or reflected from clouds or other objects. On clear days it increases with solar elevation up to 30°C but after this it remains constant. It is diffuse radiation which gives the light in **shaded areas** and this is the main source of light for *Clivia.*

Diffuse radiation is very important for places of **high latitude** where low solar elevations reduce the direct solar energy due to **thicker** atmosphere passage, hence more absorption. For example, in England diffuse radiation may contribute from 50 to 100% of the total radiation used by plants. Hence the typical English glasshouse has the maximum amount of glass in walls and roof to catch this omni-directional radiation.

In South Africa our proportion of diffuse radiation is much lower but we still build English-European style glasshouses, then promptly cover them with shade cloth to reduce the intense direct radiation on to the glass. What makes it even worse is that we use green shade cloth!

Figure 8 shows the various light inputs to a typical horizontal leaf. These are

- Direct radiation from the sun (S_A)
- Diffuse radiation from the sky (S_D) - on overcast days this may be the main source of light

- Both direct and diffuse light reflected from the ground: R (S_A + S_D), where R is the reflectance from the ground, or the **albedo** value. These albedo values can be of great help when we have a problem with too much or too little light.

In the case of *Clivia* we usually never have direct radiation falling on our plants, hence the light used by *Clivia* to photosynthesise mostly comes from diffuse radiation and reflected radiation (albedo) only.

Light reflectance (albedos) of certain surfaces

Surface	Reflectance
Dry soil : light colour	0.3
dark colour	0,15
Asphalt	0,05 to 0,2
Concrete	0,1 to 0,3
Brick	0,2 to 0,4
Glass - sun angle 60° +	0,08
- sun angle 10° - 60°	0,09 to 0,56
Whitewash	0,5 to 0,9

Table 1 indicates the albedos of certain common surfaces.

The higher the albedo value the better the reflectance of the surface.

Remember that the radiation energy (or light) we measure at our *Clivia* will be the 'combined effort' or **sum total** of all the diffuse and reflected radiation reaching the plants.

The correct unit to measure radiation energy is in watts per square metre (Wm^{-2}). Because foot candles make more sense to me and because my light metre is calibrated in foot candles, I will use this non-Si unit. Just to give some idea of the values involved on a clear day without too much smog, with a high sun angle (warm temperature or tropical) and little cloud we could have

S_A= 10,000 foot candles; S_D = 1,370 foot candles and albedo contribution = 1,580 foot candles.

The rate of photosynthesis is proportional to the light intensity received by a plant up to a maximum of about 5 000 foot candles. At 5 000 foot candles most plants are at 100% photosynthetic efficiency and light intensity levels above this value are of little or no benefit and can only cause heat exhaustion and undue drying of the plant. The light intensity of a full sun on a clear day is approximately 10 000 foot candles - where a foot candle is the amount of light cast by one candle at a distance of one foot. At 5 000 foot candles most common **outdoor** plants are at **100% efficiency** and light levels above that can only lead to heat increase, plant exhaustion and undue drying of the plant. This value will be considerably lower for shade growing plants.

As a general rule *Clivia* can grow happily in a light intensity as low as 650 foot candles of **quality** light! An error I frequently make when measuring the light intensity near my plants is to assume that the reading represents that of **quality useable** light. If there are many trees nearby or green shade cloth is used, a fair percentage of the light reading will be due to 'green' or useless radiation, giving one a false sense of confidence about the intensity quality of the light.

PHOTOPERIODISM

Plants of our temperate zone can be categorised into short-day neutral and long-day plants. The dividing line between day lengths favourable to vegetative growth and those to cause seed and flower formation is called the **critical light** period. For most species the critical light period is between 11 and 16 hours per day.

The intensity of the light and the duration of exposure combine to let us know the **quantity of light** received by the plant. As a general rule the intensity of 1 000 foot candles is the **minimum light intensity** for ordinary plants and the **minimum quantity** of light is 15 000 foot candle hours (light intensity multiplied by the duration of exposure in hours).

The relative length of the daily light and dark periods controls flowering of many kinds of plants. This phenomenon is called **photoperiodism.** Hence photo-periodism is the length of time a plant is exposed to light. Some plants, such as certain varieties of *Chrysanthemum, Poinsettia,* morning glory, are short-day plants and flower in nature only when the days are short and the nights are long. Certain varieties of spinach, beet, barley, and tuberous-rooted begonia are examples of long-day plants, which flower in nature only when the days are long and the nights are short. Flowering of many other kinds of plants is hastened but not absolutely controlled by the appropriate day length.

Bulbing and tuber formation are also controlled by day length. Tuberous-rooted begonia, which is a long-day plant for flowering, produces tubers on short days but not on long days. Onions, on the other hand, produce bulbs on long days but not when the days are short.

Dormancy, and thereby the preparation of woody plants for the coming winter is another plant response regulated by photo period. Even in a warm hothouse many plants can be stopped from becoming dormant by using artificial light to keep the days long.

Responses of many plants are regulated not by the length of the light period but actually by the length of the dark period. Thus, a long-day plant is really a short-night plant, and a short-day plant is really a long-night plant. Therefore, when a long dark period is broken into two short periods by a relatively brief exposure to light near the middle of the period, long-day plants bloom, dormancy in woody plants is prevented and onions produce bulbs. Under the same conditions short day plants remain vegetative.

This poses an interesting question : Is it not possible that the *Clivia* is also susceptible to photoperiodism? *Clivia miniata* flower in spring but many produce 'surprise' flowers in autumn at times when the days (and nights) are almost as long as in spring!

Quite an interesting thought to leave you with, isn't it?

Clivia miniata selection - Clivia Unlimited

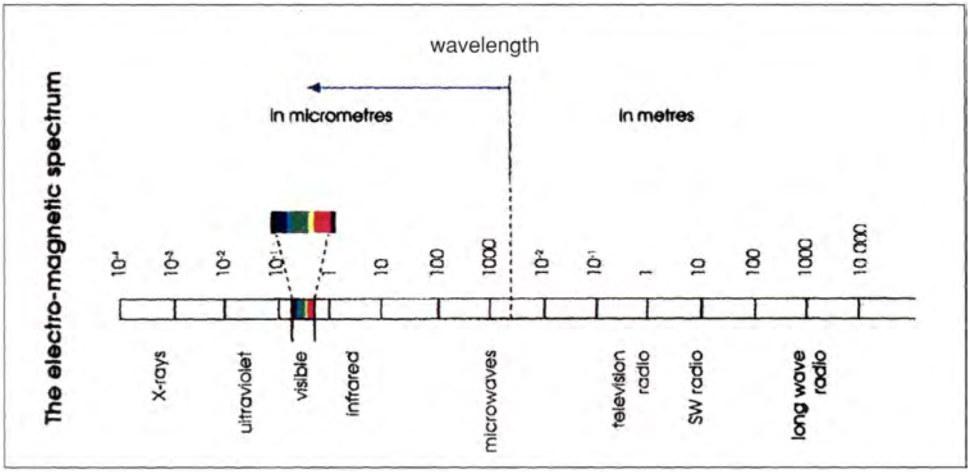


Figure 1: The electro-magnetic spectrum

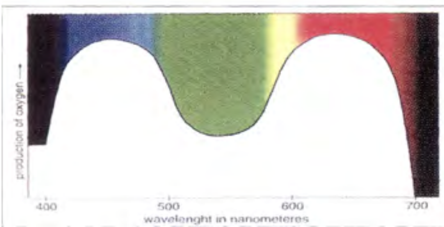


Figure 2: Photosynthesis *vs* colour (action spectrum of a typical leaf)

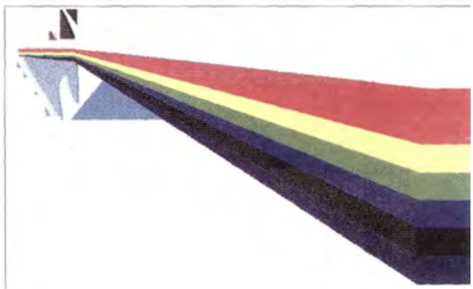


Figure 3: Reflection of 'white' light through a prism

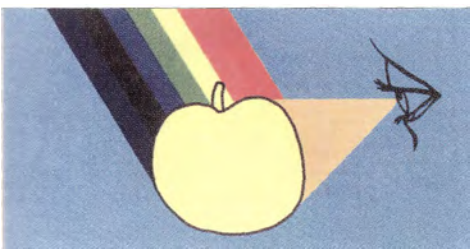


Figure 4: An apple appears yellow because it reflects the yellow wavelengths that it does not need for it's chemical reactions

Figure 5: Black is not a colour but only

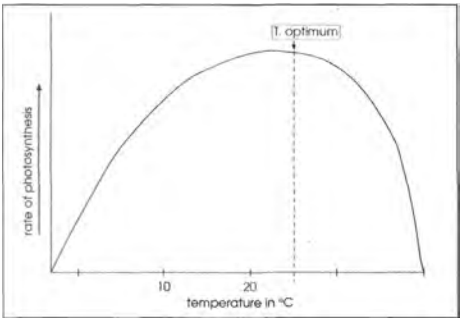


Figure 6: EFFECT OF TEMPERATURE ON PHOTOSYNTHESIS

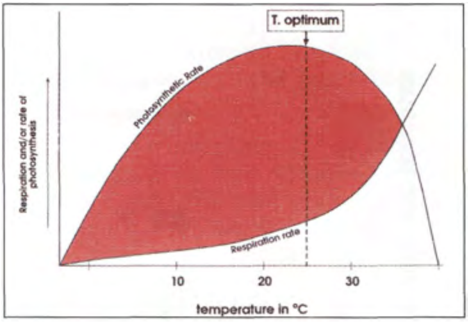
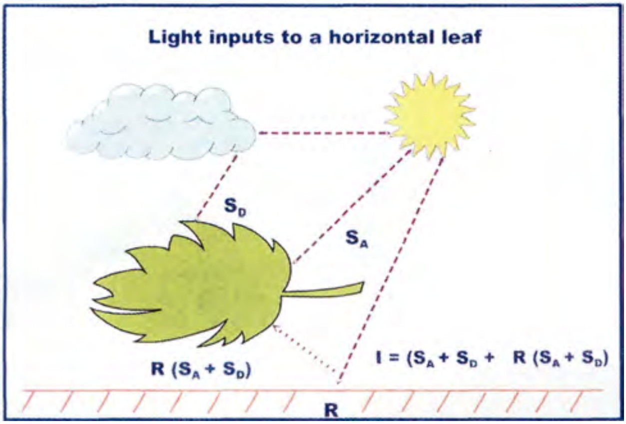


Figure 7: EFFECT OF TEMPERATURE ON PHOTOSYNTHESIS

Figure 8:



Interspecific *Clivia.* Grower: Bertie Guillaume

Clivia miniata var. *citrina.* Breeder and grower: Bing Wiese

PLANT DISEASES - NEMATODES

Sean Chubb

Leaf tip die back noticed in a large percentage of potted *Clivia* plants growing in a bark /sand mixed medium. Plants were taken for a diagnosis with Plant Aid Services.

Initially a bacterial infection was suspected but no significant bacteria (or fungi) in association with leaf lesions was found. On examination of the roots several parasitic nematodes were found. These were diagnosed as *Paratylenchus.* 83% of all nematodes found were of this species. The proportion of *Paratylenchus* sp. (common name = Pin Nematodes) was extremely high and was the major contributor to the symptoms. Nematodes are minute organisms not generally visible to the naked eye which feed on the sap contained within plant roots. The damage is seen as root knots. This damage can cause a drastic decrease in yield in commercially grown crops. All plants suffer to some extent if infested with nematodes.

The Pin Nematodes are a large group of external parasites of plant roots with a wide range of host plants. They are fairly common in South Africa, particularly from sugar cane fields in Natal. Thus the origin of the nematodes was probably the water source and the sand/soil mixed with the bark.

It was suggested that water used for irrigation might not be nematode free. The irrigation water should therefore be allowed to stand in a holding tank with minimum turbulence as Nematodes and their eggs have appreciable sedimentation rate and will sediment to the bottom of the tank. The outflow from the tank must be placed as high as possible so as to ensure minimum amounts of Nematodes in the water used.

According to Agrios (1997) chemical control is based on fumigants such as methyl bromide, cloropicrin, metam, sodium, dazomet, etc., broad spectrum nematicidal and insecticidal carbamates such as aldicarb (Temik™), carbofuran (Furadan™), etc., as well as organophosphate nematicides such as phorate (thimet), disulfoton (Disyston™), ethoprop (Mocap™), fenulfothion (Dasanit™), fenamiphos (Nemacur™) etc. Some organophosphate nematicides are available as water-soluble liquids or granules, have low volatility, can be applied before and after planting and are effective only against nematodes (Agrios 1997). Most nematicides are hazardous, broad spectrum and expensive.

This harmful nematode can also be controlled biologically with the fungi and other nemotodes which are its natural predators. These are found in natural organic matter which should therefore be added to the growing medium.

Recently a biological control product called Plplus™, has become available and the active ingredient is the fungus *Paecilnmyces lilacinus* strain 251. It may be tried in the soil around garden plants or in pots. Ensure that all *Clivia* are raised in previously unused growing medium.

Chemical control was administered on effected plants with little or no further leaf tip die back.

To avoid nematode(eelworm) infestation to Clivia *it is suggested that the following should be borne in mind:*

Use only organic material as a growing medium, such as composted milled pine bark and milled pine needles, which will reduce the prospect of nematode infestation.

Practise hygiene in growing areas by raising plants off the ground, providing efficient drainage and disinfecting areas where your plants stand.

Eds.

C. m*iniata* winner pink section NC 2001. Grower: Anna Meyer

C. *miniata* 'Oxblood' winner dark orange/red section NC 2001.
Breeder and grower: Louis Swanepoel

C. *miniata* yellow with persistent green throat.
Breeder and grower: Gerrit van Wyk

C. *miniata* best in red section CC 2001.
Grower: Gert Wiese

PESTS AND DISEASES AFFECTING CLIVIA IN SOUTH AFRICA

Henriëtte Ströh

We regard *Clivia* mostly as resilient, semi-hardy and drought resistant plants. Their ability to thrive under a variety of conditions, some most unlikely, is commendable, but eventually some will fall victim to a disfiguring or even fatal pest or disease. To aid our beloved plants, we need speedy and accurate identification of these pests and diseases. An immediate response is necessary in order to minimise severe setbacks in our growing program or even the tragic loss of a rare or unusual cultivar.

Although not always perceived as being environmentally friendly, the ruthless measures taken to ensure the future existence of exceptional clones can be justified when the loss of rare colour forms and multi-petal mutations is at stake in our diverse *Clivia* gene pool.

In this article some chemicals might be mentioned that are not available at your gardening shop - these are probably not registered for home use. As many growers are in need of both nursery and agricultural chemicals both types will be mentioned in relation to various factors such as economy and severity of the problem as applicable to the home or commercial grower. In the text the active ingredients are italicised and brand names highlighted. Search deeply for the academic in you and read, as well as comprehend, the instruction leaflets included with all the chemicals. By simply not applying them during the heat of the day and not concocting your own version of biological warfare, by boldly mixing different chemicals you can avoid the very real danger of burning your plants *{figure.* 1*)*.

Figure 1 Chemical burn on Chinese raised tessellate surface leaves. At a recent lecture Prof. Hannes Robbertse mentioned the very thin wax layer found on the leaves of these plants

'Cocktails' are not recommended 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 LD50 mg/kg value. This simply means the amount of chemical needed (Lethal Dosage) in mg/kg body mass, which will kill off 50% of a population of test animals. The smaller the LD50 value in mg/kg the more toxic the chemical e.g. if a chemical has an LD50 value of 3mg/kg it means that only 3mg of chemical is needed for every kg of your body weight to kill you.

INSECTS AND PESTS

With the use of the naked eye, these can be identified and controlled in time to prevent devastation. Although not daunting in their diversity, these pests may be numerous, but effective control makes them the least of the grower's problems. Of all the different insects only a few are troublesome as pests on plants. Only these 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 acts in a totally different way. The systemic insecticide is absorbed by the plant and transported to all plant tissues. The sucking and chewing insect, wherever it may start, will be poisoned. 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.

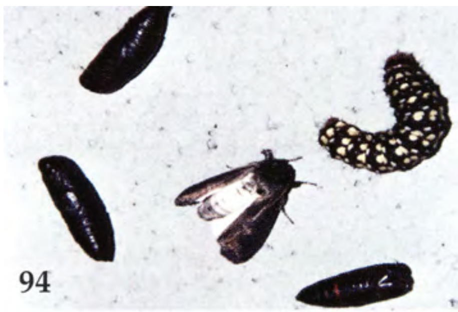
The South African B*rithys pancratii* and it's Australian cousin *Brithys crini,* creatures unworthy of such eloquent Latin names, are also cursed bitterly as the lily borer or amaryllis caterpillar. The former are well known to most KwaZulu-Natal and inland *Clivia* growers. They have a larval stage characterised by transverse yellow and black stripes. In the case of *B. crini* larvae have white and black stripes and are 30-40mm long. The egg packages, which are laid on the underside of the targeted plant's leaf *(figure. 2),* bring forth small larvae, which immediately burrow into the leaf.

Figure 2 Egg package and hatching larvae of the lily borer

The eating marathon then courses downwards, the climax being the rhizome *{figure* 3).

Figure 3

Left unchecked the demise of the plant follows. Do not discard the remaining roots and rhizome, as they are sometimes robust enough to produce several side shoots in response to careful treatment.



A little grey moth *(figure* 4) of a centimetre in length is unnoticed by most gardeners during the nocturnal hours, but she is the true culprit in the lily borer crime. Meg Hart and James Haxton finally solved the mystery of this nasty creature's life cycle before it found its deserved place on the 'Compost heap' of our quarterly newsletter.

Indicator plants such as *Albuca, Crinum, Nerine, Cyrtanthus, Hippeastrum* and *Zephyranthus* planted in the garden can be of help in the early warning of their ominous presence. The lily borer is most active during the months of October to April, the summer growing season. During this time you can apply a full cover spray or drench by watering can with a broad-spectrum systemic chemical containing ***cypermethrin*** - **Garden Ripcord**™ (or **Polytrin 200 EC**™). Other fast acting but less effective contact insecticides may also be used *(figure* 5).

Figure 5 The lily borer's habit of eating between the upper and lower epidermal layers of the leaf dearly shows why little success is achieved with contact insecticides such as the Blue Death powder the grower has so liberally sprinkled on the plant by the grower

Dimethoate™ insecticide granules marketed by Efekto and Bayer are reported to be very convenient to use as well as effective against several sucking and chewing insects.

Young looper damage has been experienced only by a limited number of growers in Gauteng *(figure 6).* In Australia the Lily Caterpillar, *Spodoptera picta,* is found in eastern Queensland and NSW and can cause major damage to *Clivia.* Give them the lily borer treatment.

Figure 6 Young loopers eat the leaf from above, leaving only the bottom epidermal layer

Flies. These could be sciarid flies (fungus gnats) and other unidentified flies. These vary in the different growing regions of South Africa. Damage is caused by their larvae to the soft new inner and unexposed leaves. Wounds caused by larvae can be entered by fungi and bacteria causing severe secondary infection. We often see fungus gnats flying or their small reddish-brown pupae on our plants. They 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 *(figure* 7). Contact insecticides containing *Mercaptothion* - **Malathion™** (or **Malasol™)** or *Chlorpyrifos* - **Chlorpyrifos™** (or **Dursban**™), can be used.

Figure 7 Fungus gnat pupae on rotten roots, most probably due to *Phytophthora* root rot

Snout Beetle. With their curious proboscises, these creatures have a healthy appetite for *Clivia.* They vary in colour from brown to charcoal and are 10-25*mm* in size. They are mainly creatures of the night, during which time they can erode away substantial areas of *Clivia* leaf, leaving a disfiguring lacy effect of circular lesions *(figure* 8*).* They are also not above gnawing at flowers and fruit, thus also affecting your seed crop (*figure* 9).

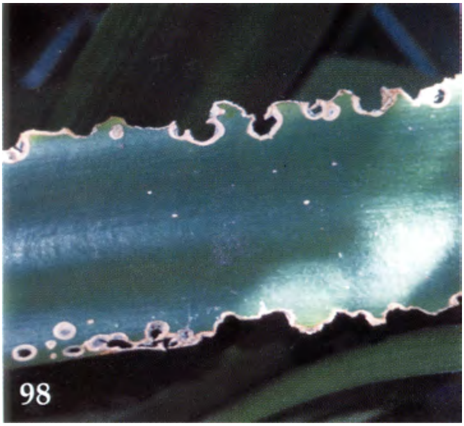


Figure 8 Circular lesions on *Clivia* leaf

Figue 9 Ripening and exposed seeds

Growers in the Western Cape and the eastern coastal regions of South Africa must be especially vigilant against this snouty foe. A retired entomologist friend of mine suggests that biocontrol, in the form of the little golden creeper mole, can substantially reduce its threat. Otherwise, control of this pest involves seeking it out with a strong hand-held light and great cunning and stealth, as they promptly drop off the leaf at the slightest threat.

A contact insecticide containing *Mercaptothion* - **Malathion™** (or **Malasol™)** or *Chlorpyrifos* - **Chlorpyrifos™** (or Dursban™), can be administered if an essential sticking agent such as **NuFilm** P™ is added. Systemic insecticides (such as **Garden Ripcord™** can also be used. *Fenitrothion* - **Folithion™,** (beta-cyfluthrin - **Bulldock™** insect granules and *dimethoate* - **Efekto Insect Granules** are also effective. A Port Elizabeth grower suggested spraying late in the afternoon to reduce the effect of the chemical breakdown of the toxin due to exposure to heat and light. This is important because the beetle, in his deviousness, also has a little built-in alarm clock, which goes off to announce his dinnertime at around 9pm.

Mealy Bug. These are small 3mm, 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 honey-dew and are therefore betrayed by the presence of ants. Mealy bugs cause severe damage during the warm summer months, targeting the tender new leaves (figures 10a & b).

Figure 10a Mealy bug infestation

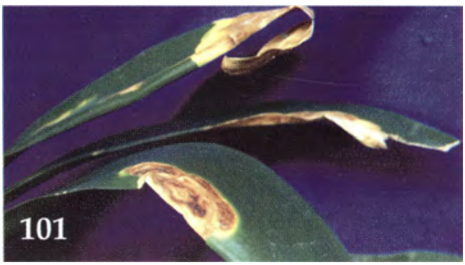


Figure 10b Mealy Bug Damage

They will also gather in masses like cottonwool underneath the leaves and into the upper roots if left unchecked. The best indicator plants are the *Agapanthus* species in your garden. Mealy bugs dislike strong air movement; therefore you will find them mainly in sheltered areas. They transmit serious viral diseases or cause wounds for fungi and bacteria to enter. Immediate action is important to combat this bothersome pest. You may use *Chlorpyrifos* - **Chlorpyrifos**™ or **Dursban**™ or *Mercaptothion* - **Malathion**™ or **Malasol**™ in controlling this infestation with full cover spray, using a wetting agent. Indoor plants need the use of methylated spirits and hand picking for control. Occasionally, the roots can become infected with **Root Mealy Bug** and this is more resistant. The pot will need to be submerged in a solution of proprietary insecticide and it is best to allow the plant to soak for at least 10 minutes. Several treatments may be necessary at intervals of 7 to 14 days if the infestation is particularly extensive.

Red spider mite. Red spider rarely causes many problems unless the atmosphere is excessively hot and dry. Sponging the leaves regularly will help prevent this pest becoming established, but should it become necessary, the plant will need to be sprayed thoroughly using a systemic insecticide. It is best to apply several treatments at 10 to 14 day intervals. Regular sponging of the leaves - particularly the undersides, will prevent recurrence.

Even badly affected plants clear rapidly once remedial action has been taken - it appears that *Red spider* is not an entirely successful pest on *Clivia* in South Africa but has been noticed in other parts of the world.

Scale is a well-known pest, but not necessarily on *Clivia,* although growers in China seem to have a problem with this. To remove scale, use **Oleum**™ (suspension spray or a systemic insecticide.

Slugs and snails, our arch enemies, love plants in well-watered areas *{figures 11a &b).* 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. Snails and slugs find the buds on your show plants irresistible *(figure* 12*).*

Figure 11(a) Snails on *Clivia* leaf

Figure 11(b) *Clivia* bud damage

Fig. 12 Pustules on the leaf can be disfiguring

But they also love eating the bait that you leave out and respond appropriately to liquid killing spray. Anti-snail chemicals should contain *Carbaryl* and *Metaldehyde* in combination for the best results. Research has shown that the blue colour of the pellets is unattractive to birds.

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 and kill them or spray with a *carbaryl*-containing insecticide.

The large **Dune Molerat,** another *Clivia* enthusiast, is likely to incense you with rage after making your magnificent *Clivia* plant disappear into his subterranean dining room. Remember that there are good moles (insectivorous) as well, before you embark on a 'molecide'.

Rodents, however, are a problem. *Clivia* fruit are a delicacy to them 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. Surprise the rodents in late winter when their normal food source is low, with rodent bait as a control. This is normally the time for berries to ripen as well. Recently, a grower from Kimberley found the outer leaves of the plants eaten off to between lto *5cm* above ground level.

DISEASES

Fungi, bacteria or viruses invading living plant tissue can cause plant disease. Plant tissues are damaged by the pathogen itself. To identify the type of pathogen is very difficult because the symptoms differ from plant to plant under different environmental conditions. Exact and reliable identification can only be made by a plant pathologist in a well-equipped laboratory.

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.

Fungi. In *Clivia* there are two main groups, namely rusts and damp-off disease.

Rusts caused by many different fungi account for reddish-brown or yellow pustules above and below the leaves *(figure* 12*).* They begin slowly, but multiply rapidly during favourable weather conditions. Although sometimes seen as a cosmetic affliction and seldom fatal, they do reduce active growing area and thus photosynthesis. The plant, thus weakened, 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 our best defence against them. In short, spray regularly with m*ancozeb* - **Dithane M45™,** *triforine* - **Funginex™**, *dithiocarbamate* - Zineb™ or chlorothalonil - Bravo™. Some larger growing concerns have tried the locally new systemic chemicals such as **Folicure 250EW™, Baycor 300EC™** and **Score 250™** with success, during the recent wet summer after heavy infections. The active ingredients in these are different *triazoles* claimed to be locally systemic. They are absorbed by the contact surface but not translocated to the roots or other untreated parts.

The new Chinese plants with tessellated or raised vein leaves are less than hardy and chemical burn is prevalent. Never experiment with new chemicals on rare plants. Instead, use reliable agents such as *mancozeb* - **Dithane M45™,** *captab* - **Captan™,** *chlorothalonil* - **Bravo™** or

Figure 13 Brownish smudge marks showing only on the weaker yellow parts of the leaf

Figure 14 *Amaryllis* stalk spot only appears in extremely humid conditions

Figure 15 Stem damage is linked to potassium deficiency by expert growers

dithiocarbamate - **Zineb**™. All of these are good broad-spectrum prophylactics that should suppress the disease. The rusts affecting our variegated *Clivia* leaves *(figure* 13*)* can be treated as above.

Leaf and stalk spot - Stagnospora curtisii. These form visible, bright red to brown, sunken lesions on members of the *Amaryllis* family *(figure. 14).* This fungus has been suspected on *Clivia* during extremely humid conditions. Do not confuse this with the tearing effect due to potassium deficiency *(figure* 15*).*

Leaf dieback. One of the first to be identified and best-documented fungi is *Macrophoma agapanthii.* Apart from *Clivia* others affected are *Haemanthus* and *Veltheimia* spp. 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 *(figure* 16*).*

Similar lesions were observed in illustrations of Chinese *Clivia* which were attributed to *Macrophoma* sp. It is possible that the visible symptoms among cultivars such as the 'ordinary narrow pointed leaf and the 'broad leaf could differ. 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 following methods: application of *flowers of sulphur,* **Dithane M45**™**, Bravo™** or **Zineb**™ (undiluted). It is convenient to use **Mycota**™ foot powder and spray or **Merthiolate**™ spray.

Figure 19 depicts the extremely aggressive fungal infections experienced by several growers in Gauteng this past wet season. Early stages show small chlorotic spots, a red-brown area developing in their centres.

Fig. 16 *Macrophoma agapanthii* left untreated. Do not confuse with sunburn

Fig. 17 Possibly caused by *Rhizoctonia* or other unknown fungus

Fig. 18 Possibly caused by *Rhizoctonia* or other unknown fungus

Figure 19 Could be *Macrophoma* or a related *fungi imperfecti*

The infection begins at the side or middle of the leaf. These areas expand, coalesce and rapidly move to the leaf base. Without treatment the plant will die. Different chemicals were used by growers, such as **Bravo**™, **Zineb**™**, Dithane**™ and *Triforine* - **Funginex**™ and others, but only various degrees of suppression were achieved. Reasonable success was achieved when the affected area was cut away and the wound sealed, as described for *Macrophoma agapanthii* leaf dieback.

Damp-off disease. 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. The quartet of the worst rot-causing fungi to attack plants consists of *Phytophthora, Pythium, Fusarium* and *Rhizoctonia.* All four of these pathogens have been positively identified during the past

Figure 21 Cleaned surface with Bravo™

Figure 20 Plant fallen over with leaf base still intact

extremely wet and hot growing season. *Phytophthora* and *Pythium* are amongst the fastest and most destructive fungi known. They are soil-borne but can also spread via contaminated water through splashing when watering.

Pythium was very troublesome in *Clivia* seed and seedling trays during the past season. Infection starts initially slightly below the soil surface. Prevention is by sterilizing the seed, seedlings and growing medium with appropriate protective chemicals such as *mancozeb, captan, chlorothalonil* and *copper oxychloride.* I had no losses after I started to use *copper hydroxide* in **Kocide 2000**™ as a drench this year. This form of copper spray is claimed to cause less burn than previous copper compounds. It is also cost-effective. Do not plant too deep and do not drench or spray seedlings with *benomyl* - **Fundazol**™

Figure 22 Recovering plant with new roots as it has no curative effect for plants against *Pythium* or *Phytophtera* infections, although it works well for Rh*izoctonia, Fusarium, Botrytis* and flower spotting.

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 *(figure 20).* The roots are all soft due to root rot. It was very interesting that Mick Dower found a very small pupa on the roots. Unfortunately the insect that emerged could not be identified as it flew away when the entomologist opened the collecting bottle! This could have been a *Sciarid* (fungus gnat) that was attracted by the decay. *Phytophthora* is active in warm wet conditions and favours badly drained growth medium and poor aeration. Remember that *Clivia* have epiphytic roots that need good aeration in a light and well-drained growing medium. In this case the affected plant tissue is cut away and the clean surfaces treated with neat **Bravo**™ *(figure* 21*).* If what is left of the plant is then planted in clean sterilised filter sand new roots will soon emerge, resulting in a healthy plant again *(figure* 22*).*

Phytophthora and *Pythium* rot can be successfully treated with systemic fungicides such as *Furalaxyl* - **Fongarid**™, *propamocarb* - **Previcure N**™ **,Bravo**™ and *phosphoric acid* - **Phytex 200 SL**™ if it is detected at an early stage. Avoid planting in leaf mould collected under avocado trees. Open standing irrigation water could also be infected.

Rhizoctonia-infected plant tissue has a watery appearance with tan to reddish brown lesions that will finally girdle the stem *(figure* 24*)* and cause young plants to fall over *(figure* 23*).* Roots can still be firm. It is often found among newly transplanted plants. Avoid over-potting. Over-fertilising, a wet, heavy medium or an incompletely decomposed medium can all contribute to heavy plant loss. 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. Preventative treatment with **Dithane M45**™ or **Bravo**™ or curative treatment with a systemic - **Fundazol**™, **Rhizolex**™ and **Topsin Flo**™ have been applied by growers with a good success rate.

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, excessive soil water because this is almost impossible to

Figure 23 *Rhizoctonia* infected plants

Figure 24 *Rhizoctonia* infected plants cure. The only slightly curative chemical at this stage is *benomyl,* and as a preventative *zineb* or the new agricultural disinfectants containing *quaternary ammonium compounds* and referred to as QAC's. Manufacturers claim these chemicals destroy all fungi, algae, bacteria and viruses on exposed surfaces.

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 *Phytophtera* root rot.

Bacteria. Bacteria multiply quickly and are intensely destructive rot-causing pathogens. Prof. Mark Laing's guide in Clivia Yearbook 2 on how to deal with them is to be well heeded. *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 past growing season has also revealed the first known reports of bacterial leaf spot caused by *Pseudomonas.* The grower must remember that general fungicides have no remedial effect on bacterial infections. *Kaptab* - **Kaptan B**™ was used in the past, but it does seem that we are left with only the newer *copper hydroxide* containing chemicals such as **Kocide 2000**™ to have a tentative grasp on the bacteria problem. *Tetracycline* is used in America for bacterial infection.

Good sanitation practice and sterilisation with the QAC's such as **Terminator**™ and **Sporekill**™ is the only alternative to the copper compounds. An interval of at least 7 days should follow between a copper treatment and another chemical treatment.

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

Nematodes have been reported recently and secondary bacterial infection could have affected these growers as a result. Sean Chubb deals with this subject in a separate article.

PREVENTION

Accurate fungal and bacterial identification can only be achieved if a live sample is sent to a plant pathology laboratory. Hopefully, over the coming seasons, with input and feedback from growers, some useful answers will be forthcoming. Knowledge of the exact pathogen responsible is very important for without this the marketing personnel and manufacturers cannot give you accurate and cost-effective solutions to the cause of your nightmares. *Clivia* growers must now 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 even if they could be likened to shotgun warfare.

There are other factors involved in the control and prevention strategy. Problems with growing conditions and culture disorders can perpetuate our bacteria and fungi situation.

The following preventative measures are recommended:

- Increasing the light intensity in order to grow stronger and more resistant plants.
- A decrease in nitrogen fertiliser 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 an honourable burial away from your growing area.
- Ensure that compost purchased is well 'composted' and aerated and be certain that it drains well enough. Sterilisation before you purchase is imperative. Raw sawdust and bark should be avoided. To speed up the composting process, add a handful of *magnesium carbonate* (agricultural lime) and a handful of *ammonium nitrate* a year in advance. In this way essential *magnesium* is also supplied. Unsuitable and raw medium is a major factor in plant loss.
- Avoid adding too much fertiliser 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 weater conditions - for example, use QAC's 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 accellerate 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 QAC before placing in main growing area.
- The practice followed by Ammie Grobler of dipping all plants during transplantation in a QAC 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 mentioned in the text.

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.

At the time of going to press I still have numerous unidentified lesions like in *figures* 17 & 18. Hopefully this article is only a beginning for future contributions by *Clivia* growers. Any positive feedback or new information on pests and diseases including virus should be read about in the next Clivia Yearbook, because not all growers have access to the Internet enthusiasts' group. Internationally, if you 'read' through the Chinese Clivia book *Junzilan Zinpu* (ISBN 7-5281-3208-2) we gather they have similar problems. The Japanese book *My Green* (ISBN 4-07-929411-5) also clearly illustrates a common experience in *Clivia* growing problems. We also gather from the Internet that there are a number of other pests and diseases affecting *Clivia* everywhere. We welcome input and information from growers in the USA, Australia, China, the UK and all the other countries where *Clivia* are enjoyed, for inclusion in the next Yearbook.

Having become a *Clivia* fanatic with a special interest in pests and diseases, it occurs to me that my studies in Latin were of less use to me than Japanese or Chinese would have been!

LETHAL FACTOR

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 and can be treated with a *2ml* magnesium sulphate solution dissolved in 1 *litre* of water and applied weekly for a few weeks. You should then experience a higher survival rate.

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figure 25 Could probably be linked to collar rot caused by *Sclerotium rolfsii.* This plant was saved and is developing new roots on the less affected parts

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