Zantedeschia Production

Technical Bulletin C01/11

INTRODUCTION

1. Genetics

Quality plant material derived from verifiable genetic stock is essential. First year T1 tubers ex tissue culture (TC) or second cycle T2 stock are the most vigorous, disease free & reliable starting material. Older larger tubers may not acclimatize as well in a new enviro-location and incur high losses.

A marketable flower crop can be taken from T1 2-3cm ex TC tubers of BLOOMZ varieties. These tubers will last 4-5 growing cycles when managed well. A 25% annual replacement of TC or T1 tubers is essential for an ongoing commercial cut flower project.

Many larger growers start directly with TC. Ensure TC originates from virus tested mother stock from a reputable source. Note: TC itself is no guarantee of virus free status without serological or indicator plant testing of mother stock prior to initiation - refer #21.

2. Varieties and colours

The market (auction, wholesaler etc) and grower experience will help decide the best varieties and colour balance - white, yellow, gold, orange, peach, pink, red, lavender, purple, black.

Each variety has its own characteristics. Choose varieties for their productivity, colour and end use - cut flowers, pot plants or landscaping.

When selecting varieties, choose superior genetic material of standard clones e.g. Hot Shot, Florex Gold, Majestic Red. Registered or patented (PBR) varieties of proven performance are worth considering if they offer improved productivity and profitability.

3. Environment

Callas are naturally a warm-temperate climate crop, however are grown in many locations around the world. Cooler climates require heat retaining greenhouse structures to achieve satisfactory growth and economic time to flowering.

Callas are also very successfully grown in equatorial conditions at high altitude 1800-2400m (e.g. Kenya, Ecuador; warm sunny days up to 25-30°C and nights of 6-10°C). As a general rule, as latitude rises, altitude decreases however other local weather patterns will modify this effect.

Callas can be successfully field grown, however most growers use a well ventilated protective shade cloth/plastic rain cover - refer #7.

4. Light

Light is a critical factor in calla production. Over shading or low light may result in low flower yields, dull colours, poor flower performance and significantly lower tuber multiplication.

Callas perform better in rising light conditions and longer day length. Low light levels affect tuber maturity and flower initiation, resulting in reduced flower yield and tuber multiplication.

Optimum outside light levels is 30-50,000+ lux. Low light and temperature conditions during autumn (fall) / winter can result in low flower count, poor tuberisation and plant stress resulting in soft rot.

5. Temperature

Optimum crop performance is dependent on temperature in the crop canopy and tuber depth. Ideal day temperatures are 18-28°C and night 12-18°C. Optimum soil/media temperature is 18-20°C at tuber depth (5-10cm) with an upper limit of 23°C.

Even though greenhouse air temperatures may rise above 30°C during the day, leaf temperature should be kept below 28°C. Higher temperatures may cause stress and contribute to disease. Good ventilation/horizontal air movement in greenhouses is essential.

Use of moveable shade is beneficial in hotter conditions. 30-50% shade after the early vegetative stage; during flowering; and hot days during the latter tuberisation stage can significantly reduce stress and possible infection.

A mulch layer of clean pine sawdust or rice husk/straw is used to reduce soil heat, retain moisture & reduce weeds.

Lower night temperatures enhance colour in pinks, reds and oranges but has less effect on yellows and golds. Low soil temperatures <10-12°C may reduce flower yield and stem length.

6. Soil or growing media?

Free draining fertile soil has been the most common growing medium, but there are significant limitations for continuous cropping. Check previous use including crops grown, pre-emergent chemicals and fertilizer used, and always test soil for nutrients and pathogen status prior to planting.

Move to a new area each year and employ a 2-3 year crop rotation. Regular introduction of organic additives and composts help rebuild fertility - refer #9.

Growing media may include some or all of the following: washed coir fibre, peat, composted pine bark (fines and fibre), pumice, perlite/vermiculite and rice husk. Media is normally renewed or sterilised after each growing cycle.

Media with pre-mixed controlled release fertilizer is placed in pre-formed beds with built up sides (D200-250mm) or containers (L600 x W400 x D150 mm), Dutch lily crates or larger wooden bins on pallets (1-1.5m x 1m) which can be moved by forklift.

Another option is to grow tubers in pine sawdust or rice husk either over a layer of soil/media (separated by net) or on its own in a hydroponic system. This allows excellent water/nutrient movement and produces a clean tuber.

Greater volumes of clean, treated water and nutrient are required in a hydroponic system - refer #9, 12.

7. Greenhouse protection

Simple well ventilated plastic rain cover type greenhouses (eg. Haygrove or similar plastic tunnel) are best for controlled calla production - essential for cut flower cropping in wet conditions and TC plant establishment.

More expensive heat retaining structures are required for cooler climates & autumn/winter production. Cover greatly improves crop quality, timing and reduces tuber losses.

Ability to regulate soil moisture gives greater control over tuber maturation and tuber harvest timing - refer #31.

In dull or winter conditions high light transmission is essential: keep greenhouse film or glass clean.

Ventilation and air movement is critical. Circulating or horizontal fans are recommended.

CROP PREPARATION

8. Storage and dormancy

Crop performance is directly correlated to stable tuber storage during dormancy - refer #33. The key is uniform temperature, humidity and good airflow within the storage facility.

A minimum of 10-12 weeks dormancy after tuber lifting is normally required. Tubers with shorter dormancy may take longer to shoot and not perform as well. Pregermination - see #17, is essential in most circumstances to ensure even crop emergence.

Mid-long term storage (3-10 months) tubers are cool-stored in single layer trays at 8-10°C, 70% Relative Humidity (RH) with air movement.

Longer term cool storage - refer #36, will often result in more even crop emergence & better flower production.

High humidity and lack of ventilation will result in blue penicillium and other moulds. Remove tubers from storage, spray to run off with **Fungiflor**™ or **Kocide**® & dry before replacing in the cool store - refer #34.

9. Soil test and crop nutrition

Callas are gross feeders and respond well to regular water and nutrient. Optimum pH for callas is 6 to 6.8

Take a general soil test 2-3 months before planting to allow time for balancing nutrient and correcting pH. Addition of composted organic material can assist nutrient holding capacity and tuber growth.

A base dressing of NPKMg plus trace elements will supply the necessary balance of nutrients for plant growth. Use lime, dolomite or gypsum to correct calcium (Ca). Gypsum can be used to increase Ca without increasing pH (1-2kg /100m2).

Controlled release fertilisers (eg. **Nutricote**®, **Osmocote**®, **Triabon**®) are all excellent for callas. Rates will depend on test results for natural soil, or if a soil-less media is used.

Water soluble fertilisers (eg. **Peters Excel**, **Cal-Mag**, **Kristalon**) can also be used along with a range of natural plant growth catalysts eg. seaweed.

Foliar feeding should only be used as a remedial backup as is much less effective than liquid feeding.

Avoid high Nitrogen (N), especially later in the crop cycle as it may promote lush vegetative growth prone to plant stress. N is best applied in NO3 form e.g. CaNo3 rather than NH4.
Daily monitoring of pH, EC and moisture levels are critical throughout the crop cycle. Optimum EC post planting is 0.9-1.8. Adjust N-K ratios throughout the growing cycle:

Planting	2:1
Pre-flowering (6-8 weeks)	2:1.5
Flowering	1:1
End of flowering	1:1.5
Tuberisation	1:3

Typical liquid fertilizer rates to give an EC of 0.8-1.2 are:

N	125-150ppm
P	30ppm
K	125-175ppm
Mg	20-25ppm
Ca	60-70ppm

Prior to flowering EC can be raised to 1.2-1.8. At the end of flowering keep feeding for at least six to eight weeks progressively adjusting N-K ratio to 1:3 to maximise tuber growth.
Reduce irrigation towards the end of tuberisation - refer #31, and lower EC to avoid salt build up as the crop is dried. EC can rise sharply in dry conditions resulting in root damage, plant stress and entry of disease, leading to Erwinia.
Nutrition during flowering may significantly increase flower quantity and addition of certain elements like Fe may have an effect on colour intensity (e.g. Majestic Red).

10. Soil fumigation
Sterilisation or chemical fumigation (eg. solarisation, steam, **Basamid®**) is used after a previous crop to minimise soil pathogens. Multiple cropping in the same soil without sterilisation is not recommended. Soil direct from pasture does not normally require fumigation.
Soil is sterilised after winter when soil temperature is above 10°C. Chemical sterilisation may destroy friendly bacteria and disrupt natural balance.

11. Shelter, shade and mulch
Use windbreak or natural shelter to protect open sites. Overhead shade will help reduce soil temperatures and reduce the incidence of Erwinia bacterial soft rot - refer #24.
Application of untreated pine sawdust or mulch (8-10cm deep) over the planted rows will help stabilise soil temperatures and retain even moisture through the growing media.

12. Irrigation
Clean water with an added residual bacteriostat is a proven component of achieving optimum calla production and controlling plant mortality/soft rot.
Actual water volume depends on soil/media drainage capacity and evapo-transpiration. Plant stress may occur from too much or too little water.
Regular watering ensures nutrient availability and reduces salt build up. Irrigate in the morning, prior to the heat of the day, mist to reduce heat and irrigate again as required in late afternoon. In a semi-hydroponic regime water and nutrient may be applied 6-8+ times per day.
Larger callas (6+cm) tend to create their own shade whereas small stock can become stressed on hot days. Mulching will help ensure moisture retention and reflect excess heat.
Treat water with chlorine, ozone, peroxide, etc to help avoid fungal attack and secondary Erwinia - refer #23. 1-2ppm chlorine at delivery will also provide residual protection against pythium and other infection.
Ground level drippers (e.g. **T-Tape®** or pressure compensated drip lines) conserve water and provide more uniform watering in windy conditions.
If using overhead sprinklers, ensure correct sprinkler spacing for even water distribution (e.g. 3 m x 3m @ 70 l/hr nozzles). Sprinklers need to be higher than the flowering crop (at least 1m). The outside row of sprinklers should on the edge of the crop to ensure even water coverage over the growing crop. Check that water pressure is adequate.
In semi or fully hydroponic situations much greater quantities of clean/treated water with added residual are required. Actual quantity is dependent on media drainage, environment and crop but can amount to 6-8 hourly applications (8am-5pm) of 50 to 120l per m2 per day.

13. Weed eradication
Weeds affecting soil grown crops are best eradicated 3 months prior to planting when in active growth. Spray **Roundup®** or **Glyphosate** (1l/100l) and leave for at least 7-10 days before cultivation. **Versatill®** can be added at label rates to kill clover, thistles and flat weeds. It will have some residual action on clover and some weeds. **Fusilade®** is best on grasses.
Proven pre-emergent herbicides include **Simazine**, **Alachlor** and **Surflan® Flo** applied at label rates, all providing 6-8 weeks protection. Apply after planting time prior to rain/irrigation. If weeds are problem after planting **Glyphosate** can be applied at a low rate (3ml/l) up to emergence of first spikes when the leaves have not unfurled - do not use after this stage apart from on walkways. Never spray in the heat of the day as burning may occur and ensure soil moisture is sufficient to activate the chemical ingredient after application.
Hand weed through the crop cycle to reduce competition. Remove weeds early to avoid disturbing calla roots and provide an entry point for disease.

PLANTING

14. Timing
Crop timing is dependent on when flowers and pot plants are to be marketed - consult your exporter or broker. A cut flower programme of continuous 2-3 weekly plantings keeps product in the market and promotes the grower.
Planting in late winter/early spring with early greenhouse forcing or a late crop at the end of summer can be very profitable, however for best flower production and tuber multiplication, spring planting is the best option.

15. Cultivation and bed formation
Cultivate soil 2-3 months prior to planting. Ensure that the soil has a good free-draining structure, with adequate air fill porosity.
Form raised beds (200mm) that fit tractor wheel spacing and other machinery. Standard bed width is 1-1.2m with 40-50cm walkways.

16. Tuber spacing
Tuber spacing per m2 depends on growing conditions, availability of space and grower preference:

1cm:	80 - 100
2cm:	50 - 60
3cm:	30 - 40
4cm:	20 - 30
6+cm:	12 - 15

Lower densities often result in more flowers per tuber, larger flower heads and greater tuber multiplication.
Many growers are now using large palletised growing bins for mechanised tuber planting and harvesting (1m x 1.2-1.5m x D 150-250mm). Use treated timber.

17. Pre-germination of tubers
Pregermination promotes even crop emergence, better Gibberellic Acid (GA) absorption - refer #18, and shortens the growing cycle. This process is vital if tubers have a short dormancy (10-12 weeks after lift), and when growing in cooler conditions.
Prior to planting and application of GA refer #18, remove tubers from storage and pregerminate at 21-25°C and 85% RH for 7-10 days to trigger emergence of growing shoots. Stable temperature and humidity throughout is critical.
Ensure some airflow (use a fan) in the pregermination room. 24 hour lighting appears to help the process.
Smaller 1.5 and 2cm tubers have much less ability to withstand temperature and humidity fluctuation - these are normally not pre-germinated.
Once the growing shoots have emerged a minimum of 5-10mm, apply GA prior to planting.

18. Giberellic Acid (GA)
Flowering stock (3cm+) should be sprayed to runoff or dipped with GA prior to planting. This will significantly increase flower initiation when applied correctly - refer #17.
GA3 is distributed as tablets or powder e.g. **Berelex®**, **Grocel®**, **ProGibb®** and is applied by spraying to runoff or dipping for 15 minutes at 100-125ppm (1 tablet or sachet per 8-10l) only when shoots have emerged at least 1cm. GA is much less effective on dormant tubers with no shoots.
Adjust pH of water to 5.5 prior to mixing. Addition of a wetting agent and broad spectrum fungal/bacterial protectant e.g. **Previcur®N** or **Sporekill®** is recommended.
An alternative to GA3, liquid **Promalin®** (GA4, GA7, & BAP) is applied prior to planting the same as for GA3. The BAP assists tuberization.

Spray **Promalin®** to runoff (5ml/l -100ppm), ensuring all growing tips of the tuber are wetted. If dipping, reduce rate (3ml/l - 50ppm).
Dry tubers for 4-6 hour prior to planting to ensure GA are absorbed. Some growers have achieved increased flowering with a second GA spray 1-3 days later prior to planting.

19. Planting
Plant in a simple grid or furrow system ensuring tubers are planted upright (growing tip up) and covered by at least 5-10cm of soil/mulch. Actual depth depends on soil temperature.
The warmer the climate, the deeper the tuber should be planted. There can be a temperature differential of 5°C between soil surface and tuber depth.
Avoid planting in severe heat. Water immediately to settle tubers into the media. Apply sawdust/rice husk mulch before shoot emergence.

PESTS AND DISEASE

20. Insects
The main pests are thrips and aphids. Control is especially important to halt the spread of virus - refer #21, and to maintain flower quality for export phytosanitary purposes.
Thrips can disfigure flowers well before they become unfurled and may result in a high export flower reject rate.
A spray programme throughout the growing cycle is essential.
Insecticides should be applied from spike emergence and repeated at 7-10 day intervals up to flowering. A range of chemicals can be used successfully on callas e.g. **Attack®**, **Confidor®**, **Diazinon**, **Decis®**, **Mavrik®Flo**, **Orthene®**. Use at label rates.
Mealy bug, pseudococcus spp. can attack the growing crop in the latter stages and leave eggs that hatch post storage, as the tuber is warmed up. Treat with **Diazinon** during growth or storage with **Confidor®** (imadacloprid).
Select a combination of chemicals and alternate them to combat pest resistance. Most insecticides can be successfully combined with fungicides and some foliar fertilizers. Check label for compatibility of chemicals prior to mixing and application.

21. Virus
Callas are subject to virus. Dasheen Mosaic Virus the most common variant, is a Potato Y non persistent type virus, transferred by aphids. Symptoms are 'sword' or 'strap' like leaves, variegated mosaic patterns on the leaves and distorted flowers.
Other viruses include Cucumber Mosaic Virus, Tomato Spotted Wilt Virus and other Pot Y viruses.
Mature plants in non stressful conditions may not exhibit virus, yet may test positive. A serum test of roots, tuber tissue and young leaves are necessary to detect virus, as electron microscopy may not show up virus in some parts of the tuber.
Virus cannot be eradicated - affected plant material (including the tuber) must be removed and destroyed. A regular chemical spray programme is essential - refer #20.
Annual reintroduction of virus free plant material (TC or T1 tubers) is recommended to maintain a viable calla enterprise.
Virus can also be transferred by aphids in storage after emergence of growing tips. Check stored tubers - refer #36

22. Fungal control - Tubers
Callas can be attacked by a range of primary fungal pathogens including Pythium, Fusarium, Rhizoctonia and Phytophthora.
These often attack the root zone and may not exhibit above ground symptoms until well established - up to 7-10 days later after infection.
Withering, rolled up leaves are often a symptom of below ground problems. Left unchecked in hot conditions may cause onset of Erwinia - refer #24.
Inclusion of suitable pre-plant fungicides e.g. **Ridomil®** and **Rizolex®** mixed in the soil/media is effective. Follow with a systemic like **Aliette®** (5g/l) for up to 28 days protection. This should only be used once or twice in the crop cycle.
A drench of **Ridomil® Gold EC** (1ml/10m2) alternating with **Thiram** (3ml/l) is effective following **Aliette®**.
A routine preventative broad spectrum spray application can be applied every 2-3 weeks. Chemicals may include **Rovral®**Flo or **Defence®**(2.5ml/l), **Octave®**(1g/l), **Foscheck™**(5ml/l), **Captan**(1.5g/l), and **Kocide** (1-3g/l)
Terrazole® 35 WP may be used as an alternate to **Ridomil®** - effective against pythium and phytophthora.
Drenching is often not required where strong healthy plants are encouraged with use of natural micro-organisms and healthy soils - refer #25.
Pathogens can be transported by water via irrigation or ground/runoff contamination. Check water source & quality. If water is contaminated it should be treated - refer #12.
In cool damp conditions where plant foliage remains constantly wet, attack by bacterial pseudomonas can be a major problem. Leaves appear to "melt" and start breaking down above ground, infecting adjoining material.
Good ventilation, avoidance of soft growth and overcrowding helps avoid this infection. Treat with **Mankocide®** (2g/l) or **Thiram®** (5g/l) and allow vegetation to dry off.
Geotrichum fugus can arise in bark based potting media. This is effectively controlled by **Captan**.

23. Fungal control - Flowers
Fungal spotting on flowerheads during humid weather or rain is common. The main fungal diseases are Botrytis, Acremonium and Alternaria.
Preventative sprays should be applied every 7-10 days from bud emergence: **Bravo®**, **Captan**, **Thiram**, **Mancozeb**, **Taratek™**(systemic) at label rates. Beware of chemicals which leave unsightly residue on flowers.
Eradicants should be used in times of high disease pressure - high humidity, persistent drizzle or rain, often associated with cold nights.
Eradicants include **Rovral®**, **Octave®** and **Sportak®**. Each individual chemical should only be used 2 - 3 times per season. During wet weather crops should be sprayed in dry periods - up to 2-3 days apart if necessary and prior to forecasted wet weather.
Taratek® is both eradicant and protectant. A regular 10 day spray to runoff with **Kocide®** (1-2g/l) is a good preventative except during flowering (residues may damage flower quality).

24. Erwinia - Bacterial soft rot
Erwinia carotovora subspp. carotovora can be a major problem in callas. Good plant management and the avoidance of plant stress throughout the growing cycle is the key to control. Some varieties are more susceptible than others.
Fungal pathogen attack (refer #22) combined with high soil temperatures (>23°C) can lead to secondary bacterial soft rot, Erwinia.

Stress factors include:

- primary fungal attack eg. Pythium
- too much or too little water
- spray or fertiliser burn
- high soil salts (EC)
- damage from pre-emergent herbicides
- high soil temperatures
- unfavourable climatic conditions
- non-ventilated greenhouses

If Erwinia takes hold it is difficult to combat. Preventative practices include:

- Protect against fungal attack with a drench programme - refer #22 & 23
- Correct post harvest handling techniques
- Hygienic packing facilities - grading tables, buckets and tools scrubbed daily with bacteriostat or sanitiser
- Irrigate with clean water with active residual. Use chlorine, ozone, peroxide, or other suitable bacteriostat
- Addition of **Agrimycin** in cut flower hydration solution
- Replace hydration solution regularly
- Use disposable tissue to dry stems prior to packing

Bacterial soft rot or slimy stem can also be a potential problem in flowers post harvest and after arrival in the market. Research has isolated stress and Erwinia as the main culprits.

25. Natural growing methods
A strong healthy plant is the best defence against soft rot diseases. Friendly soil micro-organisms have been successfully used to encourage healthy root growth and reduce potentially damaging soil pathogens.
Products include:
- Proprietary soil conditioners incorporating friendly bacteria
- **Trichoflow™** - Trichoderma bacteria
- Compost tea: includes humic acid, seaweed extracts and Trichoderma.

HARVESTING FLOWERS

26. Pulling flowers
Harvest flowers in the cool morning. In dry conditions irrigate prior to harvest.
Flowers are pulled rather than cut to ensure the longest possible stem length.
Do not cut base of stems at this stage - refer #27, in the field.
Place dry flowers flat in boxes/trolleys for immediate transfer to cool store prior to grading. Ensure boxes are covered in transit to avoid contamination.

Place harvested stems, dry in cool store at 6-8°C for pre-cooling prior to grading. Stems can stay dry for up to 6-8 hours without any damage.
Stems may be dipped in clean, treated water (add bacteriostat eg. chlorine) to remove any soil or media.
Dip flower heads in a solution containing fungicide **Rovral®** and insecticide eg. **Ripcord®** to remove any insects and provide post harvest protection. Gently shake to remove excess moisture.
Absolute attention to hygiene is vital at all stages of the picking process. All grading areas and buckets must be regularly scrubbed with chlorine based bleach or sanitiser prior to grading.

27. Post harvest handling
After pre-cooling, grade and bunch (5 or 10 stems) per market requirements. Cut stems with a clean sharp blade in the basal white part of stem to help avoid splitting and roll-up of the stem.
Prepare a hydration solution of clean water and **Keystrepto™** (streptomycin), **Agrimycin** or **Enhance™** (2-3ml/20l of water) to protect against slimy stem and increase vase life. Do not use sugar based preservatives.
Place bunched stems in the solution at ambient temperature as chilled water may cause splitting and roll-up of the stem. Hydrate for a minimum of 2-3 hours at room temperature (80% of uptake occurs in the first two hours) prior to cool storage and packing.
Flower stems can stay in this solution for up to 48 hours – re-cut and place in fresh solution for longer storage. Fumigation for phytosanitary assurance - refer #29, can take place prior to cool storage and final pack out.

28. Coolstorage
Cool store flowers at 6-8°C, minimum 80% RH prior to packing. Ensure flowers are down to cool store temperature prior to dispatch (a minimum of 2 hours after packing). Use refrigerated/cooled transport.
Scrub out cool store with biocide regularly to help prevent build-up of bacterial and fungal spores that may ruin quality flowers.

29. Fumigation of flowers
For those destinations with stringent quarantine regulations, fumigate with **Floragas®** or similar prior to packing. The process takes about 2 hours and can be done in a simple plastic tent (or enclosed room). Fumigation can be completed directly after grading.
Alternatively flower heads can be dipped in insecticide e.g. **Ripcord®** (synthetic pyrethroid) during grading.

30. Packing
Remove bunches from hydration solution and remove excess moisture with clean paper tissue to help avoid slimy stem or botrytis in transit.
Final packing into cartons should be as per market preference. Do not over pack flowers as damage may occur. Use tetron or other soft material to protect delicate flower heads. Secure bunches in carton with rubber bands or tape to avoid movement in transit.

HARVESTING TUBERS

31. Tuber maturity and lifting
Commence lifting when leaves turn yellow and die down, roots regress and the tuber surface becomes tougher. Harvesting any earlier will reduce tuber multiplication and maturation.
Immature tubers are easily bruised and can suffer breakdown in storage or calcification (death of tuber tissue) within several weeks.
In equatorial conditions where there is no natural leaf senescence, grow for a minimum of 90 days post flowering prior to lifting tubers.
Restriction of water after week 26-28 can assist with natural senescence and tuber maturity prior to lifting.
Lift tubers carefully either by hand or mechanical digger. Clean off as much soil/media as possible prior to placing in single layered, mesh bottomed trays.
It is preferable to leave roots on during drying to seal up tuber and protect from invasive pathogens. Do not break off green leaf stalk as damage to the main growing point may occur.

32. Washing and dipping
Tubers should be lifted, cured and dried with minimal handling. If soil/media consistency allows do not wash or dip tubers. Only wash if absolutely necessary – avoid high pressure to minimise damage to delicate skin of tuber. Tubers must be thoroughly air dried within 4-6 hours of washing.
Set aside any diseased material and spray to runoff with broad spectrum bacteriocide/fungicide mixture e.g. **Octave®** and **Kocide®** at label rates.

Virkon® is effective. Regularly mix new solution to maintain active ingredient.

Mucor (fungal rot) can attack tubers in storage. It can arise after lifting during wet conditions and/or high humidity in early storage. Symptoms are a soft sunken area (like soft rot) around the central growing point. Identify Mucor by laboratory test. Control with **Ridomil®** and **Fungiflor™**.

33. Tuber curing
Plastic trays, bulb crates or timber /plastic mesh bottomed racks are all acceptable. Consider weight of trays and suitability for pallet stacking when designing tuber handling system.
Although tubers can be lifted and cured/dried in a greenhouse, this is difficult where large quantities of tubers are harvested on a daily basis.
Commercial production requires a purpose built drying room to achieve sufficient air movement and dehumidification.
Dry tubers in a covered air tunnel using large volume high velocity suction fans (3-8kW), commercial dehumidifiers to remove moisture (5+ litres of water /hour) and good fresh air exchange.
Cure tubers for 2-5 days at 20-25°C immediately after lifting ensuring good air movement is maintained at all times. Do not over dry or reduce RH below 50-60%. Observe closely.
The resulting outer skin of the cured tuber acts as a barrier to dehydration and entry of disease. Avoid over drying at all stages - this may result in calcification of tuber tissue (like a stone) and subsequent tuber death.
After initial curing temperature should be held constant at 12-15°C for a further 3-5 weeks until tubers are stabilised before transfer to longer term cool storage or further handling.
Do not handle tubers prior to stabilisation (normally 4-6 weeks) as tubers can be easily damaged, causing subsequent calcification and losses.

34. Tuber dormancy and storage
Callas require at least 10-12 weeks tuber dormancy after lifting. Longer term cool storage is preferable enabling faster germination, consistent shoot emergence & better flower production.
Maintenance of uniform temperature and good air circulation is the key to good storage. Optimum RH: 65-70%.
Penicillium (blue mould), aspergillus and other moulds can occur during storage, especially when humidity rises above 80%. Moulds are caused by a build up of spores in closed damp conditions and are more prevalent on damaged or cut tubers.
Good air circulation, controlled humidity and even temperature are essential. Addition of extra fans in the cool store assists air movement.
If moulds occur, either fog the cool store or remove and spray with with **Fungiflor™** or **Kocide®** and dry, preferably in open sunny conditions before replacing in the cool store. Check cool store RH is not above 75% to ensure further moulds do not occur.

35. Grading of tubers
After 3-5 weeks of stabilisation cured tubers can be de-rooted, graded and sorted ready for storage to complete dormancy.
After handling tubers, re-cure overnight prior to further storage to seal any newly damaged or exposed tissue. Avoid unnecessary handling as this may lead to tuber breakdown (calcification).
Do not divide tubers until just prior to planting - this helps keep small tubers in better condition.

36. Long term storage
Tubers can be stored for 6-10 months at 8-10°C and 65-70% RH.
Good air circulation is essential - a shipping container is generally too restrictive for good storage. Use a high ceiling cool store with circulating fans.
Prior to loading the store, clean thoroughly with sanitiser and check all cooling and air circulation equipment.
Inspect tubers weekly and observe any changes in condition. Monitor temperature and RH on a daily basis - low RH will result in dehydration and tuber loss.
Watch for aphids in the storage area as they breed rapidly and may transfer virus between tubers once green shoots emerge. Fumigate or fog the storage area with a suitable insecticide if aphids appear - **Attack®**, **Decis®**.
.Do not contaminate the store with diseased or poor quality tubers.

For more detail and pictures please refer to www.bloomz.co.nz