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Paphiopedilum culture and propagation, concepts and guidelines.

Select Orchids
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Paphiopedilum culture and propagation, concepts and guidelines.

Some technical concepts misunderstood, and their correct explanation

Wild plant size vs. culture plant

It is always surprising when seeing wild collected Paphiopedilum that there are many plants in excellent health, with many growths, and whose growths are several times bigger than any cultivated plant.

Paphiopedilum anitum is an extreme, but usually the cultivated plants are in the 30-40 cm leaf span single growth with a tiny start, and the wild collected plants can be over a meter, with flower spikes nearly double or triple the size of any cultivated one, on clumps consisting of many growths.

Paphiopedilum hangianum is considered to be slow growing, but, when we look at wild collected plants, it is clear that they grow much faster in the wild. They have a leaf span that is approximately two times bigger than most cultivated plants. Paphiopedilum emersonii, a close relative, usually sulks and dies after a couple of years in cultivation, slowly growing, but the wild collected plants are huge, with many growths as well.

There has been suppositions that in culture they 'do not need' to grow as big as in the wild, that they are as happy as possible at half their former size. However, seeing several thousand of wild collected Paphiopedilum micranthum and Paphiopedilum armeniacum in bud on sale for the Chinese New Year every year, from the remote parts of Yunnan to Hong Kong and elsewhere, one can easily guess that there is a serious problem in most nurseries around the world, as it is very rare to have even 200 seed grown Paphiopedilum micranthum in bloom at the same time.

Wild collected capsule of Paphiopedilum usually never fail to germinate, where the same plant that gave those fertile wild seeds will, over the year, become less and less fertile in many species. It is very common especially with Paphiopedilum tigrinum, most of the parvisepalum, most of the Indonesian and Papuanum mottled leafed Paphiopedilum (Paphiopedilum violascens, mastersianum). There were a lot of explanations, including that the parents in cultivation were too 'closely related', a case of inbreeding. However in a colony in the wild, it is more than likely that most of the plants are genetically very close.

It appears clearly that most Paphiopedilum species are not properly grown in cultivation, even though some individuals, such as a couple of clumps of Paphiopedilum randsii gigantean in Japan, all belonging to the same grower, can perform exceptionally well, matching the best wild collected specimen. It is due in fact, again, to a nutrition problem.

According to the CITES Trade Database too, it is very easy to see that most Paphiopedilum plants traded every year, whether species or hybrids, die after a few years, and the surviving individual is an exception.

In 1996, at the Orchid Zone, Terry Root had several thousand Paphiopedilum rothschildianum seedlings from several crosses. As of today, out of those several thousand plants, the Orchid Zone for sure still has some of the best of those crosses, but the thousands of seedlings sold all around the world are dead, except some individuals.

At another point, I got the CD of all the AOS awards in the 90's in fact I had been one of the earliest customers for the initial, extremely expensive, version. I checked the plants that I was interested in, and it made an impressive list. I started to write to the owners of the plants, some had still their plants, very few. For most of the awards, it was ‘sorry the plant died’, or ‘sorry I sold the complete plant’, which was another polite way to say that the plant was dead, as for most of the ‘sold’ plants; they never reappeared in 20 years. I would say that, out of all the awarded Paphiopedilum species by the AOS, maybe 1, if one is optimistic, 2% are still alive today. Some are dead but they gave progeny though, but that is another exception.

In Taiwan, I wanted to buy two specific plants, amongst them a division of a massive clump of a worldwide famous Paphiopedilum species, whose photo has been around the world pretty much everywhere. The nursery owner is a very kind man, so I do not disclose too much about that, though he told me that the entire clump, with 5 spikes at the time of the award, had been divided, and all the parts were dead. The second plant I wanted to buy was a magnificent clump of rothschildianum, but all I could be offered, by another nursery, was a 20cm yellowish thing with 4 leaves, that may, or may not have been a division of that plant. The owner said that the mother-plant had been sold, however it is a fact that it died. No progeny, nor the original plant, ever reappeared.

To the opposite, I bought from the Tokyo Orchids Nursery their mother-plant of Paphiopedilum rothschildianum Mt Millais, and they had that plant for nearly 30 years, added another 20 years that this plant was alive at the Eric Young, if not a bit more. At the Orchid Zone, there are a lot of old plants too, decades old. It is interesting to note as well that there are vintage plants that are some decades or a century old, sometimes even more, but they are an immense minority compared to all the Paphiopedilum plants that were in cultivation during that time. I think that, if we sum up all the Paphiopedilum growing plants that are still alive in cultivation today, from the pot plant to the rarest ones, compared to the total of all the Paphiopedilum that were in cultivation over, even the last 30 years, the survival rate is in the few per hundred thousand. I saw massive shipments of micranthum from China, as they do every year, of about 20-40,000 plants in bud, wild collected. Recently the shipment size dropped, to about 8-12,000 plants of micranthum a year, in bud, from the single supplier I know well enough in Kunming to have figures. There are Vietnamese and some other suppliers and collectors that collect micranthum in bud for the pot plant too, that would make a total of several dozen thousands plants collected per year. Where are all of those plants? They are all dead. True, the trade purpose was pot plant. So let’s take my own personal experience, Paphiopedilum stonei.

I did import 500 Paphiopedilum stonei clumps in the 90’s. The plants were about 3-7 growths, from Sarawak, with a CITES permit. I bloomed them, and kept the best 4 plants. The others have been sold all around Europe. They were exceedingly healthy plants, which I had grown after import for some years, really great plants. In 2007, nearly all of them had disappeared from the European market, and the hobbyists just waited to get more stonei, because all the nearly 500 clumps I released had died over the years in various nurseries all around Europe, without any progeny. I reimported 200 plants at that time, still clumps, established them (they were imported with CITES, and though originally wild collected plants, had been grown in Malaysia for a couple of decades, a quality that has never ever been exported to the USA or Europe, where another nursery supplies mostly runts). The leaf span was at least 80cm, some were over a meter. After some months I started to be disgusted, because they were dying or dead in many places, people kept killing them. Two years later, I had been asked again to import stonei, which I did not, because it was a complete waste to do so.

Most species need frequent reintroduction from the wild to be still present in cultivation. Species like mastersianum, sangii are still available in the trade nearly only because of frequent reintroduction from the wild. Their average lifespan in cultivation is about 2 years, some individual plants can be older, and a few outstanding individuals, or just normal plant grown by really excellent growers, can live much more, but we are talking about a few plants in the world. It is symptomatic to see too that Paphiopedilum bougainvilleanum, still common in the wild, is exceedingly rare in the trade, simply because the traders did not find a way to smuggle that species out of Bougainville or the Solomons Islands in any quantities. Paphiopedilum bougainvilleanum has been reintroduced 4 times in cultivation, including in the 80's a batch of more than 2,000 plants, in early 1991 about 800 in Europe and 400 in the USA, in 1996 the saskianum type, more vigorous, 500 plants, and in 2004 bougainvilleanum again, 500 plants. They went to many different growers, so it is not the fault of one nursery to have killed them.

The Indonesian Paphiopedilum and pretty much all the other species, are not difficult to obtain and transport, that's why we still have pretty much all the species in cultivation, at a time or another, but they are not 'bred in captivity' for most, just reintroduced as a fancy periodically. Such things do not happen for bougainvilleanum and wentworthianum.

All those deaths could make one pessimistic; however, there are individual plants and individual growers that will grow some or all of those species to perfection, for decades. On a personal note, I would be much more pessimistic into the far future of most species, in a couple of centuries, and I am pretty certain some species will be extinct and join the Dodo, in captivity or in the wild.

By learning how to grow the plants properly, we can try to extend the time before they will meet their fate, however the general prognosis is very poor, as human factors are at play not only the technical details. For all the Paphiopedilum species to be still with us in 1000 years as an example, it would require continuous hobbyists that grow the plants very well, propagate them, pass them to the next generation. Considering that some major orchid societies have lost in Europe most of their members, that many hobbyists in Germany died of old age without being replaced by newer generations, that entire nurseries of valuable plants such as Stewart Orchids, Equilab, vanished to nearly nothing, leaving in cultivation only a handful of their interesting plants, the future is bleak.

No wars, no major disaster, no weather or environment changes, no lack of interest amongst humans, unlike what happened to all the collectible things over the last centuries, and we might extend the presence of Paphiopedilum and other orchid species by some decades, a lot for us humans, nothing on the mankind scale. Whether in the wild or in cultivation, it is very clear that eventually most orchid species will be unknown to future generations except by today's pictures and books. There is no argument against that on the long term.

Vivi felice! As was the motto of many Renaissance Italian artists, and try today to enjoy what is given to us.

Water

Water is a liquid that we are all used to see, drink and use. However, the water purity is a very complicated matter.

The main sources of water:

- First, rain water. It comes and goes everywhere, or nearly so. One common misconception is to assume that it is 'pure' water. In fact, acid rains are infamous for destroying forest all around the world. The water droplets from the rains, and the clouds, both passing in the air will catch a lot of pollutant and contaminations. Thunderstorms can increase greatly the ammonia concentration in rain water. Dust will add a lot of elements as well. Smoke from automobiles, clouds from various types of smoke generated in urban areas, all will contribute to the final composition of rain water. And of course, worse of the worst, industrial pollution will bring in a lot of various chemicals and pollutants.
  However, it is usually safe to assume that rain water can be collected and used without any serious problems, as a water source. Simply one has to remember that the shading compounds and dirt on

the roof of the greenhouses can add a sizeable amount of dirt and pollutant in the rain water collected. Quite a few excellent growers collect rain water only after a quarter of an hour, or so and use it straight. Some even just collect the rain water whenever it comes.

- The second type of water usually available is city water, or in rural areas, water supplied for agriculture/horticulture purposes. Here, we have a large mix of water types, ranking from amazingly good in some areas such as parts of California, to horrible quality that cannot be used near the sea. It is required, to use this type of water safely, to have an EC meter. The EC meter is a tool to measure the conductivity, or the total dissolved ions, even if it is very far from accurate for scientific purposes. On the other side, the EC of a given solution will be always the same if the solution has the same concentration, and the temperature is more or less the same. EC meters can save a nursery using city or tap water, as they allow the grower to spot that the water source has been changed. In many instances, 'tap water' is a blend of several sources, switching to another source when one aquifer or a dam is low. Therefore some sources will be perfectly fine for growing orchids, some will be deadly, and it can change pretty much every day. By questioning the water supplier, it is possible to assess more or less, if they are reliable, if there is any risk of change to an unsuitable source.

- A recent trend for city water in the past few years was the use of chloramine to prevent water from being contaminated. Whilst they are powerful sterilant, a lot of crops resent very severely their use. Years ago, when common bleach or even chlorine gas was used, growers were advised to let tap water 'standing' for a couple of days to let the chlorine evaporate. With the chloramine, it is not true anymore, as they are incredibly stable, and will not turn into a gas to be evacuated. Others pollutants include pesticides in rural areas, heavy load of salts such as iron, zinc, etc… There are maximal limit for drinkable water, however the limits are way above the phytotoxicity level in several cases, such as sodium or boron. Rural areas water is supplied usually without any guarantee, and as such can be dangerous to use.

- Well or private aquifer drills can supply constant type of water. The help of a geologist is required to understand the origin of the water. Sometimes when the level goes down, pollutant can enter from another source, or the EC can be fluctuating according to the rain. On the other side, if the water is of good quality, it is worth to use it. In granite mountain areas, usually the water can be excellent. If it goes through limestone, and has only calcium carbonate as a 'contaminant', it can be used within some limits – see the fertilizer section – and in fact can be easier to use than pure water in some situations.

- For the city/tap water or the agriculture water, I always recommend an analysis, and if this cannot be afforded in tropical areas especially, though some parts of Germany are famous for suffering the same problem, a great benefit can be gained by using sprinklers to collect the city or well water in a primary tank, then filtering the result on a sand filter before use. In many parts of the world there can be tremendous amounts of iron in the water, and by using a sprinkler to 'oxygenate' the water before it is collected in the first tank, it becomes oxidized. The sand filter will collect the oxidized, insoluble iron.

- Demineralized water. Demineralization passes the water through resins that will actually remove the inorganic ions from the water. Therefore, the water is nearly free of inorganic dissociated cations and anions. It is an excellent source of water, except in some areas. First, some areas have very high boron content, to the phytotoxity levels. Boron salts do not 'dissociate' easily in cation and anions, and their charge is extremely low anyway, therefore the resins will not catch them. We will discuss later specifically about the boron problem, which is ubiquitous for any type of water purification system. The demineralization process will definitely not remove organic contaminants, such as herbicides residues, pesticides, etc… A separate filter can be added to remove those, which are a concern mostly in areas of intensive agriculture/horticulture. On the other side, regenerating the demineralization system, which is required periodically, involves the use of simple sodium hydroxide and hydrochloric acid, cheaply available, and is very easily performed by anyone. The initial investment can be used for a long time, which makes its use very worthwhile.

- Reverse osmosis system is another type of water purification system. Note that many companies advertise such systems as ‘reverse osmosis filters’, where actually they are absolutely not filters. Large molecules and ions cannot pass through the reverse osmosis membrane. The remaining is repelled through electrostatic effect at the membrane surface, and flushed with the residual water. It is one of the reasons why there is water rejected from the system, quite a lot of the ions are just repelled from the membrane because of their electric load, whilst most of the water will pass through the membrane. The remaining of the water is flowing with both the electrostatically repelled ions and the large molecules. One of the drawbacks to use RO systems is the water consumption. Whilst nearly all the water passing through a demineralizer can be used – the only spent water is the one used to flush the cylinders after regeneration every few months, RO systems consume a lot of water. Some systems are designed to recycle a part of the water and pass it another time, in a several step process however. The second problem when using RO, it requires a tank to store the produced water. Demineralizer will have more or less the input water pressure. RO water is greatly slowed down through the membrane passage, and must be stored in a tank, to be pumped later. Note that pure waters pose a problem to concrete and some metals, as well as cheap alloys as we will see later.

Boron

Boron itself is a major concern in some parts of this world. With chromium, cadmium, and a few other compounds, that are much rarer, they can irremediably damage a complete crop. Whilst chromium toxicity is rare – except in some parts of Indonesia and Malaysia, where it occurs naturally – boron phytotoxicity is not that rare. Get your water tested for boron every couple of years if there is a history of high boron concentrations in your area, no matter the source. Boron is one of the most boring contaminants to remove. Reverse osmosis and demineralizers usually are not very good at that. There are some specific solutions, namely an injector similar to the one used for fertilizers, that will inject an alkali before the water is processed by the RO or the demineralizer. Boric acid exists by itself dissolved at lower ph. As a result, it is not caught as an ‘ion’, and it has no electric load, so it is not repelled by the membranes. As a bonus, it is small enough to pass through the RO membranes. Since years I always ask people to test for boron levels in their irrigation water. A little is excellent and essential, but just a bit more and the cultures are permanently destroyed. I have seen nurseries wiped out by a boron accumulation problem, and nothing could be done to save the plants.

Quite pure to very pure water usually has a trend to dissolve easily many materials. There are several chemical reasons, first pure water has no ions, and can take very quickly whatever ion is available nearby, starting a chain reaction. Then RO water tends to be acid very easily by dissolution of carbonic dioxide from the air. The same applies for demineralized water and rain water. Demineralized water is usually not stored, being produced and used instantly, so there is little concern. For RO water and quite a few types of rain water, the water tanks, pipes, pumps, can be corroded quickly, releasing massive amounts of toxic compounds. A pump can release iron and tin, pipes can release copper, concrete tanks can release some heavy metals used for concrete manufacture – especially if fly ash has been used in the composition. The safest to store water remains, apart from a glass tank, the plastic tank. The plumbing must be done carefully as well, without any metal being in contact with the water, only plastics. Pumps can be very quickly destroyed by pure water; there are two types of pumps that can stand of pure water for a long time. First the peristaltic pumps, that can be used for only small structures at a reasonable cost. Second, the plastic pumps with metallic standard motor. Years ago, the Italians designed pumps to handle reverse osmosis, by a full plastic and Teflon coated pump. Now other manufacturers use a similar setup.

Another, cheaper and more elegant option to prevent excessive corrosion of metal pipes and pump parts, consists of a cheap cartridge style filter, similar to the ones sold for household as 'water filters'. The filter is removed, and marble is added in the empty cartridge. The said cartridge is placed just after the reverse osmosis system, before the tank. The resulting water is slightly hard, perfectly usable, and safe to all plumbing.

Fertilizer

In the fertilizer part, we will detail more about nutrient excesses and deficiencies. Enough to say at this point that the use of pure water directly on the plants is extremely dangerous on the medium term, even to so-call 'flush' the media.

As a side note, some brands of pelleted slow release fertilizers will release nearly all their contents within hours if they are exposed to too pure water. It has been a cause too of 'root burn', which we will detail later. Some resin coated fertilizer pellets are made to react to the osmotic pressure of the water outside, and in the case of the reverse osmosis, being completely, pure the contents of the fertilizer pellets moves outside pretty quickly and efficiently, resulting in a massive local release.

- The EC is related to the 'total dissolved salts', understand inorganic salts. An inorganic salt when put in solution in water will 'dissociate' when it is soluble.

As an example, calcium fluoride is highly insoluble, and adding calcium fluoride to water will just make 'snow', as the powder will simply precipitate.

Ammonium nitrate, NH4NO3, will solubilize. The powder disappears and is 'dispersed' in the water. In fact, the ions NH4+ and NO3- dissociate in water

From that point, it is possible to assess the quantity of ammonium nitrate in pure water using an EC meter, if we know the EC value of ammonium nitrate. This ion dissociation will change the 'resistivity' of water and can be measured using an EC meter.

Now, if ammonium nitrate + calcium nitrate + potassium nitrate are added to water, the EC will not allow knowing exactly how much of each compound has been added. The EC value of those three compounds is different, so the final EC of the solution is related to the EC value x quantity of each compound, for each one, and added.

Another instance which is very important for our purpose is 'urea' (NH2)2 CO. As it is not a cation/anion compound, its addition to water will absolutely not raise the EC. 100 grams of urea in pure water will not increase at all the EC compared to pure water. All 'organic' compounds do not contribute to the EC.

Therefore a 20-20-20 fertilizer that is solubilized at an 'EC of 500 microsiemens' as many books said can be either 1 gram of 20-20-20 with N coming all from urea, or 0.5 gram of 20-20-20 with N coming from nitrate, to give an example. The 'EC of 500 microsiemens' therefore can bring to the plants 100 ppm of potassium, or only 50 ppm, as the quantity of fertilizer added is different for the same EC, using different nitrogen sources.

I use the EC to check for leaks in the reverse osmosis system mostly, and eventually to check the water running out of the pots to roughly check for salts buildups. All other uses are pretty… useless.

- The pH is related to the acidity/alkalinity of the solution. However, it has its limitation.

In pure water, a few drops of hydrochloric acid can drop the pH to 2. This is extremely acidic, so it would be considered 'very dangerous' for the plant roots. However, this is not quite the case.

The same quantity of acid added to a fertilizer solution will maybe drop the pH from 6.5 to 5.9. pH is actually critical for quite 'concentrated' solutions, such as fertilizer solutions. In pure water, it has for horticulture purpose no meaning.

The concept is related to 'buffering'. Without doing a chemistry lesson here, enough to say that some solutions actually 'block' the pH within a certain range, so quite a fair amount of acid or of base is required to change the pH out of this range. When the pH has been brought outside this range, it requires little to change the pH.

As an example, pineapple juice is strongly 'buffered' at a pH around 3-4 depending on the varieties. It takes a lot of caustic soda-sodium hydroxide to bring the pH to 5. Afterwards, even slight addition of sodium hydroxide will strongly raise the pH.

By adding an acid and a base, we can realize a buffer. That's what people are doing when pine bark or peat gets dolomitic limestone. The result is 'blocked' in a pH range suitable for growth.

Salt concentration and pH are tightly related for practical purpose.

Consider a potting mix that has a pH of 5.8 of pine bark + dolomitic limestone as an example.

Pure water with a drop of hydrochloric acid, at a pH of 2, will not affect much the potting mix pH. In fact, it will most likely go unnoticed.

A fertilizer solution at 3g/L whose pH has been dropped to 2 with hydrochloric acid will on the other side have more 'power' because of the dissolved salts. Applied to the same potting mix, it will most likely destroy the plant roots by dropping the pH of the mix in the 3-4 range.

Therefore, pH of a fertilizer solution or tap water is very important, and to a grower, the pH should be extremely important if there are a lot of salts dissolved, such as fertilizer. In this we can say that pH is related to the EC for practical purposes. A high EC water with an out of range pH will change the pH of the root mass and potting mix.

Another important point to keep in mind is the salt solubility and precipitation in a fertilizer solution. This is the reason why it is impossible to add concentrate of calcium nitrate and fertilizer together. If they are added as concentrates, the calcium will react with phosphorus and eventually sulfate present in the fertilizers, making a precipitate. As the precipitate is insoluble, it will not be part of the plant nutrition, and induce ultimately a deficiency in the precipitated elements.

EC and pH, mineral salts, organic compounds

The EC, or Electrical Conductivity is a measurement used by many growers around the world. However the EC is useful only when one knows the ions present in the water:

- 100 microsiemens of calcium chloride will do nothing good or bad to a plant.
- 100 microsiemens of mercury bichloride will for sure kill the same plant.
- 100 microsiemens of nitrate based, mineral fertilizer will support the growth of the plant, but it will be deficient.
- 100 microsiemens of fish emulsion or organic fertilizer might well be more than enough to feed properly a plant

The EC depends only on the dissolved and DISSOCIATED ions present in the water.

- Sodium chloride dissociates in Na^+ and Cl^- , sodium cation, chloride anion. It increases the EC.
- Calcium nitrate will dissociate in Ca^{2+} and 2 times NO_3^-, one calcium cation (DIvalent, 2+) and two nitrate anion (MONOvalent, 1-). It increase the EC too
- Urea will $CO(NH_2)_2$ not dissociate in cation or anions, because it is an organic compound. It will NOT change the EC.
- Sugar will dissolve in water like the urea, but because it is not a mineral salt, it will not change the EC too
- Fish emulsion, seaweed extract are made of proteins, a wide range of complex organic molecules, and some mineral salts. It will increase the EC, but only according to its mineral salts content (intrinsic content, as well as impurities, such as seawater). As a result, one can apply 1 g of some fish emulsion brands, and increase the EC of only 100-200 microsiemens.
- A lot of boron compounds will barely dissociate, which means some borates and complex boron compounds can stay as a 'molecule', even if their structure is the one of a mineral salt. They will increase the EC, but in many cases even a plant lethal quantity will not show a big increase in the EC.
- A blend of several mineral salts, such as potassium nitrate and ammonium sulfate as an example, will have a specific EC according to the concentration of each salt in solution. It is possible to calculate the resulting EC of a solution of one mineral salt, or of several, however, if precipitate forms (such as tripotassium phosphate mixed with calcium nitrate, where a part will convert into insoluble calcium phosphate), it is quite complicated to say the least.

For safety purposes, the EC has only few functions:

- Check to see if the quantity of fertilizer applied is correct (knowing previously the fertilizer) as a routine check. When you know what quantity of fertilizer you want to add, you add it the first time and then check the EC. Each subsequent time, you can recheck quickly the EC to ensure there is no mistake in the fertilizer concentration.
- Check if the Reverse Osmosis or Deionizing Systems membranes are still working fine.
- Check eventually at the exit of a pot if there is no salt accumulation, or if the potting mix does not contain excessive amounts of dissolved salts

As for the remaining, a recommendation of 'using 300 microsiemens of fertilizer', without knowing the fertilizer, is useless.

- 300 microsiemens of fish emulsion or sojabean meal can be a lot of material,

- 300 microsiemens of a 20-20-20 with the majority of the nitrogen as urea is about 0.6 grams on average, according to various manufacturers' documentations.
- 300 microsiemens of a 20-20-20 fertilizer with the majority of the nitrogen as nitrate will be about 0.3g on average.

Detecting dangerous levels of compounds in 'pure' water cannot be done with the EC. A concentration of 10 ppm of boron, that can be very damaging, will not raise the EC much if at all (boron is a tricky thing, as under certain circumstances it dissociates, but not always, and some molecule containing boron can partially dissociate as well, but nevertheless). This is the same for an excessive concentration of most micronutrients. The EC will not show anything strange. It explains too why some growers are shocked, as their input water from a well or a river has an EC of 20-30 microsiemens, yet they get extensive damage on their culture.

The use of the EC to 'test' for tap or well water purity is not recommended either, unless the risks of abnormal compounds are known. Water with an EC of 150 microsiemens can look suitable, but in a lot of parts of the world, it can be nearly all iron, which is phytotoxic at those concentrations or even worse, nearly all boron in some volcanic areas. Therefore, if the geology and the source of the aquifer/dam/lake/river are really well known, the EC can be helpful to know if the water can be used. But if one is just testing the EC without such knowledge, it is possible to kill the plants even with a very low EC, as the low EC could well be made only of iron, boron, manganese, zinc, or whatever, phytotoxic at those levels.

pH, and the magic relation, pH and dissolved materials.

The pH is another measurement that is widely used and needs some explanation.

The pH is measured using pH-meters. First, most pH-meters used are not precise. Several well brands in the low to middle price range usually have probes that are not at all made to check the pH of organic or mineral fertilizers used for orchids in pure water. Those probes need a much higher salt concentration to be more or less accurate; as such they are barely useful.

On the other side, similarly to the EC, a pH reading has a meaning depending on several things:

- If the water tested has a large concentration of dissolved materials, organic or minerals, then the pH can be important, and a pH of 4 or 5 can be toxic to the plants.
- If the water tested is very pure, a pH of 4 or 5 has nearly no meaning, it comes usually from dissolved gas or minute amounts of salts, and when a plant in a potting mix is watered, the potting mix pH will overcome the very pure water low pH.
- In the middle of the range, with water and fertilizer added, or tap, hard alkaline water that is being corrected with acid, the pH is important, however it depends again on a few things:
    - A 0.1 or even 0.2 unit difference in the practical range of 5.5-6.5 has nearly no meaning.
    - The pH of the fresh fertilizer solution will increase or decrease, according to what the plant takes, the potting mix, and the evaporation of water from the potting mix. It is quite difficult to predict accurately by a scientific mean, and requires more experience with the specific growing conditions. There are fertilizers that, when used by the plant, will increase the pH, such as calcium nitrate, and others fertilizers that will decrease the pH when used by the plants (such as ammonium dihydrogen phosphate).
    - The final pH of the feeding water is chosen according to the potting mix and the species grown. As an example, if one grows in acid sphagnum moss, the watering pH would be chosen over 6, even 6.5 for some species, with a fertilizer that tends to raise the pH (usually nitrate

based fertilizers…). If the plants are grown in limestone chips, the watering pH would be optimal around 5.5-5.7 (ammonium or urea based fertilizers would be the choice too in this case, as fertilizers that tend to lower the pH…). Both can produce excellent plants.

- The macronutrients need some adjustment according to the potting mix pH and the water pH. However, the micronutrients need even more adjustments, as will be seen later. As an example, an optimal quantity of manganese at a pH of 6.8 can be a deadly quantity of manganese at a pH of 5.3. The solubility and independently too the uptake by the plants, of many compounds vary according to the pH, and what is deficient at one pH level can be deadly at another one. Some ions that will be discussed later are more available at higher pH as well, so there is absolutely no fixed rule as sometimes stated that ' the lower the pH the more the nutrients are accessible to a plant'. In fact it is the opposite for some important ones.

Regarding the pH it leaves a lot of questions open, which will be summarized later in this document, but more important it gives indication as to why different people can grow with vastly different potting mix and feeding schedules, whilst still getting similar pristine results.

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In pure water, a few drops of hydrochloric acid can drop the pH to 2. This is extremely acidic, so it would be considered 'very dangerous' for the plant roots. However, this is not quite the case.

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The concept is related to 'buffering'. Without doing a chemistry lesson here, enough to say that some solutions actually 'block' the pH within a certain range, so quite a fair amount of acid or of base is required to change the pH out of this range. When the pH has been brought outside this range, it requires little to change the pH.

As an example, pineapple juice is strongly 'buffered' at a pH around 3-4 depending on the varieties. It takes a lot of caustic soda-sodium hydroxide to bring the pH to 5. Afterwards, even slight addition of sodium hydroxide will strongly raise the pH.

By adding an acid and a base, we can realize a buffer. That's what people are doing when pine bark or peat gets dolomitic limestone. The result is 'blocked' in a pH range suitable for growth.

Salt concentration and pH are tightly related for practical purpose. The higher the salt concentration in the feeding water, the most important the pH is. However, the same applies to the potting mix, which usually has a buffering capacity that is way superior to any normal orchid fertilizer solution.

Consider a potting mix that has a pH of 5.8 of pine bark + dolomitic limestone as an example.

Pure water with a drop of hydrochloric acid, at a pH of 3, will not affect much the potting mix pH. In fact, it will most likely go unnoticed by the plant. The pH will change on contact with the potting mix.

A fertilizer solution at 3g/L whose pH has been dropped to 2 with hydrochloric acid will on the other side have more 'power' because of the dissolved salts. Applied to the same potting mix, it will most likely destroy the plant roots by dropping the pH of the mix in the 3-4 range.

Therefore, pH of a fertilizer solution or hard tap water is very important, and to a grower, the pH should be extremely important if there are a lot of salts dissolved, such as fertilizer. In this we can say that pH is related to the EC for practical purposes. A high EC water with an out of range pH will change the pH of the root mass and potting mix.

Temperature

There are some places where Paphiopedilum and orchids grow that are hot.

Paphiopedilum violascens as an example is growing in exceedingly hot conditions in Iran Jaya for most of its coastal colonies, yet in cultivations people had better success growing them cooler and very shaded.

Paphiopedilum hangianum is growing with temperatures exceeding 38 degrees Celsius in summer, with a cold season in winter, where the temperatures can drop to 3-4 degrees Celsius, exceptionally freezing in 2011.

In fact, all Paphiopedilum are tolerant of a wide range of temperatures, providing one understands what the temperature means.

Firstly the water temperature. The warmer the water, the lower the amount of dissolved gas such as oxygen and carbon dioxide. It is well known in the aquarium and aquaculture world.

Second, the response of a given species to the temperature. At low temperatures, plants that can be dormant will be dormant, proper temperature, the plant will grow, and their metabolism will increase as the temperature increase, so will transpiration and water uptake. When the temperature is too high, the plant will shut down, and the metabolism will be greatly slowed down. When the temperature is really too high, some cellular denaturation will happen, similar to a boiled lettuce leaf in a way, and the plant dies.

It is known by Phalaenopsis growers for ages that depending on the temperature, the feeding schedule must be adapted to get the best optimal growth. Very high temperatures can require an increase to the potassium and magnesium as an example in order to get wide leaf. The fertilizer that gave the longest, largest, biggest leaves at 23-25 degrees Celsius will produce leggy leaves at 29-31 degrees Celsius, so a change is needed. For the same optimal plant growth, the nutrition needs change according to the temperature. In fact, most commercial Phalaenopsis growers that grow the ‘cascade’ pot plant type have a very strict schedule, to produce plant with optimal, very big leaves, depending on the outside temperature and the light. More on this type of schedule in the fertilizer part, however it is important to remember that the fertilizer has to be adjusted to the temperature.

As for Paphiopedilum growers, it is the same problem. When the temperatures are high, the mineral needs of the plants change.

Conversely, if the plants are not properly fed, or their requirements, such as Paphiopedilum violascens are poorly understood, when the temperature increases, they will become intoxicated or deficient, and die. They will grow ‘better’ with low temperatures, that slow down the metabolism and the growth, which alleviate, to some extent, the problems of a wrong nutrition.

A conjunction of ‘optimized nutrition supply according to the species’ and ‘temperature’ brings the best growth possible. However, as we will see later, the nutrition depends on the temperature we can give to the plants, and in this respect, it is possible to make adjustments that are beneficial to most species.

Some other points are very important too. In many nurseries around the world growing sometimes the nearly complete collection of Paphiopedilum species, there can be some months at exceedingly high temperatures.

Frank Smith of Krull Smith has been the first to point out that he was reducing sharply the feeding when it was too hot in summer, sometimes stopping its use. Therefore, as a broad rule:

If a plant is at a temperature below its optimal temperature, feed less, as the plant will not be able to use a full strength.

If the plant is at a temperature that is optimal, that's where the maximal feeding can be provided for the said species. It is where one gets the best, maximal growth.

If the plant is at a temperature that is slightly too hot, provide a fertilizer that does not contain too much urea, and prefer a fertilizer that has more nitrate than ammonium, and a lower phosphorus level, to avoid 'stretching'.

If the plant is at a temperature that is really too hot, it will absorb a lot of water through its roots. In this case, reduce drastically the fertilizer concentration; otherwise the plant will take up too much fertilizer, which will result in fertilizer burn.

If the plant is at a critical temperature, which can vary for Paphiopedilum between 37 and 41 degrees Celsius, its complete metabolism shuts down. In this case, it is required to keep a very high humidity, and avoid watering the plant directly, as the plant is basically doing 'nothing'.

Over 45, depending on the species as some can be quite resilient, there is a protein denaturation, which makes a yellowing, then browning of the leaves. It can start immediately after the critical temperatures have been reached, but most commonly, there are patches and streaks of affected tissues all around the plant, and the symptoms can take up to two weeks to appear.

Light

A tough subject. In fact, I have seen some of the best plants of Paphiopedilum being grown in shade, including gigantifolium, rothschildianum, Paphiopedilum rothschildianum prefer shady to very shady conditions, especially if properly fed. It can reach enormous sizes, and very dark, glossy green leaves with strong flower spikes and strong growths.

I tend to give a reasonable amount of light. In general, the leaves, if the plants are properly potted and fed, should be 'shiny', like if oil had been used on them, never dull. It is a sign of excessive light if the leaves are greyish or dull looking. I tend to go for the darker green leaves rather than the yellowish leaves. If the plants have enough light, they make nice dark green leaves, with no mottling or marbling even, and the leaves are very large. They must not be floppy, just large and dark green. Apart from Paphiopedilum exul, which grows in full sun, most species grow with some sort of shade, or so much fog that they are shaded by it. The plants that are in full sun in the wild usually do not look so nice to be fair, and whilst they bloom earlier, the best blooms are produced with moderate light.

I always did the light part as a feeling, though I can say that I have seen the best Borneo Paphiopedilum species ever grown in three places, Sabah, Sarawak and in Cameron Highlands, with a triple layer of 70% of shade. It was not exactly possible to read a newspaper, and in Cameron highlands, they even had gigantic plants of Paphiopedilum philippinense with 6-7 flowers per stem, and maybe 30 growths per pot, absolutely amazing. When the said plants were brought outside, they were blackish green, healthy looking.

The amount of light depends on the fertilizer, and I know, from other pot plant orchids too, that many growers tend to give a very high level of light, and give plenty of fertilizer, without realizing that they give a lot of fertilizer to compensate for the too high light level, which nullifies the purpose of increasing both, as the plants do not grow better than with a lower level of feeding and lower levels of light. More about that part in the feeding.

Dormancy, rest, rachitism and normal plant size

There are concepts that are very well known to gardeners, yet have to enter the Orchid World properly. Or more correctly, some genera are known to require dormancy, but it is not recognized at all for Paphiopedilum. One of the most common statements about monopodial orchids, Phalaenopsis as well as Paphiopedilum is 'as those plants do not have storage organs, they do not have a rest period', which has been printed countless times.

However, the truth is really otherwise. There are some simple observations that should have bought the question before. Some Paphiopedilum grow along with garden's plants in the wild, lilium, pleione, arisaema, paris. Those Lilium, Pleione, Arisaema… absolutely need a cold dormancy, otherwise, like most garden's bulbs, the new growth is smaller, very slow growing, and after a while the plants collapse. There are exceptions, similar to some individual cultivars of tulips and lilies that can grow year round. However, most of the plants will not perform well. It is very well known to most gardeners.

There are orchids that can be grown on a year round basis, without any rest. They will even benefit from it, such as the catasetum, which can reach unbelievable sizes when grown without any rest. Phalaenopsis are another example, at least some of the 'common species'. Phalaenopsis amabilis, stuartiana have a rest period in the wild, but by omitting it, we can brow specimen size. On the other side, Phalaenopsis braceana, lowii, malipoensis are less forgiving. They will survive, but not reach the maximal size they are able to. Cymbidium, some will grow, some will collapse after a couple of years.

As a general consideration, Cymbidium goeringii as an example is growing in exceedingly hot places in the wild… during the summer, even warmer than Bangkok with its vanda. On the other side, they have a cold winter. Omitting the cold winter, and the plants quickly will regress.

Some Paphiopedilum groups are no exception. The Parvisepalum especially enjoy a cold dry winter, coupled with an extremely hot summer. In fact, by getting dormancy in winter, with low temperatures and not much water, they start an extremely strong growth cycle around march-april, until about November. During that time, Paphiopedilum emersonii can, as an example, make 3 leaves, hence nearly a full growth. If grown warm nonstop, usually, the plants either collapse, or bloom every decade.

Differents colonies have different behavior, even in the same species. Paphiopedilum violascens has colonies growing on limestone crumble, and some others growing in sphagnum bogs. They require different conditions. One more accessible example is Paphiopedilum micranthum,

- The normal ones usually prefer a cold rest, and grow in spring and autumn. They do not grow so much in the summer heat or in winter. In their habitat, they grow in fern roots and leaf mold, which is very acidic.
- The micranthum 'Kwangsee', that are very rare, come from one colony only. They grow in a very heavy loam; their growth speed is maximal during the summer, the warmer, the faster they grow. They tend to bloom as well quite easily and do not need the cold rest in winter that the normal

micranthum need. They grow with an unidentified microorganism in the wild. This yeast or bacteria can kill all the plant roots absolutely overnight with a very strong brewer's yeast smell, and seem to be specific to their habitat. On the other side, if the pH is maintained quite high, this yeast will not appear. Until the pH goes blow about 5.5, where it will immediately catch up. It is easy however to get rid of it.

- There are many micranthum sold as 'Kwangsee', however they are the Vietnamese type of micranthum, with a white pouch. Some have been awarded by the AOS and AJOS, but the plants as well as the flowers are very different. They grow in a pattern similar to the normal micranthum. However, the white pouched micranthum from Vietnam grow in degraded loess in the wild, another habitat.

The problem that people are facing is that, as it is illegal to collect plants from the wild, there are several traders from the jungle to the nursery, and eventually to the flasks, and it is impossible to know for sure the origin of the plants. Trials and errors are the only ways to know how to grow some specific plants.

The first colonies of Paphiopedilum sanderianum to have been collected were highly sensitive to iron. The plants had yellowish leaves, a bit skinny, and were hard to grow. The recently collected ones, from the early 2000's are easier to grow. In fact, all the flasks of Paphiopedilum sanderianum and blooming size sanderianum, with a few very minor exception, come from those plants collected only 10 years ago. The plants from the 80's and 90's are a great rarity, so is their progeny, as they were much more difficult to grow.

I tend to provide for all the parvisepalum, except delenatii, a cold and dry rest in winter. The plants can look a bit dried up, however, they are absolutely gorgeous when they are watered again and the spring comes. In fact, they grow faster than when, in Europe, I was growing them year round. I apply this too to Paphiopedilum tigrinum, purpuratum, canhii, charlesworthii, and a few plants that come from cold habitats. It is especially important to keep healthy Chinese and North Burmese bellatulum and wenshanense. Through the South Burma/Shan and the Thai bellatulum do not like the cold and shriveling treatment at all… that's why there is a need to know the origin of the parents sometimes to provide optimal conditions, and to know too that apparently some Paphiopedilum need dormancy not unlike a tulip or a paeony… With an arrested growth winter, and a massive growth during spring summer and autumn, in the way of a pleione or cypripedium, thinking well about it.

The unwanted selection, and some concepts about 'hybrid species'

I designed a new concept concerning the selection of Paphiopedilum too, and its consequences. We want to select plants that have this or that esthetical or growth trait, that looks really fine. However, we have what I called 'unwanted selection'. It is a phenomenon that starts from making the seed capsule, through the laboratory, through the culture of the plant until it blooms.

It goes back to the colonies in the wild and the habit of the plants. For some breeding lines, this problem has been eliminated, at least in part, such as the Complex hybrids, or the Maudiae types, over generations. Or maybe we do not know what we lost on the way, which to my mind is more correct.

I just read a story about a deep red Australian sarcochilus species, which, when used for breeding apparently gives not so nice progeny in the fastest growing seedlings, but dark red progeny in the slowest growing runts only, and it would be similar to my concept of unwanted selection.

Sometimes, I heard that one cross of two perfectly well known parents gave different results over subsequent remakes. It was a bit hard to understand, because genetically the parents were the same, though I though a part of the problem would be that the parent plants have been grown in a different way or maybe was 'exhausted'. However, I did for one nursery a seed sowing of really strange hybrids, Paphiopedilum sangii x rothschildianum. I got the work to do as dry seeds, and another lab got another part, as well as a third one. They made very beautiful glossy, deeply mottled leaves, except a few strap leaf like with some markings, and I sent the trays to the customer. He called me about 6 months later, to inform that another lab had sown the same seedlings, that they were just ready, 6 months later, and they did have strap leaf with one or two markings, with one or two only with the mottled leaves… The third lab reported the same seeds to be sterile. Anyway, it was really weird, and he wondered who between me and the other lab did make a mistake in the tags. When they bloomed (not so nice to be really honest, but anyway…), mine were mostly single flowered with some rothschildianum traits, the other lab were multiflorals with brownish color, a bit like some really bad Maudiae/rothschildianum hybrids. It was clear that I and the other lab did the job well, but in fact we did not get the same result out of the same capsule.

I started to investigate the things a bit more, and sometimes other's people runts or slow growing plants were plants that grew like crazy for me. Not to the extreme, I got two very striking cases, one involving the Orchid Zone. I got four plants of their rothschildianum breeding two years ago, one a bit smaller than the other ones, and a bit more yellowish. So far the later one is over 120cm leaf span, with two massive new growth, it is even hard to believe that the plant grew that big in two years, and the three bigger ones are about 80cm with a new growth. They are all beautiful, but the smaller one apparently had something missing for that specific individual plant, that was not missing for the other plants.

To another matter: the complex Paphiopedilum. Paul Phillips from Ratcliffe sold to me a few seedlings that were very slow growing, and he told me that when they are slow growing, for their breeding lines, it means the flowers are round. There was some lettuce from the same cross, some multiple growths. I took the risk, and those slow growing plants bloomed perfectly well. The slowest growing from the flask were the best in many breeding lines from Ratcliffe, and worth the patience. In this case, genetically one can assume that the round shape and the slow growing/crippled habit coming from Bellatulum were too close, and usually were nearly never dissociated when meiosis occurred. Bad news in a way.

On two other sides, The Orchid Zone succeeded in breeding very round (perfectly round in fact) flowers on fast growing plants, and Terry Root 'dissociated' genetically in a way the round shape, coming mostly from bellatulum, from the slow growing habit of the complex x bellatulum types. Then he could succeed to produce so many fantastic complex Paphiopedilum crosses… He has been successful too to dissociate the white color from the small flower shape that came out of niveum and its far progeny, Skip Bartlett.

Another that has been very successful at this, but for the copper and yellow complex hybrids is Fritz Hark, from Germany. He succeeded in raising the Paphiopedilum Lippewunder, and a wide range of hybrids that look a bit similar, but are different, though most were rerereresold by resellers as 'Lipperwunder', but there were Anja, and several others. The flowers are absolutely massive, and the best ones are very round, massive, and perfect. It is in fact my favorite Complex Paphiopedilum breeding line for the colored ones.

Now back to the unwanted selection. By using some technics for seed sowing, then some fertilizer, potting mix, temperatures, etc… we can either have 'runts' or in fact those runts are not runts, but they need different conditions to grow. Some died for sure at the protocorm stage, some in the flask, some were culled as 'runts' when deflasked, and at the end of the story, because the genetic loci that made them become 'runt' in those specific growing conditions might be tied to some other interesting traits, such as color, or shape, or whatever, I am certain that we have lost the potential for many excellent hybrids, because the promising seedlings never had a chance to bloom, being killed and culled by our way of sowing and growing them. In some cases I have seen weird things, such as Paphiopedilum hookerae hybrids. In Germany, some hookerae were crossed with Paphiopedilum Laser, and it gave some absolutely fantastic, glossy colors, some being vinicolor, some being coloratum, but all being worth keeping. The same breeding line has been done in Taiwan many times, and the results were always disappointing, always dull. However, the plants did not take much of the hookerae in their appearance in Taiwan, so I guess the hookerae biaised plants disappeared somewhere in the lab or in the trays.

In some other genera, it is a common well known thing. The use of too much iron as an example in pelargonium did kill a lot of seedlings and progeny that gave striped flowers. It took years to redo the crosses, find back some parents, and produce a line of striped flowers that was worth commercially for the Dutch standard. At the end, we lost about 20 years in the game, and it was clear that striped flowered pelargonium, in their early breeding, were highly sensitive to an excess of iron. I am certain we already 'screened' a lot of worthwhile Paphiopedilum plants by this kind of similar mistake in the past.

The hybrid species is something else. It is not all those fake and look alike plants that plague today the market worldwide, and become increasingly difficult to identify, except by selfing them. It is about a botanic species that behave like a hybrid.

The most famous examples are again from the Orchid Zone and from the Tokyo Orchids Nursery. Paphiopedilum rothschildianum 'Mt Millais' FCC/RHS has been crossed by Terry Root with a plant from a very different colony, 'Rex'. Because they are not genetically very close, it is of course Paphiopedilum rothschildianum, but the progeny behave like a hybrid in cultivation, with a kind of hybrid vigor. The plants are in fact like Mt Millais on steroids, because of this kind of 'hybrid vigor'. The Tokyo Orchids Nursery did the same type of cross with 'Val', unrelated to Mt Millais. In both cases they get a hybrid vigor, and they are like vastly improved rothschildianum Mt Millais because of that kind of hybrid vigor.

Most growers in the world started to self and sib those plants together, but they are now genetically related, two Rex x Mt Millais crossed together will make an improvement, so would one of those Rex Mt Millais crossed with a Val x Mt Millais. However, Terry Root got another rothschildianum, named Chester Hill, which is, again genetically unrelated. As a result, his hybrids of ('Rex' x 'Mt Millais') x 'Chester Hill' go even further in the breeding with hybrid vigor.

I would expect these to give some fantastic rothschildianum, however the mainstream of hobbyists want to get seedlings of Rex x Mt Millais x others Rex x Mt Millais, or this kind of thing, because they did not understand clearly what Terry Root was doing with those rothschildianum. Bringing a new parent, genetically unrelated in each generation, will for sure improve the vigor, and the quality of the progeny, rather than crossing plants that are from the same 'family'. In humans, we call it 'incest', and where it can be used to emphasize a trait, concentrate a trait, or get some recessive traits back on track, it is usually never good when breeding animals or plants.

That is a 'good hybrid', because the rothschildianum are rothschildianum. There are some real messes too that appeared. One example are all the brachypetalum from Thailand, except a few sellers, and not always the 'famous ones', by really far, many awarded plants are hybrids. The latest joke was those 'black leucochilum' that were bred with a shot of bellatulum from the Royal Thai Family collection. They have a bellatulum where the color is nearly uniform, and the pattern of the color is perfectly the same as most of those black leucochilum. More hidden, some godefroyae and leucochilum have been rounded with bellatulum, which is not so obvious, but the plant vigor is tremendous.

Sometimes, we do not know anymore one species, as it has been replaced by hybrids only. The cross of Paphiopedilum curtisii and superbiens is named Cymatodes, and all the curtisii tagged and curtisii-like plants (that must look like the original watercolors and description) in the trade today are progeny of that Cymatodes. Some spicerianum and insigne lines are in this case as well.

Recently, flasks of Paphiopedilum hookerae x volonteanum, micranthum kwangsee x micranthum, papuanum (real one, zieckianum in the trade) x violascens appeared. They look like the species, but of course they are not. They have added hybrid vigor, are hard to tell apart and I think in some cases they will replace the real species in the coming years or decades in cultivation. The sequential multifloral species are already doomed by that problem, and finding a real primulinum, glaucophyllum or liemianum is very hard, if not impossible today. Some growers think that, because they bought their plants from Indonesia, they had to be 'wild collected', but in fact, several Indonesian nurseries (one owned by a Dutch), had big tissue culture laboratories, and did a lot of Cochlopetalum hybrids for their local pot plant market. At a point, even another nursery imported thousands of flasks from Floricultura, for pot plant purposes, in the 80's. Those have been happily mixed with supposed 'jungle plants', and for that case, getting a rough plant potted in cocochips from Indonesia has never been the proof that it was a species or a pot plant hybrid. At a point, Indonesia had thousands of Paphiopedilum Jogjae (praestans x cochlopetalum) and Paphiopedilum stictopetalum (stonei x … Leeanum, Dutch pot plant) for sale as wild collected new species. Getting the plants from the wild can be expensive, and those seedlings were very cheaply produced locally, even cheaper than one would have to pay a collector and rent a plane in those days to go to the villages to pick up the order. Road transportation was so bad that it was out of question to get as an example Paphiopedilum victoria-mariae by road, only by airplane. Cochlopetalum from the wild can look really trashy, in fact for those cochlopetalum and the real, rothschildianum sized praestans from Papua, and in another part of Asia the Bellatulum from Burma, one wonders if they were in a paper shredder at the collector place, used the collector's bags as an elephant litter, or if they played football with the boxes… It is still true today anyway.

Recommended species for various conditions

The recommendations vary tremendously. In many books, people considered Maudiae to be easy growers. If it is true for the original Maudiae (callosum x lawrenceanum) and a few similar hybrids, which can grow like weeds in no time, it is not so true for some of the latest breeding, that incorporated more sensitive species, such as purpuratum or mastersianum. Whether the Maudiae types are albino or coloratum, the earlier generations were usually much stronger, faster grower than the more complex ones, for a beginner. Getting a real Paphiopedilum Maudiae can be a challenge today, but it can be recommended as an easy plant. For the complex Maudiae types, there are many hybrids, from the USA and Taiwan, one can choose plants that have usually two new growths at the base of a strong, well growing plants. They will be rewarding in terms of growth, though I tend to prefer the US bred ones. In Taiwan, some different breeding lines have been combined, sometimes not understanding which is the ploidy of the ancestors and results in true disaster. One example would be to cross one polyploidy albino Maudiae type with one of the Goultenianum or Gowerianum original plants, which were clearly diploids. If breeding with that progeny, at a point there will be really odd and abnormal chromosome numbers, that one could not even class in any ploidy level… and the plants are very hard to grow. Most of the Maudiae hybrids are however easy to bloom, but some breeding lines tend to die after their first flowering. It is not unlike some of the Philippine Paphiopedilum, such as ciliolare and urbanianum, where quite a few colonies had a handful of 'clumps' and a lot of monocarpic single growth plants, that collapsed once they had done seeds. I have seen the same phenomenon with papuanum in Papua too.

Recommendations:

- Brachypetalum are really excellent and easy plants at home under artificial light. The humidity is not too high, the temperatures are quite warm, and all can be grown successfully, including their hybrids. They are more difficult in a greenhouse or with cooler temperatures, but many hobbyists have fantastic results with them under light, including me before.
- Parvisepalum, Paphiopedilum malipoense and micranthum 'Kwangsee' are the two I would recommend if one cannot provide a cold winter. They are strong growing, reliable plants, if one can get the real Kwangsee type, which is a rarity, despite numerous offers of plants named as such. Paphiopedilum jackii is very easy to grow, but I find it lacks any appeal, looking just like a poor malipoense. As a small side story, Paphiopedilum jackii has been bred with malipoense in Europe, most of the progeny being sold as very vigorous malipoense. Many can be really hard to tell apart. Jackii was more suited to be grown with pot plant Phalaenopsis in terms of temperature, so commercial pot plant hybrids have been attempted. Paphiopedilum delenatii is another easy grower, in all of its variation, including the F2 generation of delenatii vinicolor/'Dunkel'.
- Cochlopetalum. Pinnochio and the hybrids like Avalon mist are very rewarding and not difficult, chamberlainianum is not difficult too, with very thick leathery leaves it is the most tolerant of dry conditions, but it is rare. Primulinum can be grown quite dry, but it is a rarity today, with its narrow skinny leaves. In most instances it has been replaced by the early versions of Pinnochio, since the 70's in Indonesia even… Liemianum is usually another not too difficult plant, though it likes high humidity. Glaucophyllum moquetteanum were recommended as beginner's plants years ago because they were very cheap, like stonei, but they are not exactly easy to grow. Paphiopedilum victoria mariae is difficult to grow usually, except in deep shade and high humidity conditions.
- For the mottled leaf species, callosum, sukhakhulii are the usual culprits. Some other species perform well in many hobbyists collection, but sulk and die after some time, several of the bullenianum varieties, Paphiopedilum purpuratum… are such plants. Barbatum is easy to grow warm so far and can be recommended for the warmer grower.
- Paphiopedilum gratrixianum is easy to grow, so can be some types of villosum, usually the Thailand types/Burma types of villosum. Some other types can be hard to grow if they are kept too warm.
- Paphiopedilum henryanum and helenae are two very easy to grow and bloom species. Esquirolei is easy to grow, but sometimes can be tricky to bloom, as it needs quite cool conditions to perform well, at least for the Chinese and Vietnamese types.
- In the multiflorals, the easiest are gigantifolium, rothschildianum, and kolopakingii. If you have warm conditions, the real praestans or the smaller praestans 'red laef' are easy, fast to grow, not prone to diseases, and clumping very well. Some types of philippinense are easy to grow as well, including the real huge philippinense with nontwisted petals, coming from Sabah… Stonei is very hard to establish usually, but a good grower if kept warm, yet it cannot be recommended to beginners.

In fact, I would say that, if proper care is given, most Paphiopedilum species can be grown really fast and well. There are some exceptions, notably Paphiopedilum ooii, the very closely related intaniae, some volonteanum and some bullenianum types, and the mottled leafed Paphiopedilum from Papua and Solomons. Sangii is very easy to grow if one has high humidity, or can water the plants very frequently, so is mastersianum

In the hybrids, the complex Paphiopedilum are easy to grow, if one can find Paeony 'Regency' AM/RHS, it is an old complex that can grow a bit warmer and is more tough than most, the Winston Churchill for slightly cooler conditions, Hellas 'Westonbirt' FCC/RHS, are antique that are quite cheap and easy to grow. In the newer generations, I would say the Lippewunder are very easy growers, the original ones from Hark Orchideen, and the seedlings made out of those original ones. The ones from Taiwan are vastly different, and tend to die easily, plus the flowers have a lot of color break. And of course the Orchid Zone white and greens, that are good growers. From Europe the spotted bred from Ratcliffe are good to excellent, and can be easy growers, though a bit slow.

As one can see, it is hard to advise who should grow what. I once had a customer who was a junkie, growing cannabis for his personal use, going to the rave parties, and bought from me some Paphiopedilum wentworthianum, two plants, as well as some sangii, mastersianum. About a year later, I went to visit him few hundreds kilometers south in France and he wanted to get some more hookerae, wentworthianum, bougainvilleanum, sangii, mastersianum, 10 of each please. I went to see him, and told him, so that's really hard to grow right? He said, not at all, but they grow well, and he likes to have some clumps for his fun, the single growth wentworthianum were about 7-8 growths big, he was growing them in fern roots and live sphagnum, in very big jars, and I never saw such beautiful plants. He still has a few clumps of each, much bigger today. On the other side, he could not grow anything else, only those species, even insigne or philippinense would not survive more than a few months. Later, he started to collect the oxyglossum, and grows them the same way.

People who grow under light, especially the fluorescent tubes or HID systems usually have much drier conditions, and very high light for the HID. The fluos people can grow easily the brachypetalum, parvisepalum, rothschildianum and the 'low light growing' multifloral, including gigantifolium, but the HID need to grow things like philippinense, or the brachypetalums as well. However, the HID growers cannot easily grow the mottled leaf paphs.

With few exceptions, especially in the Chinese and North Vietnam species as well as the Himalaya/North Burma/Indian species, most Paphiopedilum can be grown well warm, though some will not bloom well, or some will produce inferior quality bloom. As said before in the temperature, the fertilizer, potting mix, and watering schedule helps to control the temperature matters.

As for the plants to choose, physically, take good quality plants, avoid plants potted in packed sphagnum moss, they will be troublesome to repot in anything else, the plant must have several leaves, no chlorosis or bleaching of the leaves, and it must not have dead tiny new growth starts, just good growths and good new growths. Check the root system, and check especially very carefully that there is no orange color anywhere at the base of any of the growth. The orange color is a phytophthora disease that came first apparently from wild Paphiopedilum and slowly find its way all around the world. In Taiwan it wiped out a lot of plants, so did it in Europe more recently. It can be controlled, but it is worth only for very rare, precious plants, not for plants whose quality is unknown or just average.

The leaves must emerge 'clean', especially the newest ones. Any signs of strange dust or pitting can be another very common disease in some parts of this world, caused by thrips. It will get worse, and the plant will die some months later of 'crown rot'. Plants whose new leaves are stunted in the crown are usually affected by mites, or eventually nematodes, it is another very common pest that people mistake, when the damages are extensive and the plant dies, for a disease.

In general, chose healthy plants, with no damages anywhere, and 'increasing' growth, the newer leaves are bigger than the older ones, no stunted growth anywhere, no discoloration, and dead part.

As a note for the wild collected plants, it is another very different story, and to keep alive wild collected plants can be a real challenge. They are still exceedingly popular all over Asia and Europe, and partially cultivated plants find their way to Canada and the USA in quite large numbers, but handling of wild collected plants, and establishing them need to know some specific diseases of each species, that I will not detail here. Enough to say that there are some types of colletotrichium on Paphiopedilum sukhakhulii and callosum, as well as some colonies of sangii, that a lot of Paphiopedilum species have pseudomonas in the rhizome, in the dead parts, as it is a part of their natural environment, though when the plant is stressed, it can infect the new growth and the whole plant, that Paphiopedilum hookerae nearly always comes with nematodes, and Paphiopedilum bellatulum, godefroyae, leucochilum, nearly always with a species of thrips in the crown, that eats the growth. Treatments have to be done accordingly, and some are not so easy. As an example, Paphiopedilum praestans must be dipped in streptomycin and tetracyclin overnight, or they start a bacterial rot after some months, killing the rhizome. It is not something the hobbyist or even the normal commercial grower knows, or can do easily, but it is worth to know it when people buy a wild collected plant, there are risks.

Wild diseases and pests, culture diseases.

Unfortunately for the world, when collecting Paphiopedilum, a lot of diseases appeared in cultivation. Lance Birk in the 80's reported about a mysterious disease that killed his collection. In another field, Fred Hillerman lost most of his angraecoid collection to another strange disease he imported once from Madagascar.

There is, for over a decade, an orange rot that kills Paphiopedilum in a very effective way and that has been spread worldwide from wild collected batches grown in Taiwan. More on those diseases later, but enough to say that we got a lot of surprises on wild collected Paphiopedilum, and that a good range of diseases and pests have been introduced to the world through those imports. Recently, about 2 years ago, a fusarium strain came out of batches of Paphiopedilum intaniae, and it seems much more aggressive than the ones previously known. I saw already quite a lot of plants contaminated in Asia, including hybrids and other species of course.

There are mysteries too. On Ceram, Paphiopedilum mastersianum are always contaminated by a Brevipalpus. Not to an extent that kills the plants, though all of them show some damages. I saw similar damages on Karkar Paphiopedilum violascens. If Ceram got quite intensive agriculture at a point of its history, for Karkar, it is very unclear how plants in the wild can be infected with that pest.

Paphiopedilum wardii from the wild is always, and invariably, contaminated by thrips palmii. Again, the plants show no damage, but the larvae can be found in the crown, straight from the jungle to the lab, and it is one more mystery. Paphiopedilum micranthum, malipoense, and bellatulum are usually contaminated by another thrips species, whose damages can be seen on the plant's older leaves usually. However they are nearly never killed by those pests.

In the diseases department, a lot of species of mottled leaf Paphiopedilum are infected by colletotrichium in the wild. Usually, when the infection is too severe, the plants will lose all of its leaves, and restart from the rhizome at a later stage. Paphiopedilum callosum, appletonianum, sukhakhulii, sangii, hookerae, purpuratum are especially prone to that disease. What is puzzling is that exceedingly severe symptoms can start only a day after the plants being collected, from originally, in the wild, tiny brown spots surrounded by a yellow circle. It can become epidemic, and I remember the De Wilg Nursery in the Netherlands, at that time the largest orchid importer in Europe, that lost about 6000 plants of various Paphiopedilum after they got a contaminated batch of Paphiopedilum wardii. Another nursery, who imported millions of Paphiopedilum callosum and sukhakhulii for the pot plant, had to close, after they got one batch contaminated of sukhakhulii, and it eventually became epidemic, killing hundreds of square meters of Paphiopedilum within weeks.

However, similar to the human medicine, there has been considerable progress in the treatments. Ion the early days, where only contact fungicides were available, such as Bordeaux Mixture, Captan, Dithane… the hopes of controlling this kind of pathogens, that enter the tissue s , were close to 0. With the introduction of more fungicides, with different action modes, most diseases can be controlled. However, on the hobbyist side, it can be possible to treat a few plants. On a large scale, the aims of using a pesticide are not the same.

- In most cases, a fungicide or bactericide is used to lower the disease incidence and pressure, not to suppress it. As an example, a plant that has been contaminated by a rhizome fusarium can be kept alive, but it becomes a chronic illness, unless the rhizome is cut, special care is given to the plant, etc… and even so the results are not guaranteed. I got some Paphiopedilum Paeony 'Regency' that was infected for years by a chronic fusarium. The plants grew well, but the fungus was in the rhizome, obvious. As long as the plants are growing, the disease becomes chronic. Once found, some aggressive treatment on the plants got rid of it, and the plants grew much better, retaining leaves on very old growth even for much longer.
- In a commercial nursery, if a batch is infected, it is not economically viable to train workers, and ask workers to unpot everything, treat every single plant, etc… In this case, fungicides and bactericides, sometimes extremely strong ones or experimental ones, are used to keep the disease at bay. It is not killed, but the use of the chemicals will allow producing a plant that can be sold, that's it. It has happened to many batches of Paphiopedilum released on the hobby market

Diseases identification

Experiences, coupled with some technical skills, allow distinguishing the various Paphiopedilum diseases. In fact, the PCR, that is used nowadays widely in human medicine, is not yet useful to diagnose diseases, it is even, in fact, really a step backwards with today's knowledge.

There are increasing numbers of laboratories offering PCR testing for 'plant pathogens'. However, a PCR testing will usually reveal a wide range of 'pathogens', up to a point where the original problem is overshadowed by a list of strange pathogens.

Like HIV for humans, some diseases are rarely killing their host themselves, but the weakening they induce will allow more aggressive opportunistic pathogens, that will kill quickly and surely. As an example, fusarium can take a couple of years to kill a plant, yet an infected plant can be infected and die pretty quickly of Pseudomonas, a bacteria or even basal Pythium, an oomycete. The weakened plant, loss of root system, partially clogged vascular system of the plant will be the open door for pythium and pseudomonas. Even though the plant seems to die of a 'bacterial' rot, in fact the real cause was the rhizome fusarium disease.

A PCR analysis of a dead plant would reveal fusarium, pythium, erwinia maybe as well, some pseudomonas, possible some other things, because the way the PCR is done in many labs just tells us that this pathogen is present, but not where, which strain (some strains are absolutely harmless for the plants), and which is the 'initial' pathogen that started the problem. I saw too many reports of labs with several diseases listed, that it was a waste of time and money to make such analysis.

It must be noted that, even today, some pathogens cannot be successfully cultured, because either they need very specific hosts (hence one has to establish a culture in vitro of the host, and grow the pathogen on the host… such as some xanthomonas), or specific conditions (many phytophthora and pythium cannot be grown in vitro at all, and for some, it has been discovered recently that colonies of one species reproduced always asexually by a kind of cloning, that does not exclude mutations unfortunately, where the other colonies would reproduce as well sexually, that helps to make new strains at a faster rate. Nevertheless, it happened countless of times in the past that plants were infected by a phytophthora, that could not be isolated on a culture media, and another pathogen was instead detected. It took ages too for scientists to realize that the oomycetes are just that, oomycetes, and neither fungus nor bacteria's.

For the hobbyist, I will give some guidelines, if those guidelines are followed and the plant goes down, it must be disposed of pretty quickly.

On the commercial side, the best is to dissect some of the plants that are affected, but not yet dead. There are a lot of surprises, even in commercial Cymbidium and Phalaenopsis facilities, where sometimes a nematode, thrips palmii, or even some types of mites (the 'cyclamen root mites') were in fact the source of the strange diseases plaguing entire greenhouses.

Our purpose here is not to give a general plant pathology teaching course, but some simple guidelines to know what to do in case of diseases. There is a lot of background research behind this, including about the pathogens, but it must be clear that, unless one is willing to invest in a pathogen analysis, most of the time the visual diagnostic and photos are useless. In fact in several books, including famous ones the 'bacterial rot' or 'erwinia' roots are simply phytophthora, an oomycete, and the rhizoctonia, fusarium names are wrongly flying all around photos that have nothing to do with those diseases.

- First step, always check for insects, on the plant. A new leaf emerging with some strange pitting or some brown dry, corky stripes is most of the time due to insects in the crown. One common pathogen found was a thrips species, in some other cases it will be another insect, rarely a mite there, though it can happen.
- Foliar rots. Those can be tricky, but the usual brown area with a halo is usually due to one of the many leaf fungus, the commonly known ones are glomerella and colletotrichium, the later becoming more common in Europe lately, however fusarium and rhizoctonia can make very heavy leaf spots. In those cases, it is best to cut the affected parts, and treat with a fungicide. The bacterial foliar rots can be erwinia, see below, or xanthomonas, never formally described in Paphiopedilum, but identified and confirmed several times. First the real bacterial foliar rot tends to stop when the conditions are dry, and resume immediately after. Xanthomonas have some watery lines arising from the infected areas, going down and up. The affected places are more circular, and appear anywhere on the leaves, sometimes in clusters of yellow spots, that are watery in humid weather, and progressively become brown. The foliar fungus tend to prefer attacking from one side of the leaf in. or eventually from the median vein, but the nearly never attack from the middle of the leaf and in many places at the same time. They never have spores in the early stages. If the infection has been very far, one can see spores on a bacterial infection, because the dead matter will be attacked by a wide range of common fungus living on decaying matter.
- The typical 'bacterial rot'. At the base of a growth or in the crown, there is a kind of blistery area, becoming brown within hours, and surrounded by a yellow coloration. It is the common photo of the 'Paphiopedilum bacterial rot' everyone has seen. Unfortunately, it is not a bacterial rot, in most cases it is phytophthora, the remaining being pythium.
- The real pseudomonas bacterial crown rot, the tissues just become liquids even the base of the growth, not soft, or watery, but really absolutely liquid, they do not even have the time to become brown in the process, with a foul smell. It is not so common, except in tropical countries. The pseudomonas by itself generates some enzymes that dissolve pretty much everything, so it really becomes liquid, with nothing solid inside. Think about lettuce boiled and then completely crushed, that's more or less the texture of pseudomonas bacterial crown rot.
- Erwinia, there are some soft rot and dry rot types. The dry rot is very tricky to identify, as it can look a bit like sunburn, but extends whenever the plants have been watered or the air humidity is high, to

stop, and look again like a sunburn until the next wet cycle. At a point, it goes to the crown, not as rapidly as people say, and kills the plant. The problem being that in many cases the plant is infected in many areas, where it cannot be seen at first until the infection progresses. The sure sign is when some kind of brown dry tissues appears here and there a bit everywhere on the plant, and they progress whenever the plant has been watered. It is best to discard the plant, though tetracycline and streptomycin as a cocktail can be used. Kasugamicin, a legal bactericide in Asia and the USA can be used to try to cure the plant, but the prognosis is very poor. The Erwinia 'soft rot' in Paphiopedilum make the plant become soft, but a bit on dryish side, it is very hard to explain or even to show photos of, as the few cases I saw I did not want to get involved with those plants, and after a pathogen identification, they went to the dustbin. Let's say that the plant would look more like if it has been boiled. The browning of the tissue arrives a couple days later, and it is not so 'wet'.

- At the junction of the roots and the growths sometimes appears a tiny orange colored area that tends to 'dig' in the plant'. It is again a phytophthora in nearly all the cases, that attacked and infected a root, either a fully grown root, or a just emerging root tip. Sometimes it can attack as well the wounded leaf base where a new growth or root emerges. In many case, on wild plants, I have seen such things, and the plant healed by itself. I will provide a control measure that works nearly all the time, as long as the disease did not attack too much the rhizome.
- A general chlorotic or weak appearance coupled with collapsed roots can be one of several diseases, fusarium or phytophthora of the roots. If it reached the rhizome, usually the plant is dead. The orange rot of the rhizomes, especially in the big multiflorals, is due to a phytophthora, it is accompanied usually by watery roots full of a liquid, where the drier rhizome rot, with dry roots is usually a fusarium. If one makes a cross section of a fusarium infected root, there are usually some blackish dots on an otherwise healthy section, which are in fact the path of the fungus in the roots.
- A creamy, nearly total collapse of the root system is usually a bacterial rot. Usually it releases so many toxic chemicals that the top growth is already in very poor condition with only a single root infected. It is not common, and usually was found on wild plants or nurseries having such plants, historically.
- Insects generate some compounds to dissolve or make their feeding easier. Mites, but scales and mealybugs do so. Those compounds are very phytotoxic, and in some cases, a few mealybugs in the leaf axils can make an entire plant chlorotic.

Sick Plants

- First check the feeding schedule, if it is general to a lot of plants in the growing areas. Deficiencies, toxicities can result in a wide range of symptoms, and eventually lead to real diseases. A degraded potting mix, too much light, too high temperature lately can make a plant look sick. The environment needs to be checked first.
- Then check for any insects, very carefully. A lot of times, a disease is started by an insect or mite. The crown first, then the underside of the leaves. In the crown, it is usually a thrips or a real insect, rarely a mite. On wild plants it can be nematodes as well, that the hobbyist or the normal commercial grower cannot cure (in this case the plant must be isolated, watched if it progresses, and destroyed). Below the leaves, look for mites. Brevipalpus has been found to be associated with phytophthora in several instances too, so they need to be treated together. If you find insects or mites, treat them.
- Check the leaf bases, axils, for scales, mealybugs. There is a new type of scale, that is very narrow and long, about 1 mm wide and 1 cm long, coming from Asia, and that is quite tough to kill. It can be mistaken for 'nothing' as it is not really obvious. If any insects treat the insects.

- Remove all the affected parts on the leaves. In many cases it is best to remove a complete growth leaf by leaf, and if the stump still shows signs of infection, remove it too. I usually apply a mixture of Kocide and calcium hydroxide on the wounds, directly. I use various concentrations, but usually 1 part of Kocide to 3-5 parts of calcium hydroxide powder can be used. So far I never burned any live tissues this way, the part to be treated must be a bit moist, to get some powder to stick, the surplus is blown away, and the whole is kept to dry for one hour or so. I use the same when removing rhizomes or dividing plants. I never saw, because of the excess of calcium hydroxide, which will be converted to calcium carbonate, and keep the whole at a pH of 8.5, any signs of copper phytotoxicity, not only on Paphiopedilum, but even fragile dendrobiums or coelogyne.
- Inspect the root system, and remove any brown/orange rhizome parts, up to the clean part. Cut the sick roots root, any root that is even soft can be suspect, it is best to remove a healthy root than to leave an infected root in this case. All the wounds must be clear and clean, rhizome, roots, and apply again the same Kocide/calcium hydroxide, which can be moistened here just prior to use with a few drops of water. Some growers use straight captan powder, but it is less successful.
- Repot the plant, put a heavy load of calcium carbonate on top of the pot, and use the fungicides recommended below. I usually use for 10L
    - Fosetyl-Al 5g
    - Dithane (mancozeb) 2g
    - Metalaxyl, any of the formulations, 500 mg of active ingredient (so if the product is Metalaxyl 50%, use 1g of the commercial product)
    - Azoxystrobin 500mg of active ingredient
    - Tolclofos methyl 1g of active ingredient.
    - This blend and the large amounts of calcium carbonate will care about the orange stain of phytophthora that plagues many growers in the world today. It will as well induce after some weeks a deficiency in micronutrients, though the dithane, both as a fungicide and as a supplement of zinc and manganese will overcome the problem on the short term, but not on the medium term.
- One month, repot the plant. If the treatment has been successful, then the plant is saved and must be repotted in a mix with much less calcium carbonate, the dead parts being just removed. By that time, the infected parts should be corky and completely dry, and there should be good quality scars between the formerly infected parts and the clean part. If the treatment has not been successful, it is best to throw away the plant.

The products I am using.

Usually I use the products at the manufacturer's recommended dose, reducing the dose can eventually build up resistances. Except the tank mix above, that has specific proportions not following the recommended concentrations for each individual product, it is always best to use at full strength the products. Lowering the strength can have consequences, including breaking the buffer agent that was included, or building up resistances. One extreme case is the Kocide/calcium hydroxide compounds, and all the copper compounds. If one uses the recommended rate, there is enough agents to ensure the pH remains alkaline. If one divides too much the rate, the potting mix or the plant can eventually acidify the whole thing, making a massive phytotoxicity. Kocide is one example, if one uses it at a low rate, say 100mg/L, severe phytotoxicity will occur, because the pH of the whole will become acid in contact with the potting mix, the subsequent feedings.

Pesticides

One preamble about the pesticides. In some cases, there are pesticides that are listed and are amongst the deadliest known. Though I have used them, I understand their mechanism of action. On the other side the LD50, which indicates how 'toxic' the pesticides are refers to an instant death or nearly so.

Three examples:

- Carbofuran is one of the deadliest insecticides known, from the carbamate family. If you take a few drops of the concentrate, you die, because it is a very strong cholinesterase inhibitor, however from the carbamate family. However, if you do not die within some hours (and there is an antidote for it), the cholinesterase inhibition reverts like if you never had been poisoned, you recover and can have a happy life.
- Parathion-ethyl is as well one of the deadliest insecticides known, but from the organophosphate family. The public mode of action of cholinesterase inhibition. However, in this case, cholinesterase inhibition by an organophosphate is bad news, because after a very short time, it cannot be fully reverted, only partially. One more extreme compound with the same behavior is the Sarin, the gas used by terrorists in Japan. It means that, even if you survive, you will be partially crippled, and never fully recover.
- Endosulfan is much friendlier; it was even classified in Europe until recently as just 'Harmful'. However, you will not die today or next week, but endosulfan will make a lot of metabolic changes that cannot be reverted in various organs, and eventually even tumors. The results is that one can be lifetime crippled with a lot of health problem, even cancer, but the original product was not considered, until very recently as toxic at all.

So I made my choice for a maximum efficiency, and tried to avoid chemicals that are too new to know their real effect on human health. Lately, some pesticides have been released without any knowledge of their even medium term effect, yet, looking at their mode of action on pathogens (or lack of knowledge of, some active ingredients being promoted as effective for some diseases, but the mode of action is still classified as 'unknown', which is weird), one can have a doubt about potential metabolic of cancer risks.

Systemic vs. nonsystemic. In fact some pesticides are said to be 'systemic' and some 'contact'. The distinction is much more complicated than that. There are systemic that are said to be:

- Ascending (acropetale in the older EU terminology), which means they treat from their impact point upwards Old leaves to new leaves as an example.
- Descending (basipetale), which means they treat from the impact point DOWNwards. Leaves to the roots. There are very few pesticides in this category.
- Translaminar, which means in practice that they treat the surroundings of the impact point, slightly further, but do not move sharply up or down.

The essential inert ingredients.

Pesticides are diluted and blended with what the manufacturer usually calls 'inert ingredients'. The Material Safety Data Sheet can give a clue to some of its ingredients, but not all by far. The inert ingredients can include:

  - Buffering agents, such as in some of the old formulations of propamocarb, which included a very heavy shot of sodium as a buffer, not really good for fragile plants.

- Surfactants, to help the spray to 'spread'. Diswashing liquid is one, but there are some strong ones, meant to help penetrate the waxy cuticle of some crops.
  - Penetrating agents, which helps the active ingredient to enter a trunk, like in the vineyards or apple trees… Again, not something really good for Dendrobium cuthbertsonii clearly.
  - Solvents. There are many ways to dissolve an active ingredient; some are primitive, using benzene, toluene and xylene, whatever… Some are latex based with the microencapsulated ingredient, or a blend of oil and surfactant to solubilize the active ingredient in the oil, and add the surfactant to get a good dispersion in the water tank of the sprayer.
- As one can realize, the composition globally of the pesticide is nearly as important as the active ingredient. I give some brands below, it is not an endorsement, nor that those pesticides are legal in anyone or any country at the moment, just that, on a technical, information side, they work, and they do work well.
- To avoid problems, I recommend choosing formulations that are used for crops with quite fragile leaves, lettuce and poinsettia, eventually tomatoes can be safe. Avoid formulations for trees and strong things such as sugar cane or palm tree as an example. Formulations for salads, ornamentals, and quite fragile crops are safe. Powdered forms are safe, though the EC formulations of the pesticides below are what I am using, again because breathing powders would be too much for me as I am a smoker, and the risks of powdered particles of pesticides entering the cigarette at any point, and reacting with the combustion and combustion products are high.
- Always try first the chemicals, though the formulations mentioned below, except those mentioned, have been used in Europe and Vietnam, which means that the temperature can go up to 35 degrees Celsius and more. Some chemicals however are more phytotoxic when the weather is cool and cloudy, as it is preferred that they dry out at a steady rate on the plant, rather than staying wet for hours. Those are indicated below too.
- People will realize from the following list that I am not exactly an environmentalist, yet I am very critical towards some pesticides, and their real effects on the environment. Virtually nothing is known, and whenever a pesticide has been around for long enough, like the DDT, or even more recently the mancozeb, we found out that it was much more risky for the environment, sometimes for the humans, than previously reported. The reason being that, I recommended to test something for 2 years to know if it is really successful, in general, potting, fertilizer… because it is a complete cycle for Paphiopedilum. Human or other living beings have longer cycles, and it is my belief that, of the pesticides sold today, and tested hastily for a couple of years before their marketing, there will be some that will be found to be extreme killers, and of the utmost danger for humans, animals, plants, or anything else. Again, that's a situation we need to accept, and we need to do and focus on the present knowledge. The indications I give here are for Paphiopedilum culture, and I do not guarantee that these are good for human health, as a disclaimer.

Insecticides

All are systemic, except the pirimiphos methyl, which acts by contact and vapor effect..

- My all-time favorite insecticide spray is Curater (carbofuran). It is efficient for all the insects, including the thrips in the crown, and is a very strong systemic. In fact, it does not leave the time for scales to die and drop by themselves, so it requires manual removal of the corpses.
- Temik (aldicarb) granules are very safe for Paphiopedilum plants, not so much for the user, but they do not cripple the plants. There have been some reports of cymbidium being crippled by earlier versions of temik, and this would apparently be attributed to the adjuvant, not the aldicarb itself.

- Actellic (Pirimiphos-methyl) is a very good insecticide too if any resistance appears to the carbofuran. It has a vapor effect/gas effect too, and is especially effective against thrips in the nursery. It can get rid as well of the sciarid flies, whose larvae occasionally eat the young root tips.
- Imidacloprid is said to be excellent, though it is efficient on insects, I avoid using it any cost, first because some scales became resistant to it very quickly, but more important because it is a growth promoter of mites. Mites' populations, such as brevipalpus, can absolutely explode after a single use, and they become more tough and resistant to the miticides… There has been some severe phytotoxicities reported after the use of azoxystrobin too, on Phalaenopsis
- Metasystox (oxydemeton methyl) is another good insecticide that I used in alternance with the carbofuran.
- In cases of big problems, parathion methyl is my favorite choice, but it is a really dangerous chemical.
- Sulfotep (Bladafum) is a gas insecticide that needs to be used in a greenhouse tightly closed; it has some miticide activity too. It is very phytotoxic if the leaves are wet, or if the weather is too cold. If the plants are a little bit dry, thirsty, it can be used safely to destroy pretty much anything living, including the operator as it happened a few times in the Netherlands… but not the plants, luckily.
- Abamectine is a not so bad insecticide, but it is very useful to control the mites :

Miticides

- Abamectine is good as a part of spray against mites, especially the brevipalpus. My second favorite blend is Vertimec (abamectine) and Dicofol
- Dicofol is a very old miticide, but remarkably effective still, especially blended with abamectine. The combination, or the next combination, allows doing a single pass treatment, however they are not systemic.
- Bromopropylate is a really excellent miticide, which is very powerful. It can be used as a standalone against brevipalpus and the cyclamen crown mite, however I prefer to blend it with dicofol. It has a very long residual activity, and plants treated are protected for many months… which made it too persistent to the taste of some people, hence it has been removed from a lot of markets already.
- Propargite is an old miticide (omite), which is very efficient, but must be used at lower temperature. It is a sulfur containing compound, and it can have some burning effects if the temperature is over 22 degrees Celsius. I use it as a preventive in the rotation once in winter, to clean anything that may well be still around.
- Clofentezine… I still have some bottles of the old Apollo, and I use it. It is a very good translaminar, partially systemic miticide, which must be blended with another miticide (dicofol for my purpose). However, I got some clofentezine later in Germany that made some plants look a bit funny after some months, so I had to buy back the antique stock from the Netherlands of the original Apollo, which is a really fine product. If you have experience with it, or can make trials of the brand and formulation locally available, it is a great product, but I cannot recommend it in general, due to that problem with the German source, and another problem reported in Thailand more recently with clofentezine.
- Dienochlor. The old and antique Pentac. It is a very good miticide, and few mites today are resistant to it (few are resistant to dicofol, in the orchids), so it can be used from time to time. It is hard to buy however nowadays
- Endosulfan had an excellent effect against cyclamen mites, which can be found on Paphiopedilum, but due to its high long term extreme danger, it is impossible to recommend it.

Bactericides.

There are few compounds in this class, and the neutralized copper based compounds, composition indicated on the box copper hydroxide are amongst the best preventative agents. It exists over some others chemicals, some highly efficient, but that cannot be recommended because they are antibiotics for human use, which is banned in many countries around the world. We can name:

- Streptomycin. The antique Agrymicin. It is a good bactericide, and can be used in alternance with the copper compounds. A very improved version is the newer products sold combined with…
- Tetracycline. It is sold mostly combined with the streptomycin. The blend is very efficient, and what keeps alive millions of Phalaenopsis for pot plant in Taiwan. It is used there as a preventative for the real pseudomonas bacterial rot, and for the newer Phalaenopsis xanthomonas disease. For Paphiopedilum it is efficient against erwinia , but it is not exactly systemic, only very partially.
- Kasugamycin is another antibiotic like compound. It is quite efficient against bacterial diseases, namely erwinia soft rot type. It has a mode of action that is different from the medical antibiotics, so it is relatively safe in terms of risks of resistance of human pathogens. However, none of the antibiotics today surpasses the efficiency of the copper based compounds as preventative. A tank mix of copper hydroxide and kasugamycin is very efficient, and premanufactured blends are already sold all around Asia, especially for the rice fields. To be noted that kasugamycin, unlike the streptomycin and tetracycline. The Kasugamycin has a fungicidal effect against several fungal pathogens, though the exact list seems to be really obscure. It seems however promising as a fungicide against some types of rarer leaf spots.
- Benzalkonium chlorides, Physan. They have a mild bactericidal activity, however as surfactants, they help to dry out water droplets on the plant, and due to their higher pH can inhibit temporarily bacteria, hence they are more bacteriostatic than real bactericides.
- Captan has a bactericidal effect, so has chlorothalonil, on some strains of pseudomonas, and a preventative effect in a nursery as a general preventative spray.
- Aliette mixed with Dithane, or more properly fosetyl aluminium tank mixed with mancozeb has some preventative efficiency against bacteria, however the most 'spectacular' preventative effect of this blend was the suppression of the oomycete (not bacteria) phytophthora doing the symptoms pictured wrongly as 'bacterial', which explains too that it has been known as a very good bactericide for years.
- There has been other chemicals recommended against bacteria, but as I have no experience, I do not comment about them. There is Phyton 27, which would be a systemic copper based fungicide according to its documentation, and at another side was said to contains organic acids that were never heard of by any chemists, though reports say it works, it is impossible to assess the truth of its effectiveness, having neither tested nor seen any reliable documentation on that subject.
- Hydrogen peroxide is said to work, based on the fact that it would, according to its proponents 'oxidize' the bacteria. In some cases it makes in fact some fuzz, some bubbles, but it is hard again to say whether it works or is another legend, that sometimes works, sometimes not.
- Cinnamon as a powder has been recommended, even neem oil. Cinnamon works, but I prefer calcium hydroxide and cinnamon, when its preserving compounds (terpenes and aromatic acids) are exhausted, can rot the whole plant.

Leaf spot fungicides

- Azoxystrobin mixed with thiophanate methyl is quite powerful. It is recommended not to apply either alone, or the pathogen can become resistant pretty quickly.
- Similarly, a newer version is azosytrobin with hexaconazole, which works as well against the glomerella leaf spot fungus (that usually likes to start at the leaf tip, but in fact is already at that time well disseminated in the plant). It is efficient as well against fusarium leaf rot.
- Triforine is another leaf spot fungicide that can be used in a rotation program; it is very popular in Europe so far, though I find it less efficient than…

- Triadimefon. That's the old bayleton, and tank mixed with thiophanate methyl stops pretty much any kind of leaf spot fungus on Paphiopedilum. Triadimefon has another growth regulator effect; it makes nicer plants during very hot weather, though I do not recommend its regular use for that purpose.
- For most leaf spot fungus it is important to note that tank mixes are important, with fungicides of different mode of action, to kill the fungus surely. Though all the combinations above are systemic, it is wise to really spray the whole plant, and as much as the underside of the leaves as well as possible. If some spray runs in the pot, it is not a really big problem.
- Captan and Chlorothalonil are two contact fungicides, along with mancozeb that can be used as a preventative. They have little if no curative effect, though they are very persistent, and can help avoiding spores to settle and start infecting the leaves. Copper based compounds can have the same role for some leaf spot fungus, though colletotrichium is resistant to copper compounds apparently.
- In tropical countries, some plants can be attacked by rhizoctonia leaf rot, which makes distorted chlorotic patches on the leaves with brown veins and nets. The best fungicide to treat that problem is tolclofos-methyl (Rizolex). The others fungicides listed here have little effect on it. In fact, it is now recommended in Malaysia as a preventative spray.
- There are many other fungicides in similar classes, propiconazole, cypriconazole, for hexaconazole or kresozym methyl, trifluxystrobin for azoxystrobin. Some are older, some are newer generation's components, however I recommend sticking on that list, or making trials. Remember too, with systemics products, the problems can happen months after the spray, so for a standard grower it is very difficult to make a test. Tests made on other crops are useless in most cases, because different crops react in a very different way to some fungicides especially. The insecticides are usually, with one or two very famous exceptions in the newest generation, less likely to be killers.
- Benomyl. It is no longer registered; however it has been used for decades in Europe and Asia, and still is as of today. It was a very good fungicide, though it is exceedingly similar to thiophanate methyl. In fact Benomyl and thiophanate methyl are carriers for the active ingredient Carbendazime. The Benomyl phytotoxicity came as a surprise, but it can well be due to impurities during the manufacturing process. Some slight changes in the place of some atoms in a molecule can convert, , a fungicide in an herbicide, or even a very powerful insecticide into an insect friendly acaricide. DDT, a very strong insecticide, when chlorinated (adding one chlore atom on the molecule), becomes the Dicofol, a very good acaricide, that can even be used on bees and insects to cure them of mites, as it has absolutely no insecticide action at all.

Root fungicides

There are two types, for the wet rots and the dry rots. As said before, the wet rots are mostly Pythium and Phytophthora, in the oomycete family, and the dry rots are mostly fusarium, rhizoctonia and sclerotium, with some other minor, more rare fungus.

For the Oomycete Pythium and Phytophtora (including the 'bacterial rot' of the books). It is important to raise the pH of the potting mix if it is a curative schedule, use the fungicide (anti-oomycete to be correct) and repot at a later time to bring down the potting mix pH at a proper level. It is very interesting to note that, apart from the Azoxystrobin that has a very mild effect on those oomycete, few fungicides are useful against the oomycete, and the anti oomycete are useless against fungus.

- Etridiazole was the earliest one. It is very efficient against Phytophthora, less so against pythium (the former generally tends to be more brownish in the decayed parts, pythium tends to be more blackish, but it is hard to assess). It has a very good persistence in the potting mix, but is not systemic. Nearly no resistant strains of Phytophthora are known in horticulture to that chemical.

- Fosetyl-Al is very good against both Phytophthora and Pythium, I use it as a preventative every few months. It is fully systemic, up and down, but it needs to be combined with a contact fungicide. Mancozeb is the chosen ones, it has little activity by itself against those pathogens, but mixed with Fosetyl-Al and some other anti-oomycetes, it is a really good combination.
- Metalaxyl, and mefenoxam were the first systemic compounds, I use them every 2 months as preventative. I still use metalaxyl in the fertilizer tank, though some people advise to use mefenoxam, which is one isomer (one configuration, in a way) of the compound metalaxyl, said to be the most active isomer, but I had the feeling it was not working as well as metalaxyl.
- Dimetomorph is an anti phytophthora, extremely good one at that, I tend to use it on newly acquired plants, as a precaution. It has nearly no activity against pythium.
- Propamocarb (Previcur before) is very active against pythium, but not active against phytophthora. It is a useful systemic product, which many nurseries used to use in Europe for even freshly deflasked seedlings.
- Cymoxanil is a newer compound, relatively, that has a very good efficacity against phytophthora, and for orchids, if a strain is resistant to the metalaxyl and it will not be to the cymoxanil. It is best to tank mix cymoxanil with mancozeb. Many products combining the two are sold, but not for horticulture, with very few exceptions.
- We can mention too Oxadixyl, Furalaxyl, etc… that are good products, but usually not needed if one has access to the products above. They have not been extensively tested on orchids as well, so one must be careful. There are new molecules that appeared on the market, but only time will tell if they are first efficient, and second non phytotoxic.

Rhizoctonia, Sclerotium, fusarium

- For Rhizoctonia and sclerotium, the two gold standards are quitozene and tolclofos methyl. Both are highly efficient, tolclofos methyl, though not being systemic is strong enough to exert a curative activity, and it is really a good product for that purpose. Some other chemicals have been used, including thiophanate methyl drenches, boscalid, and others, but they do not reach the level of effectiveness of those two ones. Azoxystrobin can kick slightly the effect of tolclofos methyl, so they can be tank mixed and applied as a drench; however it is not an absolute requirement. Quintozene is a very good chemical for plants, and I never found any phytotoxicity, though a few people reported it in other crops as temporarily chlorosis of the new growths, that would after a while turn back to their normal color.
- Against fusarium, there is little, if nothing, really efficient. Thiophanate methyl can be used as a preventative drench. Azoxystrobin can slow down the progression, but it is not so efficient. Hexaconazole slow down, but fusarium is a real concern. It comes from contaminated plants or contaminated potting mixes, and spread through bugs from one pot to the other, then after a while it can produce airborne structures, that spread all around the greenhouse. It is a pathogen for which we have little ways of treating it. There is one compound that can sometimes cure the plants, which is amphothericin, but it is not exactly something to use owing to high risks with that fungicide… If a trial with azoxystrobin and thiophanate methyl do not stop the progression, it is best to discard any infected plants. In commercial pot plant cultures, there is no way to cure the problem, only to solve it too, to make saleable plants, which tells everything about the danger of that fusarium. It appears that there are several species, and some have sexual and asexual, where some others have only asexual propagation. Like for phytophthora, the oomycete, pathogens that have a sexual stage can show

more variability in their next generation, including fungicide resistance, or aggressivity than asexual, kind of 'cloned' ones.

Sometimes some plants will show wrinkled or twisted growth; this can be due to some insects, to be treated with an insecticide, or to a fusarium starting. Fusarium in some of its strains can be tricky, and attack only some parts of the vascular system. I would recommend treating with an insecticide, then if no improvement is noted after 2 weeks on the new growth, to remove one growth affected. If there are black pin dots on the section, it is fusarium, and there is nothing to be done. It is very interesting to note too that many Paphiopedilum kolopakingii gigantea, aka. Topperi, are infected in the wild by a strain of fusarium, when they are stressed by the transport and the broken roots, the fusarium apparently is able to attack the new growths.

If the plants are properly watered and fed, most diseases are very limited, except some very infectious ones. I noticed that some diseases prefer plants that suffer from some drought. In fact, for the brachypetalum, the secret is to never let the roots dry out too much. If they dry out too much, microfissures form, and pathogens enter through that. It is valid for all orchids' species in a way or another, but especially for brachypetalum. The advice to let them on the dry side comes from the fact that, once you start to generate microfissures, the plant will be weakened, and it is better to keep it dry between waterings, which avoid rot in those microfissures, but makes more. To stop the process, the best is to drench with dithane and aliette, simply, at 4g of each in 10 liters of water, and resume normal, 'wet' waterings. Some roots will die, but the dithane and aliette proved in my conditions and several other nurseries to be more than enough to avoid pathogens infection in brachypetalum roots. The plant will grow a new root system, where the old one will collapse, which is of no concern. Some calcium carbonate can be added to the plant, again, as a measure to avoid the extremely acidic conditions that can result from the decay of rotting roots.

There is one last point. If the plant is 'plump', and kept at a reasonable level of hydratation, there are fewer risks of problems with pathogens, especially coming from the rhizome and roots. In many cases, the pathogens are around the roots naturally, everywhere in the world. If the plant has an active root system, one can notice at the repotting time that, a big part of the old rhizome and several roots rotted, but the plant was not completely infected, and healed by itself. It is very easy to explain, if the osmotic pressure in the whole plant is low, the plants do not tend to suck up anything available from anywhere, in this case it will not suck up pathogens. New roots keep the live part of the plant at a higher pressure than the dead tissues, hence a nice wound forms. If the plant has no new roots, and is weak, usually the pathogen has no trouble entering the new part of the plant, and the plant cannot cope to make a proper scar.

In fact, years ago, the Madagascar traders were collecting plants, storing them for one or two days in the field, then would throw them on a moss bed in their 'garden'. It happens today too in Vietnam. The dried up plants will suck up water, and the pathogens from the said moss beds, infecting themselves 'inside'. It is logical, and quite simple to understand. In those cases, I tend to let the plants dehydrate, and rehydrate them with a strong fungicide solution, to try to clean them up and cure them. Many jumellea from Madagascar and Paphiopedilum helenae from Vietnam had so many broken roots that the few remaining roots, and the cut sections of the rhizome, would pump anything nearby which caused their demise.

Repotting Paphiopedilum.

There are two schools to repot Paphiopedilum. I was from the more modern one, but now I went back to the old school.

- Before, the growers would cut off the rhizome without leaves, and prune the roots. The plants would be potted, and roots would be broken. After 1-3 weeks, new roots start, and the plants resume its growth. I usually removed the branching parts of the roots if they were not actively growing, the really old roots that were smooth and not hairy were cut to about 10 cm. the new roots repotted a bit carefully, and the dead dying roots pruned at 10 cm too from the base of the plant. The rhizome was cut, never at the base of the growth, but, and that's the secret, always in the middle of the older leafless growth, the said leafless growth having all of its roots trimmed too. To divide a plant, with a leafless growth and two branching parts, the proper way to do is not to cut the two divisions at the base of the leaf less growth, but right in the middle of the growth. If the plant rhizome is Y shaped, one has to cut absolutely in the middle. It can be explained by the vascularization of the rhizome, which has long fibers. By cutting always in the middle of the rhizome, it makes a minor wound, the leafless growth part make a stump and the wound heal. If one cuts at the base of the growth, one breaks all the fibers, and those stringy fibers go right up to the newer growing leaves of the growth. As a result, there is a high risk of rot, and for some species such as sanderianum or stonei, divided plant may sulk or die. By dividing as said, in the middle of the old leafless growth, there are no risks at all. I coated with the Kocide and calcium hydroxide mixture described before (hydroxide is not a mistake; it is not the calcium carbonate). The plants are repotted, the potting mix is pressed quite firmly, and the plants are drenched. Then they are allowed to dry out for 1-2 weeks, by that time there should be new roots emerging, and the plants will resume their growth.
- However, prior to my use of Orchiata, I was worried that I was losing time if the roots were broken, as the potting mixes available in Europe were, to say the least, not really long lasting. I proved to be really wrong.
- The newer technic was to keep the roots intact, handle the plant and the roots like the Graal, never break a root and put the potting mix gently around the roots. It seemed less traumatic. In fact that's the bad way of doing this.
- If the roots are half broken, or too long, the plant can still pump some water, and is not forced to make new roots. However, the old root system is not adapted at all to the new potting mix, and cannot extract both the water and the nutrients required, so in fact the plant grows slower than if the roots are broken, which stimulate new root tips, and good quality, adapted roots.
- As an aside again, the root tips are very important for the uptake of some nutrients, when they are active. A plant without active root tips can suffer from a variety of deficiencies.

Watering Paphiopedilum

That's a very tough question, there are a few points, and that's all we can say about that part:

- Never water with 'pure water', as it will create first an osmotic shock, and second it will dissolve elements from the roots as well. Pure water is a redoubtable solvent. If used once by mistake, there should be enough salts in the potting mix to tamper the effects, but if used as a heavy flush, or several times in a row, it can kill the root tips, and make an entry point to the pathogens.
- The water to water the plants should be at around 5.7-5.9 with the fertilizer added. It is possible, as said previously, to acidify hard water to use in on the plants, using nitric acid. After a few weeks, the

grower must test his potting mix. If it is too alkaline still, he has to replace the nitric acid by phosphoric acid, to get more stable water and potting mix pH.

- I water when the plants start to dry, as a general rule, for all the plants. I never let the plants get bone dry. There are exceptions, and the plants potted in tree fern of the Papua and Solomons species, as well as Paphopedilum sangii enjoy being watered several days using a heavy sprinkler. In fact, the water, when it is hot like in Vietnam, does not retain oxygen or CO2 easily. It is a well-known fact for the fish farms, and one cause of killing many fishes at once, as warm water retains much less oxygen. If the water is applied through sprinklers, the drops can cool down the atmosphere during the hot summer, and reload themselves in oxygen in the way. The roots are beautiful using sprinklers, and with live root tips, where if I was watering using a normal watering nozzle, the root tips would die, which led me to think about the water oxygenation as the culprit. Growers that grow paphs in too warm conditions in Asia reported tremendous results by using sprinklers, or the fake foggers sold around (where the droplets are relatively big, and actually wet the plant and potting mix), compared to a normal watering shower
- In winter, a part of the species, from China, Burma, North Lao and Vietnam are kept much drier, never absolutely dry, but slightly moist. The temperature can drop in my nursery to 5 degrees Celsius for the unheated one. In spring the plants restart very strongly due to that dormancy. I resume the watering when the temperature goes over 15 degrees Celsius. For the Paphiopedilum from other countries, they are in the heated greenhouse, with a temperature of 16-23 during winter time.

- There is no magic; the secret here is not too wet, not too dry.

Feeding Paphiopedilum.

There are some concepts that are very important to understand regarding the fertilizers:

- Many fertilizers were designed in experiments that have nothing to do with orchids or different crops than the experiment did not target. In an extreme example, a tobacco leaf foliar analysis has nothing to do with a cymbidium, or a maple tree leaf analysis. Yet, the early fertilizers, and mineral compositions of the tissue culture media were designed for specific crops, using a very old theory, which follows.
- The theory was that the ratio of elements in a fertilizer should exactly follow the foliar analysis, hence if there is 800 ppm of iron, 400 of manganese, 100 of zinc, the ratio in the fertilizer should 8-4-1, and the concentrations were calculated for all the elements using those foliar analyses. Then the fertilizer or the mineral composition of the media was ‘calculated’
- However, it is now proven that the plants, at their roots need vastly different concentration from the foliar analysis. , there are some elements that are poorly taken, some that are easily taken by the plant, so the ratio in the leaves has no meaning, as one specific genus can take iron two times faster and more efficiently than manganese, as an example, so the optimal ratio at the roots would be 1-1 and not 2-1 as the foliar analysis ‘predicted’ it.
- There are plants that can take crazy quantities of some elements, which would be totally deadly to some other plants. When Phalaenopsis malipoensis leaves were analyzed in Germany, the lab contacted me to ask for more samples, as they had never seen 210 ppm of boron in a plant that was still alive. The next batch of fresh wild leaves showed a figure slightly below 200, so the analyses were correct.

- I had to order for me and customers a lot of foliar analysis. I always requested a foliar analysis when the plants were in top condition too, so we have a way to compare, in that specific location, well doing and poorly doing plants. It has been very surprising, because the absolute quantities could be vastly different, Van der Weijden having fantastic Phalaenopsis with a very low level of nitrogen, and in Germany one nursery had fantastic ones too, with one and a half more nitrogen, where another nursery had chlorotic ones with the same one and a half level. I started to realize that the relative values to each other's, the ratio, are much more important than the fixed minima and maxima values. As a rule, for me and several nurseries, I target always a ratio of Mn:Zn:Fe in a range of 8-8-1 to 4-2-2, where the iron is the lowest. This produces the best plants and the manganese and zinc levels are much higher than the iron. In wild collected plants, the results were pretty much the same, if one takes healthy, good growing plants.

There are more discoveries too, where a micronutrient can completely block the uptake of a macronutrient. It is very well known as an example that nitrate nitrogen requires molybdenum. If the plant is grown with a lot of nitrate nitrogen, and deficient in molybdenum, a foliar analysis would show a proper level of total nitrogen, yet a good part of nitrogen would be in the nitrate form, unprocessed, and useless because of the molybdenum deficiency.

Similarly, calcium intoxication is very common, especially with the Cal Mag and high calcium fertilizers. It can only be alleviated in part by supplementing enough boron. Calcium:boron ratio is very important, and forgetting to supplement boron in an environment that has none can stunt plants extremely severely. The main symptoms are root tip death, plant stunting, chlorotic new leaves. The plants can eventually make several new shoots at the base, though this is not always the case. Most of the time, it just makes a stunted, mummified plant in the pot. It does not die, it does not grow. After a while, it dies. Boron is essential for all cell divisions, and has been suspected in some mutations cases too in tissue culture, as its lack can induce mutation.

Improper low levels of nutrients force as well the plant to try to take up nutrients in older parts, and 'eats' itself from the inside in a way. This is highly conductive to diseases as a result. Eventually there is a no return point, where the plant shuts down all cell division, and is unable to resume its growth, or only painfully after months or years.

There are as well a couple of 'new knowledge' in the orchid field, that is absolutely not serious, and not backed up by many people's experience.

Maybe 20 years ago I visited Mr. Schoone at Floricultura, he kindly showed to me their experimental greenhouses, and gave to me a document for their big customers, trials on Phalaenopsis growth. It was very clear that the addition of calcium nitrate slowed down the plant growth, and made the leaves more chlorotic than no calcium nitrate. We discussed for a while, and he told me that it was not imaginable for them not to use urea and ammonium. Years later, I saw him again, and I told him that I am using only urea for certain genera in flasks. He told me that they were doing the same; no nitrate no ammonium, only pure urea, and some amino acids.

I pushed the trials further in flasks, and found out that the current explanations that urea or ammonium needs to be converted/broken down to be used by orchids are just plain stupid. In a sterile flask, there is nothing to convert urea or ammonium in nitrate, or in anything else, other than the orchid seedlings. And with no nitrate in some media, if it was true that orchids can take nearly only nitrate, millions of seedlings in several labs would be long dead. I even tried cold sterilization of the urea to be sure that the autoclaving did not change anything with a weird reaction. Definitely it worked as well, so orchids had a way to use urea.

Dr. Arditti published a small booklet in the 60's that summed up all the research at that time, and made some conclusion. It was clear, from much research, that some genera prefer ammonium; some prefer nitrate nitrogen, some amino acids, some urea… depending on the genera. Dendrobium as a rule do not like nitrate nitrogen in flask, and I found it out to be true. In Thailand, they used one version of Peters to make a lot of vanda flasks years ago. That version of Peters had only urea, and the seedlings were not dead.

It appeared to me very clear that a lot of publications are just 'crap', to remain polite, because their authors have no field experience, or did not carry out any proper experience. They just followed the mainstream and its error, made experience in adverse conditions, or improper ones, and found false results, that they tried and try to push more and more even today. Orchids need nitrate, ammonium and/or urea depending on the genera, its stage, the growing conditions and the purpose of the growth.

A combination of all nitrate fertilizer and very low or no phosphorus is used to induce a severe phosphorus deficiency and dwarfing of the plant. It is the horticulture purpose, public and published. The good news with that combination, which would be a 15-3-x fertilizer or similar ratio, all nitrates, is that the stunted dwarfed plant still can bloom, and that the extreme phosphorus deficiency induces dark green, glossy leaves. For pot plant purposes, it is even better than the dwarfing hormones commonly used on various ornamentals.

This fertilizer, to my surprise (and I am not alone, though some of the major growers of pot plant in Europe do not care to comment publicly about that, they know what to think about it), became promoted as a fantastic thing, growing very dark green plants, etc… It is not a fertilizer to start with, it is a mineral solution composed to dwarf and reduce the growth, for the purpose of reducing the foliar mass, whilst still keeping the flower size, quantity and color to its normal level!

Alan Moon once told me how they were feeding their plants. A high urea fertilizer, and they added Maxicrop (a kelp extract) and fish emulsion every other watering. He did not use any nitrate nitrogen fertilizer, and the Eric Young got enough awards to prove that they were not so poor growers.

There are countless growers I discussed with that who had the same results as me. Orchids can use urea, and Paphiopedilum grow better with ammonium as a source of nitrogen, as it was reported in a series of experiments in the 70's.

There have been a lot of other stories on the feeding, and now a popular feeding schedule in the USA is a very low potassium, high calcium and magnesium feeding. The calcium and magnesium would avoid the potassium toxicity according to its users. However, ammonium would be the 'lowest' in the chain in a way, and apart from being a good nitrogen source. It would avoid excess uptake of many cation.

To other considerations, it is clear too that some species and some colonies greatly resent being overfed with iron. For the older colonies of sanderianum, the symptoms would be yellow leaves with a lot of rusty spots. For bougainvilleanum, the plant would become chlorotic and stunted, both proved by foliar analysis.

Then, there were the old tables of micronutrients deficiencies/toxicities. Those proved, again to be wrong and today they are being rewritten in part all around the world. The older wisdom was that there were two categories of elements, mobile and immobile. However, it was not completely wrong for the fast growing crops, which did not have time to pick up a barely soluble element from the old leaves to sustain the fast new growth.

For slower growing crops, it has been proved that, some genera can move immobile elements. A Paphiopedilum has ample time to move from its old leaves a missing micronutrient or even macronutrient such as calcium. In this case, the new leaf will exhibit minimal symptoms, or no symptoms of calcium deficiency, but the old leaves would become chlorotic, a sign, according to those deficiencies symptoms table that cannot be attributed at any cost to the immobile calcium.

It is easy to realize that mineral nutrition of any kind of crop, except a few perfectly studied ones, at great cost one has to say, is just empirical, made of trials, errors, and foliar as well as soil from the habitat analysis.

Back to the potting mixes, if the potting mix has an acid reaction, like sphagnum moss or fresh European bark with sphagnum after a few months of use, then it is better, if one does not want to reapply lime, to use a nitrate based fertilizer and low phosphorus one. In fact the growth will not be optimal, but the plants will be less sick. The nitrate low phosphorus fertilizer will not lower the pH further, and can raise it slightly. The same can be said for the extensive use of calcium nitrate, which is motivated in many cases only by an excessively acidic potting mix, whose pH is slowly upped by the use of calcium nitrate.

There are many growers, from Ratcliffe to Floricultura, that applied only a base dressing of limestone, and a NPK fertilizer, sometimes with magnesium, but not always one has to say, and grew plants for decades in pristine condition. I for myself use calcium nitrate very rarely and usually not more than once every 2-3 months at the maximum.

For the feeding schedule, there is one simple one, used by the Eric Young before, Floricultura for their whole nursery and two German growers that had great plants. Scotts Peters 20-20-20 (16%N urea, 2% ammonium, 2% nitrate at that time). The Eric Young added Maxicrop, a seaweed extract that is very popular amongst the gardeners in England, as a separate feeding of 450 microsiemens every other watering. Floricultura and the two German nurseries use just straight 20 20 20, occasionally a 10-52-10, that's it and that's all.

The mottled leaf parvisepalum, and the Barbata section, as well as the Maudiae hybrids in a potting mix with the proper quantity of lime to get a pH of 5.7-5.9 as indicated, performs really well with a 10-52-10 fertilizer year round, at 0.4g/L. One can use monthly or every other month magnesium sulfate at 0.5g/L, that's it.

There are many other formulations from growers around the world; one product that was popular was Jerry's Wundergrow, which made very nice plants in the USA. Its composition was a high nitrogen, and 12 ammonium-12 nitrate nitrogen, along with methanol. Only the nitrogen ratio was optimal for a wide range of orchids by itself. Many orchids prefer a ratio of ammonium to nitrate of 1-1, especially Paphiopedilum and Phragmipedium. Some prefer even way more ammonium. Of course, some growers will grow very good plants with a nitrate based fertilizer, but the growth speed and quality is usually lower.

The Cal Mag and MSU proved for me and several top class growers to be an absolute disaster, with chlorotic plants after some months. They can be used on an acid potting mix clearly, or if people do not mind having yellowish plants, but I do mind, that's why I did not like it. However, some people have excellent results reportedly, but I get far better results, and I tend to grow plants that are robust, dark green, shiny, happy, pushed to the maximum but still in perfect condition.

Some growers, like the Tokyo Orchids Nursery, use a very simple feeding, which is Nutricote 14-14-14 280 days sprinkled on top of the pot. It is a slow release fertilizer, and done. I did use the same as a complement to my normal feeding schedule.

I will now give my schedule for my plants. It is the latest version.

- I used to use the famous Maxicrop and then suddenly it became available in Vietnam as the powdered form, which I am using now. I tend to use it once per month, at a rate of 100g of powder for 2000L of water along with the normal fertilizer. It makes really much better plants.

- My micronutrient composition, in milligrams per liter is as follows:
  - NaFe EDTA (Iron EDTA) 3mg
  - $MnSO_4, H_2O$ 3mg
  - $ZnSO_4, 7H_2O$ 1mg
  - $CuSO_4, 5H_2O$ 1mg
  - Na_2MoO_4 0.2mg
  - H_3BO_3 1.5mg
  - $NiCl_2$ 0.1mg

- This micronutrient composition is applied to all the feeding, which means at all the watering's I do.

- For the macronutrients I am now at:
  - NH_4NO_3 400mg
  - KNO_3 150mg
  - $NH_4H_2PO_4$ 150mg
  - $MgSO_4, 7H_2O$ 80mg

- The macronutrients are added to the micronutrients, eventually to the seaweed extract, and the feeding solution is ready… It is optimized for Paphiopedilum, and Cattleya may well not like it at all, as well as some other genera. The cymbidium goeringii grows wonderfully with it, so does holcoglossum, but some Phalaenopsis are not so happy with it especially the violacea. They would require some change, but the purpose here being the feeding of Paphiopedilum, this is the best one can get.

- Every 3 months I use a simple tank mix of 300mg of calcium nitrate and 200mg ammonium nitrate, with 5mg of boric acid as a drench. The calcium nitrate is blended with the ammonium nitrate to avoid any calcium overdose for the plants, if the plant do not require the calcium in such an amount (the nitrate anion can force the plant to take the calcium, which is not always a good thing), the ammonium can be used by the plant to counteract and balance its uptake. The boron is required, as too much calcium with not enough boron can make a deficiency. The symptoms of a boron deficiency and calcium excess are death of the root tip, smaller new leaves, which can have a chlorotic color, and plant stunting. It can appear readily after an overuse of calcium. In some cases the potting mix has enough boron for the plant to be on the safe side, but it is hard to know. Remember too that many sources of water have boron, that is not filtered by the RO equipment, or merely, and that could be sufficient for the plants. It is interesting to note that this drench along with the use of lime will extend the repotting time, if the potting mix is not decomposing by that time. One other story that is apparently not true is that Paphiopedilum need to be repotted on a regular basis, or their roots stop growing, because they 'release' something in the media. However it is very clear that that something would be flushed sooner or later, so the reason is not toxicity, but a deficiency. Apparently by using this drench, we replace some missing nutrients (boron), the other way being to repot in fresh mix that has an initial load of boron, and gives therefore the impression to be more 'fresh' and more suitable for root growth than the 'old' mix.

- I tend to spray every other month mancozeb/dithane. It solves a lot of small problems of manganese and zinc deficiency. In fact for some parvisepalum there is a tremendous growth burst after its use, due to a chronic zinc deficiency in most conditions.

- In some cases, the root tips can have a brownish exudate, and stop growing. It is absolutely boron and zinc coupled deficiency, though this will not happen if the given schedule is followed. It must not be mistaken for the brown exudate of the seed coat mentioned in the in vitro part. This brown exudate can be extracted by boiling the seeds and leaving the liquid in the air, or even with killed seeds, so it is a real chemical contained in the seeds. The brown root tips are an oxidation process started by the lack of boron and zinc. It took me a couple of years to find out. It can be reverted if the feeding is corrected.

- I add nickel to the feeding solution, and I feel kelp extract is important too to supplement some organics, or even some rare micronutrients. , I found out too that when there are some unicellular algae here and there on a few pots, it means that the feeding schedule is correct. The plants that are contaminated by the algae seem to grow better too, though it is something completely different from the seaweed, of course, but the decomposition of those unicellular algae and cyanobacteria, like in the habitat, release amino acids, that could well be taken up by the plant. It would take a lot of investigation to know the real truth behind everything, and as long as the plants are growing very well, it is not something that appears to me to be a priority.

I hope I have given enough information and details about the reasons of the whole story, and enough details too so everything can be reproduced by anyone who wishes to have good growing Paphiopedilum. Some, I hope most people, will be successful, however there is no fixed rule for anything, and maybe some people will have some trouble after following these guidelines, or not get the expected results. Everyone's growing conditions and way of growing is different, but I tried to provide as much information as possible for everyone to succeed.