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Orchid Growing Substrates

Select Orchids
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Contents

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Introduction

There is a wide range of potting materials that can be used. In the old times, composted Oak leaf was used, so were the osmunda fern fiber and sphagnum. Worldwide a wide range of potting mixes have been and are used, from dried fern leaves in Indonesia to shredder tyre, through Rockwool, glass beads, bark, sphagnum, peat, loam and the list goes on…

Whilst there is at least one grower in the world having 'success' with each and every of these components, there must be a scientific basis on the use, and the eventual blending of the components. Some very common products in one region are an absolute rarity in some others. Tree fern fiber is exceedingly common in Vietnam and China, but exceedingly rare in England, where it needs to be imported. On the opposite, Rockwool produced in Europe and readily available is very rare in Indonesia.

To most growers, hobbyists and professionals alike, one potting mix material is the same no matter the source. Sphagnum from Europe, the USA, New Zealand, Chile and China make up for only one type in most grower's mind. Red lava rock, bark, peat represent in most people's minds 'one' compound, where each is not a component, but a category comprising vastly different products.

Recently, in Europe, the mindset has changed. After several massive storms over the last few decades, a lot of pine tree forests were severely damaged. The growers, who ordered 'pine bark' for ages, suddenly got pine bark, but it did not behave the same way as it did before. The trade called this type 'storm bark', because it was from weakened, sometimes already dead trees. A few years later, 'juvenile' bark came on the market, from younger tree plantations. The growers were buying one bark, one size, but at the end realized they got 3 vastly different materials, with vastly different behaviors. It was the awakening, which was tampered only by the sellers, explaining that, in fact, they were the 'same product', and made hidden adjustments to try to keep their customers. In America, the bark suffered the same fate too, where one of the best bark producers decided to stop its production for orchids, and most other companies decided to reserve some batches of their mulching bark for the orchid growers, instead of doing a specific product as they did before. It has been the time of the coconut chips too, which were supposed to be wonderful, and would replace within 'a year or two' according to their promoters, the bark from all around the world. They were economic, ecologic, a true 'green product', and working wonderfully… not. It did not happen, mostly because in a lot of cases, the suppliers, the traders, the sellers, and the growers have different objectives and thinking, and different results. A supplier is successful if he sells a container of coconut chips, but a grower is successful if his plants grow well. So the supplier can deem a good success, but the grower, on the same container, can kill his plants, like it happened countless times, and be on the verge of bankruptcy.

There have been a lot of companies, catering to either the pot plant trade, or the hobby trade, and even some really famous orchid growers, which collapsed partially or fully because of the potting mix. In fact, all of this is easy to explain, and that's what we are going to do here.

Parameters growers should expect

There are first some parameters that a grower should expect from his potting mix:

- It must be available for the decades to come. In some cases, a good product appeared on the market, and disappeared because its manufacturing was too expensive, or the initial stocks to make became scarce. The Royal Osmunda and the live sphagnum moss used at the beginning of the 19th century were such products.

- It must be easy to use. Coco chips were an example of something that needed intense processing, so do the Rockwool cubes at the present time. Any 'pretreatment' or 'conditioning' increase the costs for the commercial grower or the risks for the hobbyists, who cannot always follow some very complicated protocols.

- It must be present, hence stable for many months or years, but absent at the same time. Sort of 'discrete', a good material to pot the plants, but that will not disturb by its behavior; the grower. If the grower must use fungicide drenches, lime corrections, feeding solution corrections nonstop, it is expensive for the commercial grower and even the hobbyist, and in many cases they will not have the knowledge to do the proper changes or treatments. A good potting mix is just that, a support for the plant growth, and an aid that does not need more care than the benefit it provides. It is usually expressed technically in terms of pH, salt retention, absence of toxic concentration of nutrients, absence of strange chemical reactions (like what happens with coconut based products or Rockwool).

- It must stay stable; retain its structure for a long time. Here it is not the chemistry, but the physical side. When 1cm particles are used, they must remain at 1cm for a long time, and the water retention and air retention must be the same over many months, it must not decompose, dissolve, or pack, and change.

Concepts to understand

Some concepts are required to understand the potting mixes and their choice:

- 'Inert' applies to an exceedingly small range of components, and nearly none of them are used in horticulture. Inert would mean that there is absolutely no change over the culture duration for our purpose, but in fact, what can be inert can become 'active' and start some process of transformation, decomposition, degradation, when used in certain conditions. Take a limestone block that is some dozen of thousands of years old. Water it every day with hydrochloric acid, after a while, all the limestone will be gone, and it will take much less time to convert the limestone to calcium chloride than the entire lifespan of that said limestone before.

- Alkaline, or acid natural habitat does not always have a meaning. As an example, a limestone cliff can be covered with mosses, and decaying matters, branches and leaves in this case, the pH of the environment will be from sharply acid (Paphiopedilum ooii grows on a limestone mountain, yet inside a thick layer of fern roots, with a lot of decomposing fern leaves, its habitat pH is around 4.6, but on a limestone mountain. It is doubtful its roots ever see the limestone to alkaline where the limestone is exposed bare. Decomposition and decaying matters in the wild usually result in products that are acid, and will interact with the rock or mineral part sharply. The same with a percolation of rain water running through thousands of cubic meters of forest, soil, decaying matter on top of a cliff, and thoroughly wetting the entire mountain and biotope below.

- Sometimes, plants grow in one specific pocket, not in the next one. It can be assumed that they did not colonize the other pocket because they did not colonize it. It would be more clever to assume that it may well be because the pocket they are growing in is suitable, and the next one, even a couple centimeters further, is not for a reason. It is especially obvious with Paphiopedilum hangianum in the wild, even if the soil in the habitat looks the same; they absolutely prefer slightly acid conditions, from 6-6.1. We can find some pockets too where the plants are really doing badly in the wild, and those usually have a pH of 7+. They are chlorotic, and can be just a few meters apart from some gorgeous clumps. In the former case, a lot of acid materials and organic matters, decomposed, decomposing and to be decomposing are carried by the heavy torrential rains, in the later one, usually a change makes that no such matter is carried out. pH, nutrient availability, can vary greatly just a few decimeter apart.

- There are two schools of thinking, some people want to adjust the potting mix to the fertilizer, and some people want to adjust the fertilizer to the potting mix. However, it is best to work in a safe range zone of 5.5-6.2 for all orchid species. There will be maybe a couple of exceptions, Paphiopedilum ooii is one, so is intaniae, wentworthianum and bougainvilleanum, that require very specific nutrition, and a really low pH to grow well, but they are exceedingly rare. Nearly all Paphiopedilum species can be grown at a 'normal orchid pH'.

- When playing with fancy pH, like pH 8 for brachypetalum Paphiopedilum, as an example, or even alkaline pH for the poor Paphiopedilum rothschildianum that never experienced such things in the wild, people try to adjust the fertilizers micronutrients and macronutrients. However it is not always possible. For the zonal Geranium (pelargonium), if you grow the plants at a pH of 4.5 in pure raw peat, and supply a normal fertilizer, they will suffer a great toxicity from iron, manganese, zinc, and possibly even copper. But if those micronutrients are not supplied, the plants will be deficient, which is not good. On the other side, supplementing those micronutrients at a very low rate, thinking that, because of the low pH, the poor geranium can be supplemented with a very low rate to avoid phytotoxicity, is not working. It will just make phytotoxic shocks, on and off, noticeable on the growth. Because of the low pH, the pelargonium will take up all the iron, zinc, manganese, and copper available at once, poison themselves, and then will be deficient until the next time the fertilizer is applied. Plant uptake is quite fixed, and lowering a micronutrient in acid conditions, or increasing it in too alkaline conditions, is going to go nowhere. In both cases, it can correct for a short while a problem, but over some weeks, some months, the plants will not be able to stand the problem, and will become chlorotic, then die. For years, the motto was to apply 'iron' when acid loving plants planted in alkaline soil were chlorotic. It greens them up, that is true. But the said plants just take it here and there, and their internal metabolism is not tuned to cope with such situations, as a result, they will be deficient, or intoxicated by copper, manganese, zinc, eventually even phosphorus, nearly for sure calcium. Trying to fix an improper pH for a potting mix by feeding different macro and micronutrients can be met with some success for a short time, but not for the long term.

- On the other side, it is impossible to assume a pH according to the habitat. Epiphytic species can grow on weird things too, such as the chiloschista, Phalaenopsis braceana, or even Dendrobium wangliangii, which usually grow on dead, weathered branches. Such branches usually are more on the neutral-alkaline side, even if the bark on live branches on the same tree would be very acidic sometimes.

- Assuming the habitat of some species by looking at the plant is nearly impossible. Papillonanthe teres (Vanda teres) has cylindrical leaves, and is a full sun plant. The paraphalaenopsis, and holcoglossum wangii, have cylindrical leaves too, and are deep share growing plants in the wild. Some species have dark green leaves in absolutely full sun on bare rocks, such as dendrobium igneoniveum, some species, such as some liparis have yellowish leaves in the deep shade of the forest.

- A trial and error process is always required when growing new species, and hybrids between species or hybrids whose requirements vary. However, the vast majority of the orchid plants are best grown at a pH of 5.5-6.2, preferably around 5.7. Adjustments can be easily done in this pH range.

- A potting mix can have a low pH buffering capacity, which means that its pH can change sharply, depending on the watering, or a high pH buffering capacity, where it will stay in a determined range of pH. The pH buffered range can change when it becomes older, or stay stable for a long time. As explained previously, the best is to have a potting mix that does not make a lot of changes by itself. On one side, the potting mix is essential, on the other side, the potting mix must not interfere with the proper care of the plant.

- Most potting mixes are analyzed following a water extract. This is a gross mistake, and that fact was first realized when people used coconut coir with a fantastic water extract, showing no dissolved salts at all, and ending up with extreme potassium and sodium intoxication of their crops. It was the starting point of a new era, that would see both water extract (like an instant photo) and a destructive analysis to assess what is there right now, and what can be there in the future, through solubilization, ion exchange and decomposition. It is a very important point to keep in mind, and even today a lot of growers do not realize that an EC of 0 for a water soluble extract does not mean that the material tested is not heavily loaded in various components, some being very damaging, and released in the near, or far future.

- Radium watches, and even some projects of radium lightings were considered exceedingly safe and really good. After a while, they have proven to have had the slight drawback of being responsible for cancers and some types of leukemia specifically. Whilst it is claimed by some industries that their products are absolutely safe, common sense makes anyone think otherwise, especially in the light of chemistry and physics, and second, it may well be that, at the time the manufacturers claimed so, there were not enough data to claim otherwise. Asbestos has been a famous example of a 'safe' compound that proved to be quite dangerous. As for Rockwool, the structure of the fibers is very similar to asbestos, it is a mixture of various kind of rocks, processed, and it is very unclear why such fibers, entering the lungs or even the nose and being stuck there, would not make any damage, and be as friendly as a candy. Xavier's personal opinion is that it is absolutely not safe. Anything dusty or thorny that enters our body has a potential for being risky. Perlite and Rockwool are such materials , as can charcoal dust.

- There are a lot of unexplained facts, and experiment results. Most scientists will try to fit those in a way or another with today's knowledge, but it is clear anyway that a lot of things cannot be explained. Some others just start to find their explanation. Methylmercury and dimethylmercury are two of the most deadly chemicals known. Methylmercury released in Minamata, Japan, killed 1800 people, and crippled some many thousands, its source was artificial. On the other side, in Ontario, Canada, a similar disease appeared, caused as well by the deadly methylmercury. However in this case, aquatic microorganism converted mineral mercury into the deadly organic methylmercury, whilst being

unaffected themselves. It cannot be excluded that a lot of current knowledge about this material or that chemical becomes in the near or far future completely obsolete. Sometimes the practical results must be considered more than the current technical knowledge, as the knowledge changes all the time. How many people realize that only 30 years ago mobile phones with WIFI were science fiction, its technology could not even be imagined? In horticulture even, fungicides and bactericides, apart from copper and sulfur compounds are extremely recent newcomers, with some groups existing within only the last 15 years. Things are changing, and one needs to interpret and analyze everything using technical knowledge, and experience, which cannot yet be replaced by knowledge or studies.

Potting material specifications

We will now see some aspects and groups of potting materials, and some of their specificities, as well as some short histories about them.

Rockwool

- Rockwool has been popularized for a few decades. At first, it was a byproduct of the insulation industry. Rockwool was discovered and imagined because around some volcanoes, especially in Hawaii, there were sometimes some samples of wool like stone structure. This gave the idea to make Rockwool, known under several other names, stonewool, lava wool and many others. The manufacturing process of a large part of Rockwool allows the use of lime/calcium carbonate blended with the fused rock, which will help to make the spinning process, and the fiber production. Depending on the production site, sometimes recycled Rockwool is fused again, or other types of stones and rocks are added. This has dramatic consequences, that forced even one major supplier to ask for changes in the EU regulations in the 90's to accept as a fact that Rockwool can have a high content of heavy metals, mercury and lead being specifically named. According to some studies made in Holland at that time, the heavy metals would not be released when it is used for horticulture, but it can never be really predicted or proved. Nevertheless, Rockwool used to be traded with levels of heavy metals deemed unacceptable in a normal organic potting mix. It can contain for some sources as well iron, manganese, chromium, zinc, boron and other elements in soluble and insoluble forms. At a point, the blending that was required of lime and rock to make the fiber would produce fiber that has a lot of bonds too with calcium hydroxide (the result of heating the lime). When Rockwool is used with an acid irrigation, that calcium hydroxide will be dissolved, a requirement especially with the newer, cheaper types of Rockwool, to flush it. In doing so, it leaves 'gaps' in the Rockwool structure and can precipitate its demise. One type of Rockwool cube would be reduced to sludge if left in water with hydrochloric acid at a pH of 4.5. At a higher pH, like 5.7, it is clear something would be released, and its structure would change. It is also proof if needed that Rockwool is not 'inert'. In the 90's a commercial blend named Greenmix, containing lignin blended with water absorbent and water repellent Rockwool, was very popular, and earned Eric Young Orchid Foundation its reputation, under the auspices of a very skilled grower, Alan Moon. It was not easy to use, even if one of us used it for some years (Xavier), and after some years would become 'old'. Alan Moon said after 2-3 years roughly. Again a proof that it was not so 'inert'. That blend disappeared from the market , so did most of the water absorbent and water repellent types of Rockwool, which was explainable, as the water

repellent would become, over time, water absorbent, and it would pack down. It has been replaced more recently in a lot of application by Rockwool slabs, not convenient except for some thin rooted orchids, and Rockwool cubes. Some other disadvantages of the Rockwool is that it needs to be used in an intensive hydroponics system if one wants to flush it properly, initially from the manufacturing residues, then from the salts that may accumulate. As it is inorganic too, it is highly conductive to various pathogens and opportunists fungi and insects, which can happily live on the only organic source still present, the plant roots and leaves.

- Rockwool is exceedingly cooling the roots too, and for many orchid cultures, it was required to bottom heat the plants, like it was done at Eric Young for their Paphiopedilum. The feeding solutions were complicated by themselves, blending mineral and organic materials for optimal success, using some root rot fungicides protectants, and because Rockwool after a while has no buffering capacity, great attention has to be paid to make a feeding solution that will not sharply change the pH at the roots.

- If Rockwool had been an absolutely inert material, without any chemical or physical flaws, it could have been interesting. However, added to the fact that Rockwool disposal becomes extremely expensive (in many countries now it is considered an industrial waste), the suspicions that some lung problems are related to it, or to some batches of it, despite some claims, and the not so long lifespan makes it not worthwhile, especially for Paphiopedilum. For some short growing crops, it can be successful, such as tomatoes, short cycle food crops and some flower crops. But it does not outperform in longevity for those food crops things like even coconut coir. Rockwool and coir are both used in industrial setups, with many flushing weekly to produce food or cut flower non-orchid crops. The flushing reduces the risks of any phytotoxicities, or any problems of nutrition, but they cannot be adapted to any orchid crop, except, eventually, Cymbidium. There are growers that are successful with Rockwool for orchids, and some are very successful, but they have to repot often, and follow up both the potting mix chemistry and fertilizer chemistry very accurately. In case of drought too, the plants can be killed within hours, as the Rockwool will draw the water out of the plant's roots, the said plant roots being used to being in a nearly always wet media, and not being drought resistant as well. A drought in a Rockwool grown culture can be the end of the culture, with no possibilities to go back.

- Another aspect of Rockwool is that the shards constituting the Rockwool and the abrasive power of the Rockwool can hurt soft tissues, making entry points for diseases. When freshly potted, or when the plant root system starts to compress the Rockwool, or grow inside the pot, it can hurt itself, creating microwounds that are a perfect entry door for pathogens.

- Rockwool has been found too in Paphiopedilum to be highly conductive to root and crown rot pathogens; those can be controlled by specific fungicides, which need to be reapplied periodically. It is very difficult to move a fully grown plant to Rockwool, or to move it out of Rockwool. The shock, and disease risks are very high, and the ways to do are simple, before potting a plant in Rockwool, it must have a strong fungicide and bactericide bath, the most successful to date being a mix of tetracycline, tolclofos-methyl, mefenoxam, azoxystrobin, fludioxonil and cyprodinil, all together as a bath. Not something the average grower can afford to do, even less so legally. To move a plant out of Rockwool, Alan Moon gave the following technic. Remove part of the Rockwool only, maybe half, and keep the root ball more or less intact. Repot in the new potting mix, drench with mefenoxam and quintozene. About 6 months later, repot again, remove all the Rockwool at that time, and all the dead

older roots. The new roots that are formed in the new potting mix should help the plant to restart. However, for some plants it cannot be done without a great setback to them, especially the odontoglossum and miltoniopsis, which can be killed in the process, or severely stunted. The whole root system was acclimatized to very wet conditions, and is not hardened enough to survive in a drier potting mix, or even with pathogens, fungus, bacteria around, so it will die. Usually, when a sympodial plant loses all of its roots, like an odontoglossum, the older rootless bulbs and growths will die, as the new growth will make roots for itself, can sustain in part the older bulbs, but not completely. When some of the older bulbs die, they can start to rot, generate acidity, which greatly helps pathogens entering the new growth, which means a total plant collapse.

- On a medical point, there are some unclear points, even as of today. Maybe we do not have the required knowledge to understand, but so far several countries charge a premium for Rockwool disposal, as a toxic waste. , the dusty thorny Rockwool with residues of some years of phytosanitary chemicals do not seem to be good for the environment. On to two other points, it has been claimed by some manufacturers that first, Rockwool, unlike asbestos, even if it will target, and successfully reach the same location in the lungs will 'dissolve' in the lungs by the 'acidity'. On the other side, it is not dissolved by hydrochloric acid, at least it is only partially dissolved, with a residue. It is hard to understand where the solid residues from such a magic 'dissolution' would end up in the core of the lungs, if they would be teleported like in Star Trek out of the human body, or encysted, or whatever? The second point, some years ago Rockwool showed unacceptable levels of arsenic, lead and mercury. Again, it has been claimed at that time that the strong alkaline reaction of Rockwool prevented their assimilation and uptake by food crops on Rockwool slabs. However, plants do generate organic acids at their roots, the feeding solution is acid, and there would be a lot of microorganisms that can do a lot of funny to some compounds.

Lava rock, aggregate, stones, perlite


Lava Rock


Pumice


Perlite

- A lot of recipes call for various types of stones, pumice, red lava rock, clay aggregates, seramis, perlite, gravel. However, depending on their sources, the results can be really different, and their chemistry makes them non inert. I suspected for years that growers using red Lava rock got some micronutrients out of it, and apparently it is the case. Some lava rock sources have a very high content of iron, manganese, eventually even potassium. It depends on the volcano, and even on the particular eruption. Without entering in a lot of details about geological matters, this kind of stones and aggregate materials have a wide range of application. However, there are some things that are little known from the users. First, pumice is one of the best stones available out of the whole series. It has a grey color, and can be calibrated to a uniform size. Some types can be partially or totally hygroscopic, retaining easily water, whilst providing good drainage. However, most serious traders of pumice have to either extract it from permafrost areas, or areas with an extremely cold winter. The reasons lie in the fact that some sources have been found to be very heavily contaminated by pathogenic nematodes. Nevertheless, for all those stones, including the processed perlite, the salts concentration must be assessed, and this needs to be done in two ways. Some pumice as an example floats for the first few days when dropped in a water bucket. Then, suddenly, after one or two weeks, they will absorb a lot of water, be saturated and drop at the bottom. If one tests the pumice water extract the

first day, when it is floating, there will be nothing abnormal. If one tests the pumice water extract once it has been saturated, then there can be a lot of components, some unwanted ones. A range of those materials can be extremely alkaline, and not surprisingly, the red lava rock can contain extreme levels of aluminum, that are released. Though, one has to say, Paphiopedilum can survive very high aluminum concentrations, which would kill a lot of other plants. It is not yet clear, but it would appear at least that some even may need it. Other orchids can be much more susceptible to aluminum however.

- All of the aggregates suffer from one problem; they act a bit like a sponge. If you take a sponge, and put in black ink, let it dry out, you can wash it dozens of time, there will still be some black ink visible. If you take some of those aggregates, such as pumice, perlite or diatomit the wet/dry/wet/dry cycles during their use will slowly 'stain' this kind of materials and at a point there can be a sudden release due to the pH of the total mix becoming lower, or for whatever reason. It is very hard, unlike the urban legend, to 'recycle' such materials, like the sponge, you can soak a dyed sponge for months in water, most of the time, the stain will still be there.

- One of us (Xavier) has been using before pumice and lava rock, though mixed with components that were not stable enough for the long term. In this case, it was working very well, with re-potting every 6 months. To keep plants in a lava rock or pumice containing a mix for some years is feasible, but not easy.

- Clay pellets can vary, if they are not baked properly, or made of clay that has some specific physical properties to start with, they can degrade and decompose. Clay pellets can be water absorbent, water repellent, smooth or rough, and they come in a wide range of shapes and qualities as well. Depending on the manufacturer, they can be quite stable, or degrade over time, retain a lot of salts and become toxic to the plants roots after a while, or be completely water proof. The ones that may have a use would be the waterproof ones, mostly to increase the aeration of a potting mix. Some with rough surface can be used as well to improve the aeration and retain a little bit of water on their surface, but their benefits are unclear in practice. The water absorbent pellets are better being replaced by straight grey pumice, which is cheaper and more reliable.

- Of the whole group of ingredients, red lava rock is interesting, but only a few types, it has been used in Hawaii and at the Orchid Zone successfully for decades, Xavier did use it successfully from Greece, but some growers killed their whole nursery, because the lava rock looked 'the same', but was, in fact, a vastly different type chemically, though optically and physically the same. Lava rock however is very heavy, and can be abrasive to the plant's roots.

- Pumice is very interesting as well, and a lot of growers are using it successfully. It is smoother, does not have sharp edges, and retains a fair amount of water. Some types of pumice however make a lot of powder, which can be abrasive. The powder can be a problem as well because it will clog the other material's pores, resulting in anoxic conditions after a while, with fast decomposition and proliferation of bacteria. However, it is an additive that can be considered for a Paphiopedilum mix, shall this be required.

- Diatomite has been popularized by the Maidenwell diatomite. However, there are many careers, from seawater species to clear water ones and the sodium content can vary dramatically. Its structure is determined too by the geological formation, the species that made it and many other parameters.

Some will just collapse and be converted to dust, like some originating from PR of China, while others will release a lot of sodium. Whilst on the paper it seemed promising, it did not have the commercial success expected. Like most of the other aggregates named here too, it is mined from some areas, and a specific type may well exist only in a few locations in the world, in small amounts only. It is not a renewable resource, like most of those stone products, but in this case, there are too many different diatomite, and variations of diatomite, to safely recommend it. It gave good results with phragmipedium according to some US reports. Diatomite is usually highly abrasive too, which can eventually hurt new root tips of Paphiopedilum.

- There have been many claims that perlite contains very toxic levels of fluoride. However, in this case there is fluor present in many samples of perlite, on a purely analytical level, but most of the fluor atoms are included in molecules not likely to dissolve or be available to the plants anytime soon. Truly, there are other compounds in some perlite types, aluminum, chromium, nickel, sodium even, that will be slowly released when the perlite starts to degrade and that were more likely to be the culprit of some phytotoxicity outbreaks than fluor. The very coarse grade of perlite are a mystery, as they are highly sought after, and very rare in Europe, but they do not differ from pumice in their properties except that all types of perlite tends to crush easily over pressure, sometimes even they 'decompose' for some sources, where pumice does not crush easily, and is much cheaper. Perlite needs to be de-dusted, and usually a grower will do it in two steps. The first, open the bag, and his lungs will filter the first part of the dust and then dump it in a bucket of water, with his lungs still taking full strength dust. In the second step, the perlite is soaked, and the dust falling to the bottom is removed, the supernatant kept for use 'de-dusted'. Unless it is dried and stored again, where at that point it will start making dust again by friction.

- Vermiculite is of no practical use to our minds. It is a laminated kind of material, which tends to decompose and clog after a while, leaving a lot of tiny plates. It will become too compact after a while, and it sometimes contains phytotoxic levels of aluminum. Some vermiculite tends to become extremely acid over time as well.

Plastics

There is a wide variety of plastics compounds. Overall, some are good ingredients, but none can be used alone.

Tyres.

- Starting with the funniest, shredder tyres. It has been popularized in the 90's as a very cheap and 'green' potting material, recycling old tyres. Without going to the joke to know if the grower had a Goodyear with the plants repotted in it, it has been a failure. First, tyres can have incrustations of a lot of things, including oil, petroleum, whatever wheels travelled on. Second there are many compositions for the tyres, including as well some heavy metals, namely copper, to prevent their degradation. They are released in the potting mix after a

while. Third, it looked really ugly, and not very practical, with no direct water retention. Some attempts that were close to this material was plastic artificial sphagnum, looking like a kind of feathers, or like a kind of plasticized sphagnum. Those compounds retain water droplets, but are not moist. It is one of the keys, a lot of orchids and plants do not like water droplets for a long time, but they like to have a water film on a porous material or moist surface to put their roots on. Furthermore, if tightly packed, it would be well sealed, and some parts of the pot would never dry out, which is not good.

- Two more interesting materials, but not ecologically speaking, are :

Polystyrene.

- The white polystyrene, either cubic chips made of small grain polystyrene, or bigger individual beads provides a good drainage. Some roots like it, up to the point of growing through it or even attaching to polystyrene. there are mounted orchids that really love polystyrene and make an extensive, attached root system on the plate and through it. It is hard enough to avoid potting mix packing, and soft enough to be compressed to some extent by the roots. On the other side, it can look ugly to some, and to dispose of a potting mix made with it is not really easy.

Polyurethane foam.

- A 'Magic Ingredient' in Europe for some decades, it is simply soft polyurethane foam, similar to the one used to fill the pillows, in small particles, usually about 1cm and 2 cm. It prevents the packing of the potting mix, and keeps an excellent aeration. Straight after watering, it retains a lot of water, and a few hours later it is just moist. At a point it has even been used alone for hydroponics, with success. However, both Polyurethane foam and polystyrene can fly all around the nursery when a fan is used, second they are hard to quantify. A usual standard for such materials, as well as for sphagnum moss, is to weigh it, and not to check the volume. As an example, most formulations using polyurethane foam will call for 10kg/cubic meter of polyurethane. 100 liters would have no meaning; 100 liters very tightly packed would be over a cubic meter loosely packed.

- Both of those plastic compounds are good additives to a potting mix. There is one version, of polyurethane foam, from Taiwan apparently that is much more hard, and comes in a 0.5mm-1cm size. It appears to be quite fine as well to use in a mixture, but the plants prefer the softer version obviously.

Mosses

Historically mosses were used for potting orchids for centuries. It is clear too that some early Chinese and Japanese grower's manual, when speaking of moss, did not consider Sphagnum moss, but what we call 'sheet moss', or 'wood moss', which is the usual growing media of quite a few Paphiopedilum species. It is as well the usual growing media of quite a few epiphytic species. However, there are a nearly infinite number of mosses genus and species, some suitable, some not. Lance Birk, the noted Paphiopedilum grower, did design a mix using bark and sheet moss nearly 40 years ago. It is a very successful mix, partly because most sheet moss has a poor buffer capacity, and therefore will not remain acid for a long time. It is aerated, and moss can regrow in the pot. However if the moss dies, it will kill the plant by decomposition after a while, and depending on the temperature, the feeding and other elements it can become really sour suddenly. Xavier used successfully moss in the mix; however it has now been replaced. Irrational thinking's can always come, and when using sheet moss and bark, the plants grow well, notwithstanding the decomposition of the potting mix, that can be pretty fast. The next question was to find out what the moss really brings to the plants, and, apart from some water retention, that can be easily reproduced with other materials, or adjusting the watering frequency, it provided, through its decomposition, organic compounds and micronutrients. The microflora harbored in the moss could have had its importance, but so far the effects can be reliably reproduced without the use of sheet moss anymore. Study the two aspects of a product, physical and chemical, that's the key to find how to replace some 'magic ingredients'.

Sphagnum.

- Sphagnum moss is probably one of the most popular compounds around the world. It has been used for a long time, since the early days of orchid culture. In the 19th century, live sphagnum moss was used mixed with osmunda fern roots. It is important to note that the sphagnum used was from Europe at that time, and alive. In the USA, sphagnum harvested locally was used too, with various successes. Many growers reported that some 'colors' and structure of sphagnum grew pristine plants, where some other 'colors' especially the red small headed types were strongly phytotoxic to the plants. Now, we know that there are many sphagnum species, and some can even colonize sodic marshes, pure water stream, forests, bogs and swamps. In Europe the harvesting has been strictly controlled and prohibited subsequently, as sphagnum became rarer. Anyway, with the tissue culture, and the massive productions starting in the 50's of many hundreds of thousands of plants around the world, it was not feasible to harvest sphagnum in Europe and the USA to re-pot such plants. Sphagnum was used in Europe commercially until the mid-90's as a local harvest in France and Germany, with some further supplies from Denmark. However, most European sphagnum moss would not last very long, and it was always preferred live. The attempts to use it dried were sometimes successful, sometimes not, and anyway it required a very low mineral salts content of the water not to decompose. Most moss from the Northern Hemisphere would not become a popular commercial success, because of problems of availability, lack of resources, especially renewable ones, and the fact that most of the easy to harvest sphagnum moss did not react well to many chemicals. As an example, the French Sphagnum moss would become gray and metallic smelling nearly overnight, killing the plants, after a single application of either a copper compound, or fosetyl-al fungicide, or even of some fertilizers containing urea.

- First, there are some things to state about Sphagnum moss. A lot of misconceptions arise around 'sphagnum bogs', and again 'very low mineral content' sphagnum moss. In fact, sphagnum moss tends to grow first in full sun for the commercially harvested varieties, with its 'feet kept cold'. In New Zealand, it grows on apparently very old grey clay, with a junction that is wet, and the fibers are

nearly growing straight on that kind of structure. Rarely can we see the peat usually associated in most people mind with sphagnum. Some bogs can be really wet, but they can endure wet and dry cycles apparently. In China, there are several species harvested commercially, in many instances by local farmers, or even very poor minorities, which bring some truckloads on four wheel engine powered things that barely resemble a truck. It is stored after harvesting on the ground in several villages, sometimes even in the water from the rice field. Some species are harvested from volcanic lakes, some from more 'terrestrial' areas, and there is a mixture of species. In Chile, there is one species, sphagnum magellanicum, which can grow with a water rich in salts, with a high EC. It is not a renewable resource in Chile at all, but more on that later. All the sphagnum species commercially harvested grow in full sun or nearly so. This explains too why many people trying to grow live sphagnum in their greenhouse are unsuccessful, because they do not provide enough light. It would appear too that sphagnum benefits from UV light to some extent.

- Sphagnum bogs in Auvergne, Central France or some even in Illinois, USA, can be really dangerous, with a floating island of sphagnum moss on top of a lake that can be a couple dozen meters deep, in the core of some volcanoes in Auvergne. In Germany, it sphagnum can be on top of a millennium old peat layer or on top of a massive water reservoir. In some other instances, the sphagnum is just on top of a massive amount of peat. One must remember, where there is peat there is or has been sphagnum, but where there is sphagnum, there is not always, if not rarely peat below in most parts of the world. Sphagnum occurs in many areas, and it is possible to find Sphagnum growing in Cambodia in exceedingly tropical conditions, or even in the Malaysian Sabah lowland area, close to Sandakan in the 'black water area', some rivers and streams that are so high in organic matters and decomposed tannins that the water is black. On top of that black, exceptionally acid water that would leave rashes on anyone's skin, one can find sphagnum locally named cuspidatum, which looks like healthy, live green sphagnum, happy with that water supply. It appears too that the sphagnum determination is difficult, and poorly studied. As an example, botanists in Siberia, Denmark, Czech Republic, England, Africa, the USA, and Chile claim that sphagnum magellanicum is a local species, which is hard to believe, though some photos show some similarities. DNA analysis and mineral composition could greatly help to determine the species and make proper identification, but this has apparently never been done. It appears too that 'sphagnum magellanicum' has been tried three decades ago in Florida on Paphiopedilum by Dr. Atwood and it killed Paphiopedilum planted in it, which would be different from Chile's sphagnum magellanicum behavior. This tends to indicate that those are two different species, though habitat differences could not be ruled out completely, but it is quite improbable to have the same species growing scattered in many colonies thousands of kilometers apart in various places of the world.

New Zealand Sphagnum.

- New Zealand started after Europe to become a source for premium sphagnum moss. A large part went to the Japanese trade in the early days and then it became a worldwide, popular commodity. Tasmania and Australia did export some, but the production is much less industrial, though it is apparently the same species. This resource is now closed and unable to

be harvested any longer. It is important to remember that first, there are different species and second there are different areas where the same species grow. In some areas, one species can make one type of growth, but in a warmer place, the cell walls, and general plant chemistry and metabolism will be different. Not only must the natural resource be harvested of the proper species, but from the proper place as well. Tasmania at a point did produce for a short while sphagnum, however the capacities were much lower than New Zealand in terms of areas that could be harvested sustainably. Xavier was very surprised when he visited New Zealand to find out that the sphagnum is not harvested from very old bogs, like people used to see in Europe or North America, but from fields that had been pastured until quite recently, or decades old cleared forests and bushes. In fact in New Zealand, the sphagnum comes from artificially managed lands, nearly all the time, not from a natural ecosystem that is poached. Sphagnum is harvested every 4 to 7 years, depending on the location, and it comes from places that were cultivated before for various agriculture or pasture purposes. The two most important species are sphagnum cristatum, the big head type, and sphagnum subnitens, a smaller variety. However it is interesting to note that nearly all the time they grow together, except in a few places, and it can be troublesome to make a 'pure' batch of one or the other species.

Chile Sphagnum.

- Later, Chile sphagnum moss started to become an alternative. First, Chile traders claimed that it was the same as New Zealand. It appeared from the early growers trials that it looked a bit the same, though it had the reddish color typical of Sphagnum magellanicum, but soon some growers in Japan and the USA found out that some species would simply refuse to grow good root system in the Chile sphagnum vs. New Zealand sphagnum moss, in their conditions. Some years later, it has been made clear that those are different species. It is absolutely not a renewable resource, and nowadays it becomes scarcer, despite a very low, attractive price. The bogs are cleared one after each other, and now most of the stock comes from the south, and further south in Chile, at increased transportation expenses. The quality suffers especially in recent years, as it is required for the Chilean exporters to harvest lower quality, or previously discarded bogs. It does not renew, in the way that the orders are so huge that everything is really cleared. It is interesting to note too that it grows in areas with quite high water salinity.

Chinese Sphagnum.

- China is a very old, newcomer. They harvested Sphagnum for their own culture for ages, at least 150 years, if not more. There are growers that get absolutely amazing results in China with their local sphagnum moss, unfortunately there are many species, and as previously said,

the hygiene conditions are really bad for the harvesting. Some batches were contaminated by fusarium, some others by phytophthora, and usually there is a lot of debris and various things, from leaves and branches to dead animals in the bags. One second market developed which is recycled sphagnum moss, processed in a clothes washing machine with some bleach, and sold, sometimes hand processed the same way, a bit of bleach, a bucket of water, one or two rinses and it is dried, ready to be sold. One grower in Kunming grows in Chinese sphagnum moss absolutely gorgeous Paphiopedilum, but because of the fast decomposition rate, he needs to repot every few months. In this, the Chinese and former European sphagnum moss seem to be similar, in their short lifespan.

What are the differences between sphagnum?

- The Chinese sphagnum moss retains less water, and it tends to be less resistant to breakdown. As a result too, it tends to be less acidic, with lower water retention. It is easy to obtain Chinese sphagnum moss with a pH of 6 after some weeks of use. Unfortunately, some weeks later, it is the time it will start to breakdown, which will suddenly lower the pH and destroy the plant's roots. The Phalaenopsis hybrids bred from pink lineage, incorporating schilleriana and eventually equestris prefer the Chinese sphagnum moss over the Chile sphagnum moss as it has been reported by several top growers. Same for the Paphiopedilum, for the same reasons. Chinese sphagnum moss is not strongly buffered on the acid side, so its pH can be 'higher' than the strong salt containing, strongly buffered Chile sphagnum moss. It retains less water, so the resulting potting is less water retentive. However, it needs very frequent re-potting. In fact in Taiwan, from flask to blooming size, repotting every 2-3 months is the norm. In those conditions, Chinese and Chile sphagnum moss can be used for the pink/equestris Phalaenopsis types, or the white/others respectively. For Paphiopedilum, Xavier did not have good results with Chile sphagnum moss at all, even in the mix. It tends to be too acidic and releases salts after some weeks. To pack plants for transportation it can be fine, but not more.

- Both the New Zealand and the Chile sphagnum moss can be used with high fertilizer concentration, without fast breakdown. In this they are similar. However, the remaining properties are completely different. The concentration of micronutrients in the Chile sphagnum moss is much higher, over a destructive analysis, and when the Chile sphagnum starts to decompose, it will release toxic quantities of micronutrients. It is one of the reasons too the Phalaenopsis growers who use Chile sphagnum moss, to keep the plants at their absolute best in that moss, need to repot very frequently. New Zealand sphagnum moss on the other side stays stable longer, though it is too acidic for some Paphiopedilum species, it has one interesting property as a mix ingredient.

- If Chile sphagnum moss is blended with lime to adjust the pH, a mess occurs, with a massive EC (salt concentration) rise and it the roots will take this up. If NZ sphagnum moss is blended with lime to adjust the pH, it will accept it and not release anything harmful. Therefore a mix of bark/sphagnum moss will be more successful with NZ sphagnum moss than with Chile sphagnum moss, if one wants to add lime.

- Sphagnum moss from New Zealand contains a lot of zinc, and some other components that inhibit a lot of fungal pathogens and bacteria. Those components are apparently present for a longer time than in the Chilean sphagnum moss.

- There is one interesting exercise, not pertaining at all to Paphiopedilum. A lot of species need extremely wet conditions, like sphagnum moss provides. Amongst them, dendrobium jacobsonii, dendrobium cuthbertsonii, brevicaule, a lot of the oxyglossum species, some anoectochilus… They need neutral to sometimes alkaline conditions (dendrobium jacobsonii is covered with highly alkaline ashes from the volcano nearby). The secret to grow them is to grow them very wet but with something to raise the pH, otherwise they suffer and die. That's why many growers need to keep those species and some others, either 'very dry in sphagnum moss or barely moist' and periodically loose them. One good way to pot such plants, which include a lot of strange orchid species from Papua New Guinea is to pot them in New Zealand sphagnum moss, and add a top dressing of calcite or aragonite sand. Prior to that, Xavier used sand made out of limestone, which is working really well, but not always available. This way of making very hard to grow species alive and expanding like beginner's plants cannot be done with Chile sphagnum moss, as the addition of lime based compounds will raise the EC, and decompose the Chile sphagnum moss, which will result eventually first in a spike in salinity at the roots, followed by a sharp drop of the pH, as a result of the decomposition.

- Maudiae types Paphiopedilum have some ancestors growing in sphagnum moss in the wild, like Paphiopedilum lawrenceanum and some strains of callosum, which actually grow in sphagnum bogs. Maudiae types are easy to grow in New Zealand sphagnum moss, providing they are not kept too wet. Though, with some other species incorporated in the ancestry, some will prefer another mix, but some growers produce dozens of thousands of Maudiae Paphiopedilum in New Zealand Sphagnum moss, with great success. However, after some years there can be acidity related problems, which can justify the use of another potting mix.

For commercial growers, sphagnum platelets can be used for deflasking. One seedling, one dry platelet on each side and then is placed in a tray. After watering, the platelets expand, and form what is called a plug, with the seedling in the middle.

Sphagnum comes as well in powdered form - Petals, it is primarily used in this stage as an additive to potting mixes. For a standalone product, fibers are preferred, ranging from 10cm up to 30cm, sometimes 50cm. The fashion in Japan is to use exceedingly long fibers, though it is very unclear if it has any benefit other than aesthetic. The basic product is still the same. To pot Paphioepdilum using only New Zealand sphagnum moss, a grade of 5-15 cm approximately is preferred. The way to pot plants as a standalone in Sphagnum moss is very important. The fibers are placed in rows, the plant is placed in the hand, and the sphagnum is placed in careful lines, parallel to the plant growth. When enough has been placed, in order to have the sphagnum fibers vertical in the pot rather than all mixed, the whole root ball and fibers are pressed slightly, and inserted in the pot. The whole ball is forced a bit in the pot, to flatten the bottom. Then the top of the pot is leveled by hand, to make a uniform, flat surface. However, the fibers being vertical, it improves greatly the drainage of the plants and they will grow better this way.

Sphagnum has antiseptic properties; however those have never been studied extensively. It seems a fair part is washed out over time, or degraded, but at least the New Zealand sphagnum moss seems to retain those properties for longer time. One of the antiseptics identified is an organo-zinc compound, but little more is known today. Sphagnum as well contains high levels of calcium and magnesium, under an insoluble form, but it appears that nevertheless it is made available to the plant slowly over time. It must be noted that some Sphagnum from Chile had unacceptable levels of sodium as well. In fact, according to more recent studies, Sphagnum is able to exchange cations, potassium, sodium, calcium magnesium, with

the ion hydronium, acidifying as a result its environment. It would act like a kind of 'filter' and 'ion catcher', concentrating the minute amounts available to it.

Lastly, but we will have opportunities to discuss more later about that point, acid conditions can block some pathogens, but can be conductive to some others. In some cases, the Sphagnum effect is related to its low pH.

Peat

- Peat is again one name for a wide range of various compounds. However, it comes from the decomposition of various sphagnum mosses. In some countries, however peat is applied to a wider range of products, including carex decomposed products, which have nothing to do with the horticultural peat. Regarding peat, there used to be a lot of products in the past that no longer exist. German Peat as an example was very famous and a very good, stable product. Xavier did grow for years all of his plants in a mix of German Peat with lime, and pre-blended fertilizer, along with some ingredients to keep the mix open. It required however a repotting every 3-4 months, before the peat pH started to drop, which would stop the plant growth.

- Since then, other types of peat have been harvested, and the old type of German peat disappeared from the market, along with it some long fiber sphagnum peat, that looked like big strands of black sphagnum moss. Those products were of good quality, but no longer exist in the market, with the same quality. Some copies are here and there, but they are not suitable for plant growth. In fact, the long stranded black peat moss from Germany was a premium media to grow Phalaenopsis and Miltoniopsis in the 80's in the Netherlands, until it became absolutely unavailable.

- More recently, peat has been supplied from various sources, all having a low pH, and a very high salinity, along with toxic levels of micronutrients. Some types of peat, produced in anaerobic conditions, in some specific, but unfortunately heavily harvested bogs in the Baltic Countries had as a bonus the capacity to decompose further in the pot, releasing a smell not unlike methane, which is interesting to say the least. Peat can be successful still, yet the type has to be chosen very carefully, and rechecked when a new batch comes in. Peat has been used in the Peat Perlite mixes in the USA. In fact, Xavier did use a version of Peat perlite mix in France, using Germany peat with lime and micronutrients, perlite, and polyurethane foam, with a little bit of small French bark and perlite to help for the drainage and avoid the crusting at the surface. He used it very dry all the time, and at no time was it thoroughly watered. Repotting was required at least 4 times a year, if not more.

- In the USA, a chemical version of the use of peat perlite products surfaced, entitling the use of always wet peat and perlite, along with heavy drenches of various fungicides to keep the diseases at bay. It was not at all the European practice, which gave results even with fragile things such as Dracula vampire, or the thin rooted cool growing South American plants. The secret was 'never wet, never dry, but repot frequently'. It is to be noted that whilst the top growth and overall growth were of excellent quality, in such a mixture, the plants did not develop a massive root system, just enough to take water, and be able to pick up the nutrients from both the fertilizer blended to the peat and the

watering/fertilizer solution, applied only to damp, but never water the mix. It was an art, but working well.

- The hidden peat. Many companies blending mixes of various ingredients, for commercial purposes, with lime and slow release fertilizer (usually PG Mix) use a very low amount of peat to dilute the initial ingredients, and help for their dispersion during the blending process. It is usually very fine graded peat of not really good quality, and it can pose problems, when the roots of the plants encounter it, if they are sensitive to low pH it can stop them. For a Phalaenopsis or a kitchen table dendrobium, it can be fine, and the root will die, that's it. For some sensitive Paphiopedilum, that make only few roots per year, losing a root tip this way, and the usual root rot that follows can be a disaster. In the Netherlands one grower lost benches and benches of Paphiopedilum just because of the low quantity of peat added, that settled at the bottom of the pot, in a really minute amount, but was at a pH of 3.7.

- Peat can be really acidic, and values down to 3.1 are not unheard of. It is usually blended with dolomitic limestone by some sellers, though some people sell it straight, and it is up to the grower to correct the pH. It is always best, if someone wants to buy straight peat, to buy some of the famous brand 'buffered' peats, even with the micronutrients and fertilizer blends included, though we no longer can recommend the use of peat like it would have been possible over two decades ago. Nevertheless, it has never been a long term potting mix or even potting ingredient.

Coconut and coco products.

- Xavier has been one of the first users of shredded coconut in Europe for Orchids and especially Paphiopedilum in 1992. At that time, it was usually limited to some Asian and African countries, which had ready access to coconut. In those days, the results were absolutely amazing, blended with bark. However, the product of that time, that helped to establish the fame of the coconut products for orchids, and many other crops, will never be available again. Here is the story.

- The Sri Lanka Orchid Society published a pamphlet in 1952 regarding the use of coconut for planting orchids. It is the earliest mention in a 'westerner'publication of the use of coconut for planting orchids, though it was done in those days already by some growers in Asia. It is funny to note too that Sri Lanka would become, nearly half a century later, the 'base' for coconut products production around the world.

- In the 80's, some people oversaw huge stockpiles of rotting and rotted coconut shells, sometimes decades old stocks. They had the idea to process it to make potting mix. The fines went to make a kind of peat, and the intact parts were crushed, to make a kind of thing that was akin to the long fiber peat moss, brownish black, fluffy, retaining a lot of water, like a sponge. It would look like torn apart, pieces of a brand new brown coconut shell, but of a black color, and completely water absorbent. The coconut had been weathered for ages, and it had no longer any salts, except the powder, that was harvested at the bottom of the stockpile, and could contain both sea salt and sand as a bonus, not to mention fusarium spores and a wide range of weird things along with insects. However, those shredder pieces of black weathered coconut, mixed with big size European bark, that was still of

acceptable quality in the early 90's, were doing a really good potting mix, the pH was not too low, nor too high, and it would be airy and retain enough water. It was usually blended with some extra lime to counteract the acidity of the EU bark, and some pre-blended fertilizer. That was a really great, working potting mix.

- The quality of the coconut supply was however grossly inconsistent, and the decades old piles disappeared quickly, being sold for horticulture pretty quickly. Many factories had the idea to process new coconut, and make 'fresh' coir and 'fresh' cocochips.

- Unfortunately, that proved to be a very bad idea in the early days. They would process green coconut (whose shell was not yet ripe, hence susceptible to decomposition) and some a bit more mature, chop them with a blade equipment for the green ones (being not yet ripe, it is easier to get perfect cubes), wash them in the sea to remove the coir eventually, and sell those products worldwide. The unsuspecting growers, of orchids and other crops around the world, checked the EC (conductivity, to know if there were any dissolved salts), the pH, and happily, they would start to use it. The coir looked like extremely good peat, the chips, like extremely good, perfectly shaped pieces of bark, why not.

- People potted initially a wide range of crops in coconut based products, and were amazed at the root system produced, which is absolutely correct however later, they would be more amazed by the fact that whilst the root system is extensive there were no more leaves, and that the plant growth was completely stunted. In-between, some yellow chlorosis appeared after some weeks of cultivation.

- The early analysis report showed that the plants were intoxicated by sodium and potassium. A legend about sea water soaked coconut, not properly checked on arrival, started. Then THE disaster arrived. People realized that they were testing the fresh coconut coir (prior to this it was called coconut peat, but some peat manufacturers groups complained, so it became pith, which generated still some complaints, so it became at the grand finale, 'coir' or as the dutch say 'cocos'), or coconut chips, that the EC was fine, but after some weeks, the EC was disastrous, and the plants were poisoned. They ordered analysis, that showed no sodium or potassium in the original product, all fine and nice, or levels that were so low, that the growers flushed until the EC 'proved to them' that there were no more salts. Great. But the problem was still there.

- It took a while, and I did find in 1994, to make a destructive analysis (reduction of the samples to ashes, then dissolution using strong acid cocktails, then analysis), that showed tremendously high amounts of sodium and potassium, that were not detected over a normal 'water extract analysis'. The soaking with calcium nitrate was born, to remove the sodium, and Xavier did introduce it in the orchid field at that time.

- However, it did not solve the problem fully. The age old piles of coconut products did not have any problems related to strange chemical behavior, or strange release, but it appeared that:
    - Coconut products contain as well a variety of lectins, auxin and cytokinin related and look alike compounds, some water soluble, most of them liposoluble, or soluble under specific conditions.
    - The coconut products can react with the feeding solution, and make strange cation exchanges, anion captures that are not yet, even as of today, well understood.

- It started to be the decline of the coconut products, especially in the Netherlands, where many growers, originally enthusiastic, experienced severe problems, which killed sometimes their entire crops. It appears that coir as well as cocochips cannot be managed for a culture like orchid culture, whilst they can be managed well in a hydroponics system, strong growing plants, short cycles, and more important massive amount of water applied to the coconut or coir slabs in the hydroponics system. This alleviates any micronutrient deficiencies, even if the coconut product would catch any, as there would be always fresh fertilizer around the roots.

- Coconut products have an out of range pH for many crops, in the 6.2, which is strongly buffered at that level, which brings a lot of issues with the fertilizers.

- It appears today that, some growers have been too optimistic with their use of the coconut products, because they looked 'optically' perfect. They were not exactly the panacea, and many growers have abandoned them. It is weird to note too that most major nurseries in the Netherlands would never, ever, want to hear about coconut product forever.

- Coconut products were supposed to be very stable, due to their lignin content, however it was not true, and coconut products can decompose very quickly, depending again on the source, the environment, the age, and the growing conditions.

- Coconut is an exceedingly good support to grow mushrooms, as, once washed, it supports readily mycelium. It is not exactly what we would expect from a proper orchid potting mix.

- There are only FOUR ways to use coconut products in horticulture as of today:

    - Use in a hydroponic system, with heavy flushing using divalent cations (calcium nitrate, supplying the divalent cation Ca++) during the first days or weeks of culture)
    - Use in pots blended with calcium supplementing compounds, such as lime (but remember that coconut coir tends to be already too alkaline), or gypsum. Eventually with some other additives to lower the pH, but this could not be used for salts sensitive or fragile plants, as nevertheless, the sodium that will be purged from the coconut products will be in contact with the roots, hence taken up by the roots.
    - A very complicated and fast process, under high pressure, with hydraulic presses and water to process and neuter the coconut product quickly.
    - Or another process, involving soaking coconut products in water containing a high rate of calcium nitrate for some days, changing the water periodically, and analyzing the batch for its sodium and potassium extra content.

- There are intermediate ways to use coconut products, as previously said, the sodium and potassium will be slowly released over some months, if no calcium and magnesium (divalent cations) are supplemented, so some growers have success using fertilizer without calcium and magnesium, and flushing, though they will have calcium and magnesium deficiencies at a point. By avoiding calcium and magnesium in the fertilizer, they avoid the basic coconut problem: sodium release. However, there are more problems, including chronic deficiencies, and this phytotoxicity, unexplained as of today, syndrome. It appears though that the heavy flushing in hydroponics drip systems gets rid of the problematic chemicals, whereas in a pot, as we do not flush several times per day, the level will build up, up to an even more toxic level.

- Some growers will have good success at first, using various means, including organic fertilizers blended with the mineral ones, etc. However sooner or later, there are problems that appear. Most growers experienced at a point or another some strong difficulties when using coconut products, which makes them not recommended to most growers.

- In the tropical countries, where some growers use chunks of coconut, or big pieces, they are usually first from really ripe coconut, and second the weathering in such countries helps to get rid of any potential harmful component readily. Though, most plants potted for some years in coconut in tropical countries end up dead from fusarium.

- Coconut products have a quite high pH to start with, then after some years, after heavy decomposition, the pH will be exceedingly low, which is another problem. The problem is much faster with green coconut and some fungus and bacteria that attack it. In some instances, coconut chips were converted to sludge within a few month, and it was not related to the temperature .

- Another, more risky way, to use coconut for some genera, orchids and others, is to use the fertilizer at a level way over the normal rate, which will reduce the problems related to sodium and potassium ions. However, first it cannot be applied to all the plants, and second it needs both extremely heavy flushes, and careful EC monitoring between the watering to avoid 'pickling' orchids.

- The dreams of some growers were so high to replace their local product by the magic, cheap coconut products, that even in Brazil, to replace the Xaxim tree fern, they coined the term 'coxim' to call the coconut products. Unfortunately after a while, they realized that it had a lot of problems that remain to be solved, even as of today, in terms of plant nutrition.

- Some claims that coconut contains content of lignin and cellulose are higher than bark, hence the 'remarkable stability', however, coconut coir contains about 50% of lignin and 35% of cellulose, where pine bark contains 45% of lignin and 30% of cellulose, which is a really insignificant difference technically.

Tree fern products, osmunda

- In general tree fern and fern root products are remarkably resistant to decomposition, over some years. However, to achieve such products, the ferns harvested have to be really old. In some countries it has been strictly regulated, or even banned. Osmunda harvesting in Europe is impossible, and in Brazil, whilst it is still possible to get 'xaxim' the local tree fern, it is very hard, and to be done legally it is very complicated, as well as in small quantities. In Asia, it is however easily available.

- Osmunda fern was a very popular potting mix, extremely stable and resilient to decomposition. Dig up the fern, remove all the fiber, clean it, a little bit like the Asians clean the birdnest to make the soup, string by string. After that procedure, wash and soak it for a while, and use it to repot. It had to be

placed in the proper position, to allow for proper drainage and water absorption, and usually packed very firmly. There are still 'potting sticks' from that era, which showed how hard it was to push the fibers around the roots. It was either used alone, or blended with sphagnum, in clay pots. The results were really good, but with some drawbacks, explained further.

- Asplenium, various fern roots. Those are the complete root systems of many different species of ferns, including Platycerium and polypodium. The fern is dug up, the roots removed, remaining discarded, and the roots are washed. It looks like a kind of stringy cotton. In fact, in Vietnam and China the vernacular name is 'fern cotton'. It can be used as chunks, loosely packed or to fill up a complete pot. Many plants grow really well in that fern root, including Paphiopedilum gratrixianum, insigne, and villosum and also the Indonesian mottled leafed Paphiopedilum too, at least at first. The plants need to be repotted quite regularly, breaking a lot of roots, so it has to be done at the proper time, and second in some cases, an infection can set up. The pH is an amazing 4.5, but in the countries where it is used, they use very alkaline river water, or even alkaline city water, which makes a coherent blend, so the roots are not kept too acidic. It is very interesting to note that :

    - Whilst plants are beautiful, they need to be kept really wet and watered very frequently. If they dry out a little bit, many growths will die, no matter what is attempted.
    - If trying to repot in another potting mix, many growths will die, usually becoming yellow, then suddenly brown. Pseudomonas sets up in the rhizome and many parts of the roots and growths base, and kills the plant. Moving a plant out of this kind of cotton fern roots is exceedingly difficult, and requires the use of antibiotics.
    - Blending those fern roots with bark and the resulting mix will surely and shortly kill the plants, no matter the care given. There are a lot of things not understood about this media, that is very successful as a stand-alone, but due to its rarity, very few analysis have ever been done, or will ever be done. It is locally feasible to use it, but not on a commercial or export scale, for sure.

- Osmunda has some of its own problems, including the growth collapse, though osmunda, when available, can be successfully mixed with bark, unlike the fern roots mentioned above. However, it is very hard to use another mix after osmunda has been used. The general theory is that those fern types potting mixes changes something in the micronutrient composition, and when repotted, some become suddenly toxic for one reason or another. It can be very spectacular, when seeing some huge Paphiopedilum henryanum potted in those fern roots being potted in any other mix, and getting yellow leaves overnight, followed by a yellow plant one or two days later, completely brown and collapsed.

- We cannot be exhaustive for all the potting mixes existing, but fern LEAF is another funny one. There is a terrestrial fern in Indonesia whose fronds looks like the leaves of a very big Zamia. These fronds are harvested, and Paphiopedilum are potted in chopped fronds, still green, with the stems and the leaflets. It was exceedingly successful, and the grower had the best Paphiopedilum superbiens and tonsum I have ever seen, visibly potted for some years.

- Tree fern. It is the 'bark' if one wants to use this term of some tree fern species, dicksonia, even cibotium and more genera. Again, there are many species, and many types, not clearly identified. In Vietnam and China we get a type that is more like osmunda, quite fine, branchy thin straw. In Mexico and South America, they are using both a big straw and a big hollow straw type. It is very unclear how

many species are used, though it appears that in South America they report frequently problems with 'rhizoctonia' or 'sudden plant death', that they attribute to the acidity, or sometimes to some mysterious 'pathogens' present. It appears however clear that some tree fern can have tremendously high amounts of iron, zinc, manganese, and other compounds, that could well build up and stunt the plant. On the other side, no such problem in China or Vietnam, even in Malaysia or Indonesia, where various tree ferns are used, sometimes to grow absolutely amazing specimens. It is very stable, and long lasting.

- To mount a few plants, it is quite easy to find the proper part, however, it is nearly impossible to standardize. On the same trunk of the same species, some places will have loose fiber, some tight fiber, some dusty fiber, so one trunk can give only sometimes a few plates or slices with an optimal composition, the remaining needs to be processed. In Vietnam, some people pay workers the whole day, to disentangle the fibers one by one. Afterwards, they have to be de-dusted, and dipped in water to finish cleaning it. The resulting water is very heavy in tannins, but surprisingly it does not seem to be a major problem. Some purists add calcium hydroxide to the bath, and stir, to raise the pH, as tree fern fiber, at least from South East Asia, is very resistant to pH changes, and changing the pH will not change the fiber structure or behavior.

- It is very long lasting, and it can be a good ingredient, to make the mix more airy, and sometimes to provide a path to follow for the roots. Paphiopedilum praestans as an example has thin roots on sometimes massive plants, but the roots love to follow the thin straws of tree fern in the media, for quite odd reasons.

- One grower in Malaysia is using chunks of tree fern for his Paphiopedilum, and some very big pieces of stones. He never repots, but has optimal water and weather. He has, worldwide, probably the best culture of Paphiopedilum gigantifolium and rothschildianum ever seen. So tree fern can be successful.

- In fact tree fern could well be one of the best orchid media, except one 'slight detail':

    - It is absolutely not a renewable resource, and to get the proper fiber quality, one has to chop off decade old tree fern. It cannot be grown successfully, as some plantations have been planted and they produced too fresh subjects, too much fed, whose fiber was unsuitable. The few species that can have their trunk chopped off and regenerate side growth are unfortunately not the ones at all that can be used for orchid culture. Therefore, the supply is very limited, to what can be gathered from the jungle. And in terms of plant conservation, it is much more damageable to chop off 20-30 years old tree ferns, that take at least this time to reach a proper size, if not much more, than to remove some Paphiopedilum from their habitat. The Paphiopedilum can regenerate, and new plants can grow from seed in a relatively short time, some of the majestic tree ferns are just gone after being chopped off.

    - There were some massive species, once a collector in Lai Chau in Vietnam had a photo of a batch of tree ferns in a well-known valley. Going back to the valley and looking at the surrounding cliffs, it is easy to see that those tree ferns were well over 20 meters tall, most likely 30 meter tall, which would make Cyathea brownii a pygmy. He had a massive table made out of a slice of it, and it was a tree fern. He and his family chopped off the whole forest of those giant tree fern, to sell the head/new growth to China for medicine, and converted the trunks to various things, being so happy that they 'never rotted in twenty

years. It is clear that it was an unknown species to science, and all attempts to find more failed, as it was easy to collect such huge ferns. Hopefully they exist nearby, but it is doubtful, as the whole area around that valley had been converted to rice fields for ages, only the valley was untouched. His family is still in the tree fern business, and they commonly remove 4-7 meter tall tree fern, at the rhythm of a logging truck every 2-3 days.

- Some species are highly unsuitable for orchid culture for the medium or long term, whilst there are no problems in Asia with most of the stocks, there seems to be a lot of complaints from time to time arising from growers in Hawaii or Mexico, down to Brazi that some batches killed many plants.

- Whilst highly appealing for orchid culture, and required for a few specific species, it appears that tree fern does not have any commercial future, though it is worth noting that it is a very long lasting, and stable, at least for some species, media.

Various bark

We will not mention at length the various bark, wood, pieces of cork, or slabs of teak are used to 'mount' orchids. The composition, behavior and chemical properties can vary tremendously from one type to another. Sometimes, wood has been used in a potting mix, meranti sawdust was popular, and Norris Powell would use crushed pine cones in his Paphiopedilum potting mix. One educated guess was that the resins and some complex liposoluble compounds would degrade, and release ingredients that can promote plant growth. In a similar way, one successful grower in Belgium used sawdust from his wood manufacture to pot his odontoglossum, in clay pots. He would plant as well one plant of parsley per pot, and when the plant's leaves would start to bend, it was time to water the orchid. He was exceedingly successful, and grew some of the best odontoglossum plants. Similarly, Charlesworth used sawdust in his later years, and in both cases it was really fresh sawdust, mixed from many species. In both cases the tap water was very alkaline and the marriage of water quality/sawdust seemed to be very successful.

Types of bark

Bark is the outer part of the tree. Several types of bark have been used, so we will start by some very exotic ones.

Cryptomeria japonica bark

- The famous 'Cryptomoss' from the Japanese. The texture and behavior is similar to tree fern at first, and some excellent growers use it as a potting material. It is very acidic, and usually many growers who used it had to apply some marble powder, or dolomitic limestone, to keep the pH at a proper range. It has some oils, and some compounds, that have been sometimes extracted and sold as a growth promoter. In fact, the 'HB-101' additive, promoted by the Japanese as a cure and grow all product, is an extract from cryptomeria bark, containing derivate of 'resin acids' (abietic acid, dehydroabietic acid…). Cryptomeria use is very marginal, and very rare outside of Japan, though it seems to have some qualities at first. However most

Japanese growers report that the plants must be really repotted in a timely manner or the whole root system can die.

Sequoia bark, or 'gorilla hairs'

- Sequoia has got its time of glory in California about 20 years ago, some growers still use it. It is extremely acidic, and hence can block some pathogens. It releases as well a lot of tannins, terpenes, etc. However, it is reported to be very successful to grow odontoglossum and cymbidiums, and some growers use it exclusively. It is very similar apparently chemically in some of its properties to the 'fern cotton' or the roots of ferns used in Asia. In fact, like the 'fern cotton', it cannot be mixed with pine bark, or a disaster results, and it is very difficult to use another media once the plant has been grown in sequoia 'bark'. It looks more like a very fibrous material than bark actually.

Cork

- Many species exist, and we will understand with the discussion about pine bark the real problems behind, but enough to say that the country, and the forest where the cork is harvested make a huge difference in its behavior. Some cork will stay stable for a couple of years; some will turn into mush within some months in a pot, though for mounting orchids, it is a quite fine bark. Re-aggregated cork is being sold in Europe as slabs to mount orchids, they are very popular, though oddly people do not notice that they are not very colonized by the orchid roots, which tends to stop growing after some centimeters on it, or even die on contact.

Pine bark

Fir Bark

Orchiata

Pine bark

- Pine bark has been used since the 50's. At first, it was a waste product from the timber industry, and an attempt to replace the famous Osmunda fiber. Rod McLellan in America was the discoverer and promoter of the use of pine bark for orchids. In fact, what we call pine bark can be either pine bark, or fir bark, which makes a real difference. The earliest use involved, as per Thomas Sheehan who reported about it, a mix of Abies concolor (fir bark) and pinus ponderosa (pine bark), in a 80/20 ratio.

  - **There are many species of pine and fir**, each with their own characteristics. Some growers showed in the early day's a preference for one type over all the others, such as Pinus

maritimus, or Pseudotsuga (Douglas Fir bark), depending on the country, and on the availability. In fact, some need to be fully composted or dried for a while, and some real disasters resulted from the use of fresh Pinus maritimus in France and Italy, or even fresh Douglas fir bark. Depending on the process, the initial acidity, the original species, the forest location, the characteristics can vary tremendously.

- **In the USA**, the best bark ever produced before was made by Weyerhaeuser about 20 years ago. It was Douglas fir bark, hand screened after a complex heat treatment that would remove the resins and most of the contaminants. It was not economically viable, so they stopped doing it, but this was one of the best barks of those days.
- **In Europe,** one Italian company would choose all the chunky bark, by hand, and again process it by a steam system to extract the resins and then use lime to make a really fine product. They stopped, again because both the USA and the Europe process, owing to the sourcing of their materials, the species available, and the methodology, were not sustainable, financially.

- **Europe started to get bark from Europe**. These were the glorious days of the 'French bark' though the mills selling that 'French bark' to either orchid growers or the potting mix manufacturers in the Netherlands who mixed several species. At a point, some truckload of good looking bark ended up being very phytotoxic, and wiped out some nurseries, in the 80's. A decade later, the same company supplied bark that had been stored and herbicide treated during its storage, to avoid weeds. Another disaster, once on one truck, but enough to scare many growers. Then, one of their competitors got bark from a forest heavily sprayed with herbicides, and this time the bark was contaminated by the 2,4-D herbicide used. Another disaster. Then cometh the tempest. Several tempests in the production area crippled or broke many trees. As a result, the next decade since that time was made of poor quality bark, rotten bark with a lot of wood or unwanted products (bark is needed without any wood, cambium or liber included, as those tends to break down much faster, and have a vastly different chemical reaction). Then cometh the bark from Portugal, then Serbia when the things were more peaceful, Romania, the Baltic areas, a bit from everywhere. All were different species.

- **A short note is required**. Depending on the conditions the trees are growing, the bark can be vastly different. A tree growing in a natural environment can produce, if it has the proper temperatures, chunky, good bark. If it is too cold, the cold can damage the bark structure. If it is too warm, the bark tends to be made of many leaflets, and it will 'delaminate' easily. So, depending on the production area, the same species can give vastly different results in terms of bark quality. If the forests get some fertilizing, like they did in the south of France, the growth is very fast, but then the wood and the bark are of much lower quality, and more suitable for making paper paste as a result.

- **Bark has been extracted from many areas**. Vietnam has bark, from Pinus maritimus planted by the Frenches. It is a very spongious bark, which can be explained, as the tough Pinus maritimus endure 80 percent humidity and up to nearly 40 degrees Celsius for some months of the year. The quality is not good. Indonesia is producing a very hard pine bark, yet it is extremely acidic, and has a huge content of resin. Here, it is a tropical pine tree species, which grows very hot, but has a very tough bark. However it is not a renewable resource, and huge trees are logged, which is not sustainable, and the acidity is very hard to correct. Add to that that this bark stays hydrophobic for a long time and recently some insects appeared in many of the shipments.

- **With organic products we are vulnerable to the pests and diseases of the area**. With some diseases or insects, the bark can be contaminated and contaminate other grower's area, or even the orchids themselves. It has arisen a couple of times in the past, and will happen again.

- So far, in Europe, many problems arose with the local bark supplies, that led first to those failed trials with the cocochips, then the growers were forced to go back to pine bark, but unhappily as the quality was not really standardized. In most cases, including the USA, the bark is just a byproduct of the timber industry, true, but nothing is monitored, the resulting bark is just sold in bulk, involving many species, stages, qualities, without careful screening. Further processors will eventually screen it, and do 'something' out of it, but does not really have a professional look.

- Apart from the US and the Italian companies, now defunct in those businesses, Pacific Wide started to sell bark a long time ago. First, it was weathered bark, as requested by the Japanese market. The bark piles that had stayed for years below the rains were screened, cleaned, processed and sorted out to make what the Japanese considered to be an excellent orchid potting mix. After a while came the decision to go further. In New Zealand there is a massive timber industry, with one species predominantly, Pinus radiata (the 'Monterey pine'). Oddly enough, in California the Monterey pine is a protected species, but its bark is not of good quality for orchid culture, hence it has never been locally used. In New Zealand, not too cold, not too hot, not too dry, the Monterey pine has a growth speed unheard of, and a bark, as well as a wood quality that is not reached in most other areas.

- Monterey pine bark is planted in many parts of the world, including Europe, Chile and Australia however the plantations from some areas of New Zealand showed the best bark quality, because of the environment. The chips would stay stable for years, chunky, with no change in their structure or chemical behavior. In the early days, it was supplied 'fresh', but it became clear that another process was needed.

- Most Pine bark in the world is processed using one of the following technologies:

    - Composting with nitrogen, and screening afterwards. This greatly damages the bark structure and makes it very weak.
    - Simple drying in the sun followed by a heavy liming to correct the pH, this is the Dutch method. Some more lime will be added, and some other ingredients are added to the bark, which is at first water repellent, and would not retain enough water to sustain growth in the earlier steps of the plantation.
    - Mixing with a lot of water absorbent materials, and lime again and using a heavy watering schedule at first, to wash the residual acidity.
    - Some others process exist or existed, such as steaming, boiling, leaving the bark for some days in a water pool but they would not usually remove enough of the resins and organic acids to make the bark 'ready to use'.
    - Some growers had success with fresh bark, owing to some specific genera and specific conditions in their growing area.

- The idea was to develop a process that would make a bark that retains water from the beginning, without composting it (the composting would remove the resins, and organic acids, but it would degrade the chemicals that make the bark structure, mostly lignin and cellulose, hemicellulose). Some components in the bark will promote growth, such as dihydroabietic acid and other diterpenes. The monoterpens however do not promote growth, and some are suspected to be growth inhibitors as well, the same for some of the other compounds. By designing a process where composting is not involved, which would shorten the lifespan of the bark and destroy a lot of valuable compounds, it was possible to make a bark that is remarkably stable over some years, is on one side chemically neutral, but on the other side buffered to a pH suitable for plant culture. That's where Orchiata started to be produced. It is not bark anymore, as the raw Pinus radiata is not reliable enough to be used on a lot of species, owing to its water repelling properties at first, and its contents of some compounds that only some acid loving plants can withstand, until they are overcome by the feeding over some weeks. The design was to make a water absorbent, pH buffered product that would be very long lasting, by not destroying the cellulose/lignin/hemicellulose structure, and removing just what was not required. It is now called Orchiata.

- When Xavier started to use it as a grower, I had extensive experience with the European barks, and even some US sources of Douglas fir bark. In those days, to keep the plants growing, it was required to add some water retaining materials, lime, PG Mix (a slow release type fertilizer for potting mix manufacturers predominantly) and repot after some months. It was not possible to keep the plant at its peak growth. A lot of potting mixes analysis and foliar analysis showed some problem of toxicities, which were mentioned even by some of the largest orchid growers in Europe as something that could not be avoided. Trying to see how long Orchiata can be used, some plants were left not repotted for some months, unlike the typical schedule of every 6 months repotting. Some years later, some just had to be repotted, but the Orchiata chips did not change, and the toxic effects that were experienced with the European bark did not show up. The Orchiata really looked the same after some years, and there was nearly no noticeable decomposition. With the European bark, it would have been nearly impossible to keep the plants growing so long without repotting.

Other materials to make the potting mix

- Charcoal is often used. Its use is not really clear and depending on the wood used to produce the charcoal and the heating temperature, its composition will vary greatly. Charcoal tends to be acidic to start with, and after a while it will accumulate salts at its surface. It is used successfully as big chunks of 4-6cm and more in Asia for the culture of some Vandaceous types and dendrobium. Some growers grow their Paphiopedilum in charcoal and huge pieces of coconut husk, using water from limestone cliffs and are successful, but it is not practical, and not so common to see such setups.

- Isolite, haydite, crushed brick are a few examples of other marginally used potting mix ingredients.

- There are a lot of strange things, or logical things, that are sometimes used, dried palm leaf, dried beech leaf or oak leaf, hemp straw to name a few. All of those have been used at one point or another.

Additives

In the following groups are the 'additives'. In fact they are things that can never be used as a stand-alone, single component, and usually never make up a large part of a potting mix. Whilst sphagnum moss fines (powder) is one such component, there are many more.

Sand

- Sand has been used, for two very different purposes. First, the river or career sand, eventually even the sea sand (if properly desalted), can be used as a small part of a bark based mix. It increases sharply the water retention capacity. With normal bark chips or even some types of stones, water is kept as a 'film', yet, with added sand, it increases dramatically the area on the surface of the chip to keep the said film, hence increasing the water retention. Sand as a second effect can clog the pores of some materials, and it will make such material retain more water. Some growers are very successful with a sand addition to their potting mix, and some Paphiopedilum roots seem to like it, especially with a drier ingredients style based mix (bark, stones, etc).

- Some specific sands are used, such as the famous and famed 'Green sand', or some aragonite sands, highly degraded karst sand. They have the purpose of either supplementing the media with a lot of micronutrients or with calcium and/or magnesium carbonate or all at the same time. According to their composition, the effects will vary. Some prove to be very good, such as the karst limestone degraded sand, but they are not always available everywhere. Aragonite and calcite 'sands' are finely grounded aragonite and calcite rock, used to supplement calcium and raise the pH. In this they are quite similar to the dolomitic and calcitic limestone amendments, but they are released a bit slower.

Lime

- This is a very vast subject. First, Xavier discovered that some 'lime for Paphiopedilum' sold in Europe had a very large amount of manganese, which explained the grower's success with them. However, 'liming amendment' or 'base dressing' is usually done with a type of calcium and/or magnesium carbonate, which can contain from 0-100% of calcium and 100-0% of magnesium as carbonates, and some other impurities. Some lime sold are in fact hydroxide, and some industrially available 'agriculture grade lime' has been heated, which means that a part of it has become calcium hydroxide, that will burn the plants roots if applied directly to them.

- Lime primary function is to correct and amend the pH. Another very important function is to supplement the media with calcium and eventually magnesium. Calcium is a tricky element to supply to the plants, and some species do not like so much to get calcium in the feeding solution, preferring instead a slow release form. There are some other chemical interactions that can make calcium carbonate preferred over calcium nitrate in a general program. In fact, in the Netherlands, several

studies showed that commercial Phalaenopsis performed about 30% better with some feeding scheme if they were supplemented with calcium carbonate as a potting mix base dressing rather than with calcium nitrate in the feed solution. Truly, there are quite a lot of growers, including Xavier, that found out that calcium nitrate supplemented to some plants can make them look very chlorotic.

- For liming purposes, a natural source is preferred. It will have impurities, hopefully including boron. Very pure chemical grade calcium carbonate can stunt the plants within weeks, and 'burn' them, where the problem is a too higher availability of calcium carbonate and a sudden deficiency of micronutrients, especially boron. As seen before, boron and calcium are a couple that cannot be dissociated. The plant can suffer heavily if supplemented with calcium and without the proper level of boron. It is one of the main causes in Paphiopedilum apparently of growth stunting and 'multiple tiny leads' appearing at the base of the plant. So, better to use lime sourced from natural sources, and preferable finely powdered dolomitic limestone for Paphiopedilum, at least to prepare the potting mix.

- Aragonite and Calcitic sands are a good source of slow release calcium carbonate and can be applied as a top dressing. They are not so recommended inside the potting mix, because their particle type will not 'stick' to the potting mix ingredients, making the distribution uneven. As top dressing, they are very good. Some people use the more exotic oyster shell or even mussel shells in some instances. Crushed oyster shell is quite pure calcium carbonate, but here again, one must pay attention to the sodium content, and it looks a little bit weird visually. One grower in Malaysia was using Orchiata bark in clay pots and complete clam shells on top of the pots, along with fish emulsion. He had for sure the biggest dendrobium antelope types ever seen, but the accumulation of clams on top of the pot was really weird.

- Karst limestone sand is an excellent material, combining the advantages of limestone and being of very fine grain texture. Some sources, especially from Vietnam and from Kanchanaburi (where it is sold as Kanchanaburi sand) include as well some types of clay. Some sources can kill the plants as well, so it is hard to recommend it, but if you try on a fresh root tip and the root tip is still alive after a week or two, it is a really an excellent additive. Some came as well from the former East Germany and from Belarus at a point in Europe, though the real origin was really obscure, and it would be very difficult to find the exact places back. Arthur Elle was using the one from East Germany in his potting mixes.

- Synthetic or too finely grounded calcium carbonate will always try to keep the pH at 8.5, as long as there is un-dissolved calcium carbonate available in excess. That is why the more natural lime is better. Over liming and raising the pH to 8.5 is deadly for most orchids, as it will shut down the absorption completely.

Gypsum

- Gypsum (calcium sulfate) got its fame more recently, especially in attempts to supplement coconut based products with calcium, without raising an already too high pH. Gypsum is interesting also to

improve the water retention of a potting mix, maybe to supply some calcium as well, but again, some of those things are not really proven. Xavier tends to follow the Dutch and European styles of growing, and some weird improvements, if they do not pass a clear test, are not worth a second look. Gypsum is one of them, and usually was useful in the case of low calcium nitrate supplementation for calcium hungry crops or of poor fertilizer (pH raising types) used on potting mixes that had too much lime, hence were already at a too high pH to start with. Replacing the lime by the gypsum solved the 'problem' and the grower got 'good growth' however, it was easier to keep the lime, and adjust the fertilizer or to do the opposite, remove the lime and change the fertilizer as the crop was an acid loving one.

Other additives

Kelp Powder

Bone meal

- There are other additives, such as seaweed/kelp powder, bone meal, blood, horn for example. They can be tried, some are interesting, though they are not 'necessary', as a liquid form exists that can replace most of them. Some others are really strange things, and used sometimes by very famous nurseries. If HB-101 has its working power contained in diterpenes molecules extracted from cryptomeria, instead making its use 'scientifically sound'. Some other things, such a 'numinous principle' extracted in Scotland's wetlands from water dropping out of plants after a 'clean rain', like was used by one major nursery in the Netherlands, or other things similar, do not seem really justified, to say the least.

Important Parameters

With all we listed previously, we can start to work out a potting mix. Now, remains to design what are the most important parameters :

Pots

- Clay pots will need a bit more water retentive mix.
- Plastic pots will need a less water retentive mix, and more draining one.
- Some growers in the USA use baskets lined with sphagnum moss. They give great results, however on a commercial scale, that would be somewhat hard to imagine, getting a wood basket, eventually plastic one, lining it from top to bottom with moss, hanging it and there are other options, so why bother?

The MAGIC pH.

- There is one pH that suits all the species, except a few exceptions that will be listed afterwards, with a specific how to pot part 5.7-5.9. There are in fact very few Paphiopedilum species growing at a higher pH, or the measures were gross mistakes. Paphiopedilum armeniacum grows in fern roots and some sorts of herb roots, at a quite acid pH of 5.3, however the whole clumps are growing on top of genuine limestone, with a pH that can be measured at 7.5-8. But the roots never venture in that alkaline limestone part, they are in the humic/acidic layer. As for Paphiopedilum rothschildianum, I saw them in the wild some years ago, and again they did not grow in pure rocks or alkaline matters, but in decayed leaf mould, fern roots, decomposing material, at a pH of about 5.9. True, there was a lot of serpentine, but for sightseeing only, the rothschildianum roots were always in the humus cover.

- Asking Tony Lamb, who has seen more wild orchids than most people in this world from Sabah, he said too that in his mind the plants need to be on the slightly acid side, because with all the effluents, the rain passing through the canopy, decomposing matters and the material that always supported the roots, he never believed that the Sabah Paphiopedilum needed alkaline conditions. He grew at Tenom some fantastic clumps of rothschildianum, using leaf mould, tree fern, a few stones (but not alkaline ones, more a kind of granite), and he did that again now in the Kipandi Butterfly Farm. One can see as well at the Kundasang dozens of Paphiopedilum rothschildianum, stonei, hookerae, volonteanum, on the ground, in a blend of leaf mould, debris, and tree fern, with some rocks to prevent compaction. So much for the 'alkaline loving' Paphiopedilum.

- In Burma I saw Paphiopedilum bellatulum, growing in humus, extremely wet. It was hard to see any of that 'limestone' and bellatulum is an acid loving Paphiopedilum, but with calcium carbonate available at its roots. It seems complicated, but as seen previously, that's the way to grow it.

- In the Netherlands, the target pH for most commercial potting mixes is 5.7, though some might say that the Netherlands produce disposable plants. I think that the entire Floricultura motherplant collections, grown in potting mixes buffered at that pH, is more precious than the entire stock of most orchid nurseries around the world, yet they use the pot plant potting mixes.

- So our objective, to grow Paphiopedilum will be the pH of 5.7-6.

- Carbonate/lime availability.

- There are effects of calcium carbonate that are very hard to understand as of today. Trials to replace calcium carbonate by elemental calcium, at the same pH did not prove to be successful, so it can be assumed that calcium carbonate as un-dissociated molecules has some properties that the roots need, at least for some group of species. It is hard to know whether it is due to the carbonate part, or to the calcium carbonate availability and capacity to blend with some organic acids to neutralize them.

- Another effect, that seems to be clearer, some pathogens need to generate acid conditions to be able to invade the plants. In this case, especially at the root system or the rhizome, calcium carbonate can, by its capacity to buffer the pH, prevent the pathogen from entering. In Thailand, there is a mixture of calcium hydroxide and manganese that is sold as a powder, the growers dilute it, and apply the liquid to the wounds or to phytophthora infected growth. It stops most of the time the disease successfully, and Xavier uses it to paste on the wounds. Calcium hydroxide will be converted with the CO2 from the air to calcium carbonate, and straight calcium carbonate powder pasted on some starts of bacterial or phytophthora rot stops it. It the only way, as a massive topdressing and coupled with two fungides, to stop the phytophthora induced orange rot that plagues a lot of Paphiopedilum growers around the world for the last two decades.

- We use dolomitic limestone (eventually calcitic limestone) to make a buffer with the potting mix, so the pH is kept at the right level. Acid potting mix and alkaline liming, if properly done, the result will be a mix at the proper pH

How to choose the ingredients

To assess the value of an ingredient, it is in fact quite easy:

- Availability. It is useless to stick to a specific ingredient that is rarely available or really expensive to start with. There are cheaper alternatives for most of them. Water retention, air retention, speed of drying, and which space it leaves in the potting mix. Fines particles or flat particles tend to settle in layers, impairing the drainage as an example.

- Stability, its original pH and salts content, and what can be expected of it a year or two later.

- Reaction with the fertilizers. Some potting mixes can have an adverse reaction, such as the European sphagnum moss and fertilizer, which will make it decay really fast, or some types of stones, that are buffered at a low pH or high pH depending on their types, and whose pH can hardly be changed (limestone chips would be one example of high pH buffered material, some types of scoria and lava rock, of a low pH buffered material).

- Late reaction. This was specially emphasized with the use of coconut products, which would release hidden sodium and potassium, but can happen with a wide variety of potting mix. As a rule, many complex organic compounds will 'hide' nutrients, especially cation, that will not be seen in a water extract analysis. When the potting mix decomposes, or the ions are exchanged (as sodium and potassium are exchanged with calcium or magnesium in the coconut products), the plant roots can absorb something that was hidden. Sometimes it has no consequences, in fact many times.

Sometimes too it will be phytotoxic, like the sodium with the coconut. Another example, that happens from batch to batch, is hidden manganese in some fresh pine bark products. The manganese is released and available to the plants, up to a grossly toxic level. Haydite, which looks like a stone, can release too heavy metals to the plants, so can some types of zeolithe.

- Reaction with the plant. After using an ingredient for a while, observe the root tips and the roots. If the roots tip collapses when they reach the material, or never adhere to it, it means there is a chemical problem with that ingredient. It can be subtle, but with good observation of some plants, grown in a proper environment with a proper watering and feeding schedule, the grower can get the correct idea about a potting mix.

- Testing should be done over a year or two for a potting mix, at least. As an example, coconut product usually start some plants with good roots and nice green leaves, but after some months, deficiencies and toxicities can give the plant a bleached appearance, completely stunted plants.

- Regularly test the water running out of the pot for the EC and the pH. As said previously, there is no need to use really expensive EC meters, a pen type give a rough approximation as to what happens. As for the pH meter, a low range is usually enough, the more expensive, in a couple of hundreds USD can give a more accurate figure, but they are usually not really longer lasting than the cheap ones. A good pH meter is really expensive, and can really read the pH of very dilute solutions, such as the ones we are using for orchids, accurately. But it is not really required. Enough to know from the reading that we are at approximately 5.7, or approximately 5.1, plus or minus a little.

- The potting must be 'reproductible', which means that a few dozen or hundreds potted plants must behave in the very same way after potting, or after some months. One example of something hard to use as 'reproductible' would be the soft polyurethane foam as a standalone. Depending on the mood of the potter, it is more or less packed in the pot, with more or less water retention.

- In fact, as seen in the nutrition part, if the potting mix is relatively stable, there is no need for frequent repottings, other than if the plant has outgrown its post. We forget that nurseries like McBeans, Ratcliffe, and even some Californian ones were repotting their plants in the 70's and 80's only when the compost was badly broken, or when the plants were too big for their pots. Ratcliffe, especially had a section after their move to their newer nursery in the 90's with great growing Paphiopedilum plants, that were not repotted for 5-6 years. They would, on the other side, add some lime on top of the pot every 3-4 months, a practice that did not pass the Atlantic Ocean apparently as a rule. The lime they use is a natural one, and apparently contains some more micronutrients, which explains their success without repotting for years. Some other nurseries, all around Europe, Wichmann, one of the largest Paphiopedilum grower in Germany, but Karge as well would repot their plants whenever they would be grossly out of their pots, but all of them, on the other side, would add lime, and use a feeding schedule similar to the one described before.

Blending a potting mix.

The characteristics to make a mix, as outlined above are simple. The first step is to choose and make a list of the ingredients that are available, and long lasting.

In this case, there are some physics laws that apply too. Flat ingredients are best mixed with round ones, as it will open the mix, and prevent the flat ones to stay in layers. The European bark as an example is usually not chunky, but more flat, and it can settle in layers, preventing good aeration, and eventually collapsing the root system. Mixing it with a round material (polystyrene beads, clay pellets, pumice) or a rough shaped material (like the polyurethane foam or the lava rock), will avoid the formation of layers.

Another point is to try to use ingredients of the same size. As outlined previously, the 'drainage' is not required providing one is choosing the proper pot type, but the potting mix is best made, for its 'bigger' components, with ingredients of the same size, so the blend can be homogenous. Mixing 5cm pieces of charcoal with fine perlite as an extreme example is impossible as one will settle and during the blending, some parts will go there, some others in another part of the blending, which means that at the end the mix is not homogenous. In that case, the top would be charcoal, and the bottom would be perlite.

Then, one has to mix water retaining and draining ingredients. Mixing sphagnum, coconut chips and peat would be a disaster, they all retain water. Mixing sphagnum with bark would be fine, as sphagnum would retain more water than the bark, and because of the differences in shape, it would be aerated, at least at the beginning.

Mixing organic compounds and inorganic ones can be a bad idea sometimes. Where bark can be blended with flocculated rockwool successfully, mixing sphagnum and lava rock can be a problem. When the sphagnum starts to decompose, it will fill up the pores of the inert media and starting a rotting process, compacting. The media must not retain the decaying matters or fine particles; otherwise a clogging will occur, either in the pot or a kind of bog at the bottom of the pot. As said previously, organic matter decomposing is bad news, because the pH will drop and with the bacteria decomposing that 'matter' may well not recognize that the next food they intend to eat are the roots of an award quality Paphiopedilum.

Here are some blends that can be used successfully. The grower can pick his choice.

The PG Mix mentioned can be omitted; it is a slow release fertilizer, very popular in the potting mix manufacturer industry. The quantities are given for one cubic meter of finished potting mix.

- Fresh Pinus maritimus bark 1-2cm, 1.5kg of sphagnum moss, Dolomitic limestone 5kg, PG-Mix 0.5kg. The Dutch standard mix used especially for producing Maudiae and Pinnochio types has been used successfully for multifloral Paphiopedilum. However, the Pinus maritimus bark blended with the acid sphagnum makes it required to repot at the most yearly. Not to be used for sensitive species or the Chinese/Vietnamese species in general

- Fresh Pine bark 0.8-1.2 cm and 20% perlite, with a top dressing of lime every 3 months. This was the McBeans and Ratcliffe Paphiopedilum mix, simple, but working well. The absence of sphagnum makes it more long lasting, but it needs high quality pine bark, that Ratcliffe used to order from one specific UK factory, where it would be hand screened. Paphiopedilum were expensive in those days, so it was worth it. It is not suitable for Paphiopedilum like hookerae, mastersianum, and in general most Indonesian Mottled leaf Paphiopedilum.

- Dried Pine bark from Southern France, polystyrene and polyurethane, ratio of 2-1-1. Lime added as a heavy top dressing every few months. The size used for the ingredients were ca 1cm for smaller pots, and ca 2cm for the bigger pots. It was the old Vacherot and Lecoufle potting mix, very successful for complex and Maudiae Paphiopedilum, not suitable for brachypetalum and more sensitive species.

- Waterboarded pine bark from Southern France (bark left in a pool for some weekswith regular water changes) and coconut chips, in a ratio of 3-1, with 3kg of Dolomitic Limestone and PG-Mix at 1.5kg. This was the potting mix used by several nurseries in Germany and the Netherlands. Initially, it made very good plants, but frequent repotting is required, and the coconut chips used were the weathered ones, not the new ones. The growers switched to the Pine bark and sphagnum, but it was a very good mix.

- The Orchid Zone old mix, Fir bark, lava rock, and flocculated Greenmix rockwool. It did work well with the US fir bark, even when it was imported in Europe, but the trials made by Xavier in France with the local bark were bad, except by importing the said fir bark.

- Norris Powell type mix, bark, a kind of aggregate that looked like pumice, and crushed pine cones, at a ratio of about 20-4-1. This mix was really good, but made from locally ingredients, and using very pure water, in optimal conditions. The plants were in pristine condition.

- Cambriamengsel met Oxygrow. This was a mix used by Floricultura, before for the Cambria, hence its name. It used high quality peat, to which was added 10% of perlite, 5% of fine bark, 6kg of Oxygrow, 4 kg of dolomitic Limestone, and 2kg of PG Mix. This mix was excellent, but it is not made to water the plants, they must be moistened. As it falls down easily from the roots, repotting was easy, every 3-4 months, and it produced in Europe in the 90's some of the best Paphiopedilum around. Later attempts with Baltic peat were a failure, so it has been abandoned even for the Cambria, but it was a really interesting mix.

- Tree fern and pumices, various mixes of stones of various types. Those are very popular in Thailand, where they mix some pumice water absorbent stones with some water repellent clay pellets, some polystyrene, and a little bit of organic matters, either coconut or tree fern, sometimes Orchiata bark, which is very popular for this use in Thailand. Those mixes are very 'inorganic', which has two reasons. First they are easier to manage during the monsoon and the heavy floods, where a more water retentive mix would never dry for a month or two, killing the plants (except, if like some high class growers do in Thailand, one adds a huge quantity of dolomitic limestone whenever the rain comes, which allows Mr. Yen, who got fantastic Paphiopedilum concolor albums and some other selected things, to let the rain water flood his brachypetalum without any rot). The second reason, an inorganic mix avoids any rot problem that can be related to an improper feeding scheme. If the fertilizer is too acidic, in an inorganic potting mix, it will not help to decompose the organic part, but if the mix is organic, then it will start the total demise of the pot. That's one of the reasons in Thailand many growers stopped using straight coconut chunks to grow the brachypetalum, as after some months, the gorgeous, beautiful plants would start to rot, no matter what was attempted. Acidification of an organic material, and then decomposition, which kills everything.

- Some wonderful plants were grown with a drip system (constant watering) in a mix of equal parts of perlite and vermiculite in England.

- Many growers used and use just straight bark. It was the most popular potting mix of De Wilg, who just potted their plants in pure bark. In the USA, several large nurseries used only straight bark to repot their plant, a bit of lime on top or even hard tap water and completed. It can be prepared for a wide range of hybrids, and some species, but not for all by far. When the bark becomes acid, it can be compensated by the use of lime; however the resulting product of liming acid bark will release salts. At a point, it can be toxic to the plants, and there is little that can be one to save a plant that has been intoxicated. One way to remove the acids from the bark is to compost the bark, but then the bark breaks down much faster.

- A mixture of bark, sheet moss and sand has been successfully used by Lance Birk and quite a few hobbyists around the world. In some conditions it seems to last for years, depending on the bark quality. Lance Birk has been one of the few to point out that liming to raise the pH to an alkaline level was useless and except for some species, his concept was right.

- Terry Root from the Orchid Zone uses a mix of bark and lava rock, with some sand added for extra water retention, as well as helping to flush some of the waste organic matter.

- Xavier's former favorite mix was a mixture of 700L bark, 300L pumice and a very low level of coconut coir, about 1kg/cubic meter, lime 3kg and PG Mix 3 kg. It would provide good water retention and root growth, but still require frequent repotting due to the coir breaking down.

- Since moving to Vietnam, one successful complicated mix was Orchiata bark 9-12 mm 50 parts, 1cm pumice 10 parts, 1cm polystyrene beads 5 parts, shredded cut in 2cm pieces tree fern 2 parts, and karst limestone sand 0.5 parts. Later the karst would be replaced by coir at the same rate, which was blended with dolomitic limestone, to reach 3 kg/cubic meter of final potting mix. Nutricote 14-14-14 180 days was added on top of all the species, at the rate of 2g/12 cm pot, and it required regular repotting, every year. Though some plants potted in this mix are still in the same mix after 6 years. For the bigger to big pot size, some Orchiata 12-15 mm would be added, and some bigger polystyrene added, though the bigger side pots do not have a bottom, but more a mesh as is usual in tropical Asia.

- At the same time, trials showed that the growth was equally good in Orchiata 9-12 mm, sometimes with a bit of pumice (about 20%) added due to the fact that Hanoi can become extremely wet in summer, and extra drainage capacity must be provided. Switching to the bigger size of Orchiata avoided the use of pumice for the bigger pots and now all the plants, except some mentioned afterwards, are grown in straight Orchiata, the thin rooted species getting a blend of 6-9mm and 9-12 mm at a ratio of about 1:2, the bigger rooted ones getting straight 9-12mm. Some extra lime is added on top of the pot, English style, every few months, but it is possible to apply the lime diluted in water as a drench. Due to the acid fertilizers used and the heat and humidity, it keeps the Orchiata at the perfect level, and as explained before, the lime seems to be required for purposes other than the simple pH control. The plants are growing successfully, with a strong root system in that single component mix. Some other growers have begun to change to the use of straight Orchiata in tropical countries, China and Thailand, for their Paphiopedilum. The plants need to be repotted usually when they have outgrown their pot, which makes the management easy.

Standalone products

Apart from Orchiata, there are some 'popular' standalone products, rockwool, sphagnum moss and Tree fern. For the commercial grower or the caring hobbyist it is the best in a way, if the media is suitable by itself.

- Rockwool has been commented earlier. One of the problems too is that, once it has been pretreated for use, when potting, the pressure applied will change its behavior in the pot. Sometimes too the rockwool cubes can collapse under the finger's pressure, not a good sign that they are as 'stable' as claimed.

- Sphagnum moss. It is a strange media in some ways. When very loosely used, as few fibers in the pots, it dries up very quickly. When packed reasonably, it can retain a lot of water. When packed and stuffed in the pot until it is borderline concrete hard, or nearly so, as it is the current practice of many nurseries, it retains much less water. However, tight packing makes it less water retentive, but can build up decaying bacteria's, that the roots can take up. People that pack it very tightly usually do not water as a drench, rather they moisten it regularly. It needs to be repotted, with some marginal exceptions, quite frequently. In Taiwan, the rule is to repot every 3-4 months at the maximum, very tightly packed. They use very soft pots, which tend to collapse a bit on the side, which keeps the sides of the sphagnum potted plant well aerated too. They use heavy feeding schedules too, but only moistening the sphagnum moss. In that they are very successful. In Japan, some growers use only New Zealand sphagnum moss to grow their Paphiopedilum, though the plants do not look like so happy, except with very frequent repottings, and quite hard water, where they still need quite frequent repotting. The Maudiae types and some of the species behind are well suited to New Zealand sphagnum moss as a single potting material. On the other side, the Parvisepalum can perform well in Chinese sphagnum moss, not in New Zealand sphagnum moss, for the reasons explained before. Chinese moss has a lower buffering capacity and water retention, so its pH can go up in an easier way. It requires first high quality Chinese sphagnum moss, which is usually harvested by orchid collectors on special requests with very frequent repottings. But Xavier saw big clumps of all the local Chinese Paphiopedilum species in it. One more problem, it is suitable for cool to cold growing climates, as the Chinese sphagnum moss will spoil very quickly if the temperatures are intermediate to warm. Yet it is worth to mention it.

- Tree fern has been covered previously, as said, it is one of the best potting mixes along with Orchiata, yet it is not available in reasonable quantities, its export is banned from many countries, and it is not really ecologically harvested. It is expensive to get good quality, more than to import Orchiata bark in Vietnam, if one wants the good quality tree fern. It is popular in Malaysia and Indonesia, where some massive clumps of Paphiopedilum can be seen. Like Orchiata, it is very long lasting and retains its structure for a very long time. Unlike Orchiata, it is very acidic and needs sometimes heavy pre-treatments, and unlike Orchiata, it really destroys the ecosystems.

Rarities

There is a group of Paphiopedilum, and even orchids, which will never respond to a standard potting mix. Cypripedium acaule is one famous example, but there is a whole group of Paphiopedilum that requires vastly different conditions. Oddly enough, they are nearly all from Indonesia, Borneo, and the Philippines.

Paphiopedilum anitum, randsii, ciliolare, Paphiopedilum papuanum, bougainvilleanum, wentworthianum, but Paphiopedilum intaniae and ooii as well (that are quite closely related to randsii in some respects) cannot be grown successfully in anything other than tree fern or fern products, with its low pH. There are very, very few plants alive of all of those species in the world and for sure even less that are growing well. Paphiopedilum randsii, in its gigantea form, should be about 150-200cm leaf span, Paphiopedilum ooii is a quite strong growing plant, and in the Solomons, Paphiopedilum wentworthianum grows like a Maudiae type in the wild, lots of leaves and shiny leaves. The secret lies in the nutrition as seen previously and in the potting mix. Xavier has success with those in a mixture of Orchiata and tree fern fibers, about 50/50, for the multiflorals plants. For wentworthianum and bougainvilleanum, they can grow successfully only in the fern root potting mix, without any other additive, and exceedingly heavy watering. In this case, they make beautiful plants, but they are absolutely impossible to grow properly otherwise. In fact, there is no well grown Paphiopedilum bougainvilleanum anywhere in this world in culture, most are a bit yellowish, sick looking, with few leaves, where they are akin to a lettuce in the wild.