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NEWSLETTER MAY 2020

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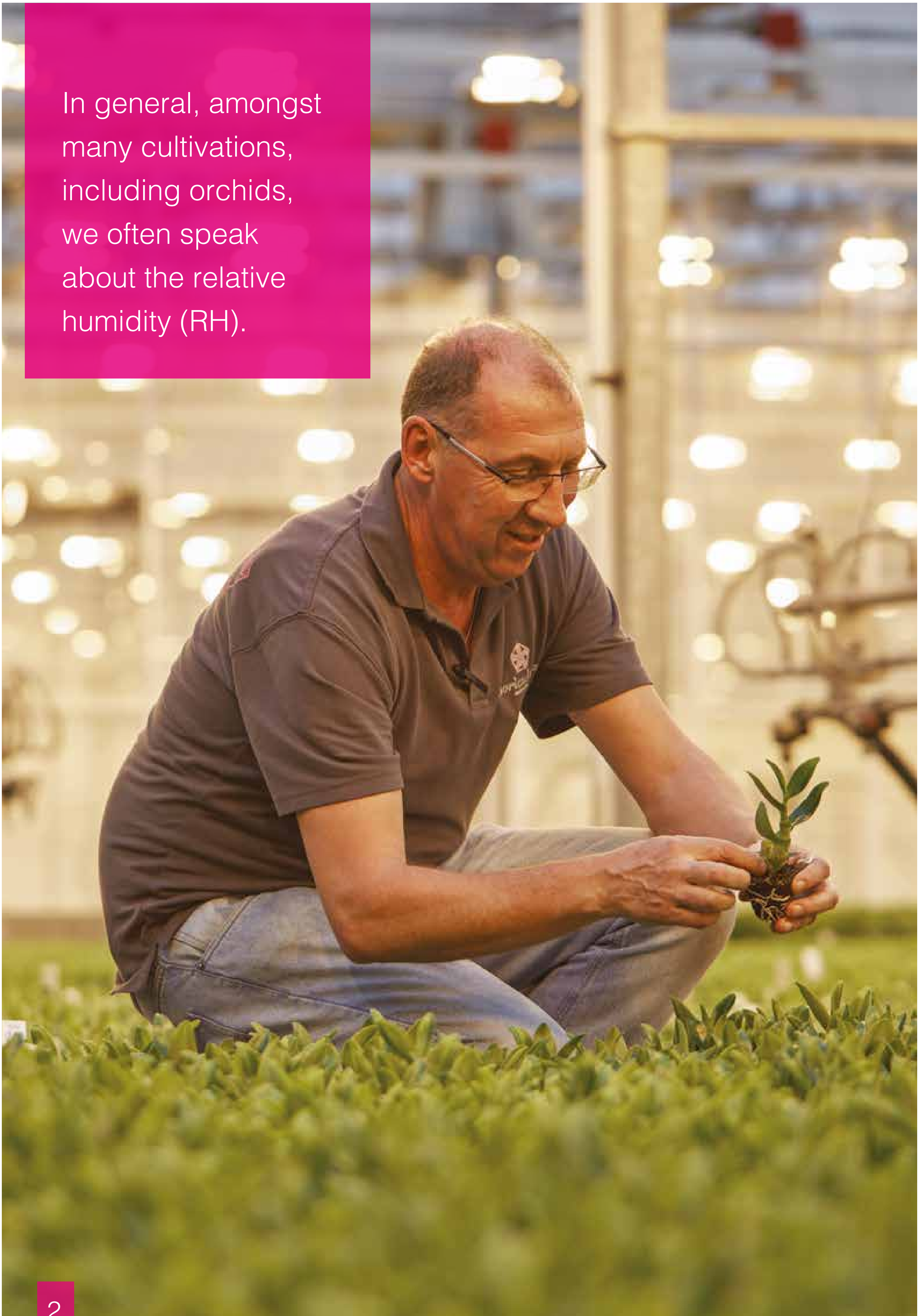

More light means higher humidity

In general, amongst many cultivations, including orchids, we often speak about the relative humidity (RH). With Phalaenopsis 65% is already considered good, even though some growers think that is too high. With Cymbidium an RH of 80% is seen as high and is actually rarely talked about too low. In Miltoniopsis and Odontoglossum, especially Nelly Isler, an RH of 65% is considered a minimum. Unfortunately, this means nothing. But why not? Two reasons:

1. What is the temperature?
2. What is the amount of light?

Temperature

At a temperature of 20°C and an RH of 65%, the moisture deficit is 6 gr/m^3. This is already on the 'dry' side, because the optimum is a moisture deficit between 3.5-5.3 gr/m^3. If you would start warming this air up, the RH will drop. Assume the temperature rises to 25°C, the RH becomes about 49% and that's a moisture deficit of 11.8 gr/m^3. The evaporation will stop because the RH is too low.

Moisture deficit is explained as; how many grams of water can there still be in 1 m^3 of air, at the same temperature. In other words, if the air gets warmer, the air becomes drier (lower RH) and more moisture can enter. The moisture deficit increases. When the air gets colder, less moisture can enter, and the air is wetter (higher RH). For almost all crops the following applies; if the moisture deficit exceeds 6, the plant will have to work harder to keep up with evaporation by absorbing water through the roots. As this value increases, the stomata will shrink more to inhibit evaporation. This even goes as far as closing the stomata. In that case the moisture deficiency has already risen to 9 gr/m^3 or more. Depending on the crop and assortment, one species will quit sooner than the other. Above approx. 12 gr/m^3 the evaporation stops (at an extremely low RH) and the stomata are closed.

In the last phase it is possible that the evaporation has already been too great. The leaf is then no longer under tension and the stomata are largely closed. Photosynthesis stops completely in most orchids. In Phalaenopsis, however, damage can occur at the end of the afternoon because the plant wants to open the stomata to absorb CO_2. This causes the leaves to slacken and if the humidity is too low, damage can even occur due to desiccation. This depends on sort and age of the flower. If the humidity is too low, the stomata will quickly close or shrink again. But that means that the absorption of CO_2 for the next day assimilation is too limited! If C3 photosynthesis (e.g. Miltonia or Cymbidium) would occur, it would stop completely. Then we see burning. Those who have grown vegetables, especially cucumbers, are familiar with the phenomenon of burnt heads. Also burnt heads in lily flowers during spring is a not unfamiliar phenomenon.

This occurred on a sunny afternoon with a moisture deficiency well above 9 gr/m^3.

The reverse process is of course also possible. The humidity is high and the temperature drops. Assume it is 20°C and 65% RH and the temperature drops to 15°C. Then the RH becomes approx. 87% and a moisture deficit of 1.7 gr/m^3. This is a situation we have in spring. The humidity is high at night, but if that doesn't take too long, the plant will still survive.

But what about the situation in autumn, or when the humidity is high as it occurs with evaporative pads and extractor fans use in certain parts of the world. Again, we assume 20°C but now at 75% RH. The humidity deficit will be 4.3 gr/m^3. When the temperature drops to 15°C, the moisture deficit becomes 0.13 gr/m^3 and that is an RH of almost 100%. The RH is so high that there is no evaporation, the planting activity is almost zero. An additional disadvantage is that calcium transport in the plant will stop at night. This in turn results in weak cells, because the calcium is not or less used a building blocks into the cell walls. If it were to be 14°C, you would get condensation on the plant and flowers with Botrytis. We often see this problem in The Netherlands during the month of August when it is warm and humid.

In more southern countries (in the northern hemisphere) that process happens 4-6 weeks later. In the southern hemisphere this process is about half a year earlier (or later) due to the reverse season. Especially cultivars with white flowers suffer more from this, because the colour white radiates more energy. As a result, the temperature of a white flower is often 0.3-1.0°C lower than a darker coloured flower. This is more likely to cause condensation on a white flower, resulting in Botrytis. Think of the following situation: on which surface would you prefer to walk barefoot in summer: a light or dark one?

"Temperature of a white flower is lower than that of a dark coloured flower."

Light

Everyone assumes that more light means more growth. In spring it is necessary to use screens, but often the best solution for a better climate is to remove the light from the outside of the greenhouse through chalking the screens or the use of external screens. In general, this leads to a better climate. What is often forgotten is that more light on the plant leads to a higher plant temperature. With assimilation lighting, we see that at approx. 5,000 lux, the foliage temperature rises by as much as 2-3°C. So, this means the room temperature can be as high as 25°C, the leaf temperature will up to 28°C. Precisely because of this the problems can only get worse.

Assume the same starting points as described earlier under 'temperature'. More light means a higher plant temperature. Room temperature is 20°C, RH is 65%, plant temperature is 21°C, moisture-deficient air is 6.1 gr/m^3 and the moisture deficit of the plant (what the leaf experiences in the light) is 7.1 gr/m^3. Air now reaches 25°C and with more light the plant temperature rises to 27°C. Then the RH becomes 49% again, the moisture deficit of the air is 11.8 gr/m^3, but the moisture deficit of the plant is 14.5 gr/m^3. The evaporation stops completely, and the plant doesn't do anything anymore. And with each degree Celsius increase it gets worse. For the plant this is a desert climate. You will have to increase the RH up to 80%, the stomata want to reopen properly, and the plant will grow well.

This is also the main cause why we see all kinds of leaf spots at various Phalaenopsis growing companies which grow in high light and low RH during the growing phase and then given even more light during the cooling phase.

Transition from growing to cooling with more light and moisture deficit which is too high.

Miltoniopsis has conducted research in the past into the influence of humidity on the production of stomata. We have seen that when plants are grown at a higher humidity, the number of stomata/cm^2 leaf increases AND the stomata are also produced in larger sizes. In another research we have seen that if you grow Miltoniopsis at 4,000 lux and you double the amount of light to 8,000 lux, the RH must increase from 65% to 80% for the stomata to fully open again. Only then will you benefit from it. This was measured with a GrowWatch and confirms the example given earlier.

"With higher air humidity more and bigger stomata."

In a more tropical/warmer environment with a lot of light and higher humidity levels, we see Phalaenopsis plants go into cooling with very high light values at temperatures of approx. 25-26°C during the day and with humidity levels of 80%. We do not see any burning phenomena that we do experience in The Netherlands. This is because the RH is higher!

It is important for the Phalaenopsis, especially in the second half of the afternoon, to ensure that the humidity does not become too low. Because that is exactly when the stomata open with Phalaenopsis. So, do not allow any more light, by opening the screen too early. A simple rule of thumb is to increase the RH after 9-10 hours of light (lamps or sunlight). At that time the malate is normally spent, and the stomata will open.

Tropical regions

In more tropical/warmer regions such as Florida, Brazil (Holambra) where evaporative pads and extractor fans are used in the Phalaenopsis growing companies, we encounter a totally different problem, namely the humidity is too high. During the day the greenhouse can be cooled with

pads and fans, but with the high humidity outside the greenhouse the efficiency will be decreased (i.e. less cooling) than at low humidity. Especially at night this leads to problems with a humidity which is too high. In almost all cases we work with plastic greenhouses, which often do not have ventilation. As a result, moisture extraction through ventilation in combination with heating is not possible. Also because of the costs of heating. As a result, the humidity in the greenhouse becomes much too high over too long a period of time.

Let's suppose the cabinet temperature is 33°C and the humidity is 69%, you will find there is a moisture deficit of 11gr/m^3. If, due to the infrared sunlight, the plant temperature is 34°C, the moisture deficit of the plant will be 13 gr/m^3. And at 35°C this will increase to 15 gr/m^3. No matter how crazy this sounds, the air is far too dry for the plant. The plant temperature will be the same as the room temperature and therefore the plant will just survive. In this case, either the temperature will have to be lowered or the humidity will have to be increased.

"The problem of excessive humidity in warmer regions."

Especially at the end of the afternoon this becomes a problem. The Phalaenopsis is a CAM plant and after a certain amount of light, often in the second half of the afternoon, the stomata open to absorb CO2. But at that low humidity, they will immediately close again. As a result, too little or no CO2 will have been absorbed. In the evening and night, the temperature drops. In this greenhouse the same amount of water vapour is still present. Because the temperature drops to, for example, 29°C, the RH will increase to approximately 90%. The moisture deficit drops below 3 gr/m^3 . Normally the stomata will open, and the leaf temperature will be 1°C lower than the room temperature.

This means that the moisture deficit falls to 1.3 gr/m³ . The leaf can no longer get rid of its moisture and the plant 'drowns' in this very humid air. As a result, there is no transport of nutrients. And if this happens several hours a day, plants become weaker. Too little calcium is stored in the cell walls, which increases plant failure.

"The solution is to turn the fans on 3-5 times per hour."

The solution is to turn the fans on 3-5 times per hour without wetting the pad, bring a little somewhat cooler outside air into the greenhouse and remove the moist air. This slightly cooler air is also humid, but because it is a little warmer inside the greenhouse than outside, the air will become drier as a result of heating and the RH will drop. After 10-20 minutes, the greenhouse air will again have an excessively high RH. By regularly replacing the greenhouse air with the slightly cooler outside air, sufficient moisture extraction can still be realised.

Let's think of an outside air temperature of 28°C and 85% RH. This air will be 'pulled' into the greenhouse. The temperature of this air rises to 29°C, but as a result the RH drops to approx. 80%. The moisture deficit will be 5.8 gr/m³ and that is an excellent value. Even if the plant is 1°C lower in temperature, that is still a good result. When cultivating Miltoniopsis, Odontoglossum, Nelly Isler, Cymbidium you have to ensure that the RH does not become too low. Or even better, do not let the moisture deficit get too high. The table below can be used globally for all crops.

Moisture deficit:	gr/m³
No evaporation	0 – 1
Very limited evaporation	1 – 2
Limited evaporation	2 – 3
Ideal evaporation	3 – 6
Large evaporation	6 – 9
Too much evaporation	9 – 12
Evaporation stops	12 – …

VPD (Vapour Pressure Deficit)

The best way to measure humidity is by vapour pressure deficit (VPD). This is a value calculated by computer where the combination is made of air temperature, plant temperature and absolute humidity. You will get values which have to be between 0.5 and 1.2 kPa. Below 0.5 there no evaporation will take place, above 1.2 it becomes too high. This is best compared to blood pressure in humans; it can be too high, good or too low. When too low the VPD is inactive, when it is too high the VPD is too active.

Note for the reader. All values mentioned in this article are based on sea level conditions in The Netherlands. Deviations may occur at locations at an altitude of 500 or 1,000 metres.

Incorrect fertilization can ruin a lot!

Fertilizing plants is a separate subject matter. Besides experience, you also need the necessary chemical and plant physiological knowledge in order to not make incorrect choices. Although this is not that important in The Netherlands anymore, fertilization is still often seen as an important factor in influencing flowering. Research has shown that temperature, light and length of the day have a much greater impact. However, fertilization does promote growth (and therefore flowering) and quality. Quality determines shelf life, firmness, but also disease susceptibility.

At the end of the seventies and the beginning of the eighties, many soil-bound crops of especially vegetable crops, were switched to artificial substrates such as rock wool. One of the reasons was the disappearance of the soil disinfectant methyl bromide. The Cymbidium was then the most important orchid crop in The Netherlands. There, too, growers switched from natural substrates such as peat to rock wool or polyphenol foam. This had more to do with the availability of good peat mixtures.

Because a lot was still unknown in cultivation, research was also done into fertilization. Following in the footsteps of vegetable crops, standard nutrient solutions were developed for Cymbidium as well. In doing so, the characteristics of the substrate were taken into account.

Rock wool has the property that the pH increases and in the case of polyphenol foam just the other way around. There is more ammonium in the stone wool scheme than in the polyphenol scheme. Those schemes could be found in a booklet, with the necessary adjustments in the various fertilizers if you wanted to give more nitrogen in the spring or more potassium in the autumn during flowering. In addition, schedules exist for when you had to use tap water due to a lack of rain or osmosis water, and how you had to adjust those schedules to keep the plant's nutrition level the same.With the emergence of the Phalaenopsis pot plants, cultivation on peat mixtures in black or red pots switched to bark or coconut chips or a combination thereof and later to transparent pots. In the first years we also used the schemes of Cymbidium for the Phalaenopsis.

This went well at first. But when the peat mixtures disappeared, that

composition seemed not to work. There had to be more nitrogen in the solution. In the early nineties Floricultura started with the advice of a combination of 30% calcium nitrate, 60% Plantprod 20-20-20 and 10% magnesium sulphate (weight). We also calculated this combination in A-B container single.

> "There had to be more nitrogen in the solution."

The main reason why we had to add a lot more nitrogen was the use of bark as a substrate. Due to the decomposition of bark (C/N quotient), the nitrogen requirement of substrate plus plant is higher than on an artificial substrate. Over the years, that ratio has worked well. However, when using 100% coconut substrates some changes take place. The nitrogen requirement is lower, as there is no bark. You also have to give less potassium because coconut gives off quite a lot of potassium by itself. You can also compensate this by giving more ammonium, or more urea. Urea is quickly converted into ammonium in wet conditions. This is often forgotten. That's why we were able to keep working with the said composition without really realising it.

Due to the emergence of coconut peat as a substrate, things changed. The coconut peat remains wet for longer, so nutrients can be absorbed longer by the plant. Moreover, this substrate does not rinse out easily, so that the urea, converted into ammonium, remains in the pot for longer. This results in acidification; the pH is too low. This can be solved by giving less ammonium, more calcium and also less urea. You should often give 12-14 mmol/L N-total with bark mixtures, but for coconut peat 8-10 mmol/L is more than enough. You will need less nitrogen because the bark is not being broken down. That certainly saves 25-30% of the nitrogen requirement.

Moreover, on coconut substrates, especially coconut peat, it is better to increase the amount of calcium to values where you almost have equal amounts calcium as potassium. The reason is that the coconut will always give off potassium and that acidification occurs as a result of potassium (K+) absorption (H+ release). By increasing the calcium slightly, the absorption of potassium is inhibited. Finally, it is better to reduce the amount of nitrogen by reducing urea. Urea is quickly converted into ammonium in a wet substrate and NH4+ uptake = H+ release. The lower the pH, the more H+ ions present in the solution.

> "The coconut peat remains wet for longer."

pH

pH is the negative of the base 10 logarithm of the activity of the hydrogen ion. (Wikipedia). The pH is a mathematical measure for the amount of H+ ions present in a solution. The lower the pH, the higher the concentration. The lower the pH, the less H+ ions in the solution. pH runs from 1 to 14 and pH 7 - neutral. Plants grow best at a pH between 5 and 6. The closer to 5, the easier it is for plants to absorb nutrients. As the pH rises, this becomes more difficult. The first reaction of the plant is to make more roots, increase surface area. Above pH 6.2, problems arise because various trace elements are no longer absorbed and calcium and phosphate also connect to each other, so they are no longer absorbable (also not measurable).

> "As the pH rises, nutrient elements become more difficult to absorb."

At pH values below 5, plant roots can burn. With a Phalaenopsis we often see no problems at pH values up to 4.5. Problems increase below these values. Roots can burn (black root tips), some elements become toxic like manganese (manganese poisoning) and when the pH gets lower than 4, root tips are burnt so they cannot absorb elements like calcium. So, you can also compare the pH with a person's blood pressure. Within a certain bandwidth the root functions fine. Outside of that, problems arise. You can control the pH by pH regulation, but a lot can already be done by adjusting the nutrient composition by more/less ammonium, urea, calcium, etc.

EC

Finally, the EC also plays an important role. Orchids are a salt sensitive crop. You should not give them a high salt concentration, so no high EC. For most orchids, the nutrient composition to be given, including the output water, does not exceed 1mS/cm. With Miltonia you don't want to exceed 0.8mS/cm, same with Cymbidium, and Phalaenopsis 1 - 1.1mS/cm.

Sometimes we see higher values for all kinds of reasons. Temporarily this can go well, but nearly always this goes wrong after a while. The salt levels increase, the roots salinate and die off. In Phalaenopsis we see that roots become thinner and greener. If you then once or twice give them clean water, the roots become thicker and whiter again.

However, what is often forgotten is that urea has no EC value. This is in contrast to other fertilizers. In a wet substrate it is already converted into ammonium the next day. And that does have an EC value. So, if you give 7 mmol/L urea in a nutrient solution, then that is in short, 7 mmol/L ammonium. That means an EC increase of 0.7mS/cm. You could give 1 EC, but in this example the EC in the pot is already 1.7mS/cm the following day. If you do this too often, without regularly giving clean water, in most cases the crop will deteriorate.

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