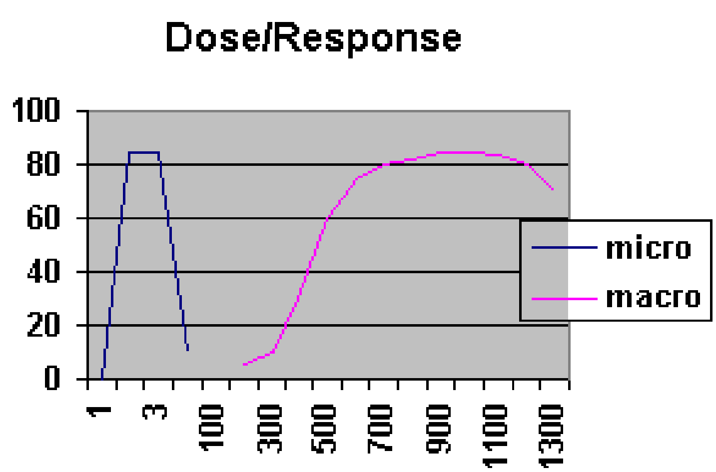
Mineral Nutrition for Slipper Orchid Growers
AnTec Laboratory - Bob & Lynn Wellenstein

Everyone's conditions are very different, and you must balance the various factors of your growing with each other. What is stated here are the factors we take in to consideration regarding mineral nutrition: it is hoped that there may be aspects discussed that may be useful to you. We suggest that careful experimentation on small numbers of plants be carried out before anyone makes any major change in their growing conditions. Also, everyone does not have the same goals in growing, and may not be interested in trying to tease every last bit of potential out of their plants. As a result, we'll also discuss some options to consider if you want to grow these plants without going into the details of matching your fertilizer with a water quality analysis.

Let's discuss mineral nutrition first in a general sense, without the detailed facts and figures, then we'll go over the details for those who are interested. You need to have some idea of your water quality with regard to the type and levels of dissolved minerals (see Water Quality for Slipper Orchid Growers). If you do not have this information, but you suspect that your water is quite hard, there are some steps you might take until you obtain an analysis. You should use fertilizer sparingly, fertilizing only every second or third watering and utilize fertilizers with highly available nitrogen sources and little or no urea, so that the smaller amounts of fertilizer you can use will be utilized efficiently. You should also flush the pots extensively with your irrigation mix with every watering. Not allowing the media to dry completely will aid in salt elimination, but can also lead to rotted roots, so using a more open mix than you normally would and watering more frequently may also be of help, letting you water without the mix completely drying out but still keeping some air supply at the roots. If you are seeing what appears to be symptoms of a mineral deficiency, or dehydration of the plants, remember that to check the most obvious and most common cause first, loss of roots due to rots.



Dose response generalization

If you have a water analysis in hand, you can then match your fertilizer better to your needs. If you have 30 – 50 ppm or more calcium available in the water, then you should choose a balanced fertilizer without calcium. If you have 20 – 30 ppm magnesium or more in your water then you can also utilize a fertilizer that does not provide magnesium. If you do not have sufficient levels of one or the other, you can either use a fertilizer containing them, or do a supplemental feeding every 2 – 3 weeks with calcium nitrate for the calcium and/or Epsom salts for the magnesium needs of your plants. Otherwise, use a balanced fertilizer for the rest of the macronutrients sparingly (try to keep TDS of irrigation mix [water plus fertilizer] at 350 ppm or lower, and the chances that you will encounter nutrient deficiencies is small. The only further caution is to check the pH of your water fertilizer mix and make sure that it is in range for the types of plants you are growing (see Use of Calcium Based Supplements for Paphs for more details). However, if your goal is to grow the plants as well as possible, we'll try to provide you with some tools here to fine tune your program, and diagnose any problems that may arise.

There is a definite dose/response curve in plant mineral nutrition, where increasing levels, as long as other factors are in balance, result in increased growth rates. At a certain point the gains start to become less rapid, and then no further gain is observed. Optimal feeding is at a level in the area where the gains start to level off. If levels are increased above this level eventually you hit a point where plant growth is reduced, in the case of slipper orchids it is usually due to salt level build up at the roots. The graph below is a simple representation of these growth curves for micro and macronutrients, the numbers are arbitrary and meaningless except in a relative sense. Please note that the response curve for many micronutrients is very steep, being absolutely essential in very small quantities, but many, such as boron, are also very toxic in quantities that are only slightly higher. I have heard hydroponic growers cite a rule of thumb for micronutrients that "twice optimal is toxic." The obvious corollary is use extreme care if you are supplementing the micro or trace elements. Another caution is that many plant hormones that are commonly used as supplements have similar dose response curves as the microelements, so again use care to follow label instructions, more is not better, at best you are wasting your money at at worst you may be damaging your plants. While the dose response curve for macronutrients is somewhat more forgiving, we still want to stay fairly close to the optimal area in choosing our fertilizer levels.

You need to consider mineral nutrition of your plants as a combination of your water and the fertilizer you add. What we currently feel is a reasonable range of nutrients for a steady feed program (combined level provided by both the water and the fertilizer) for Paphs is provided in the following chart, but please remember that the absolute values that you should use will be affected by light levels, day length, temperature, potting mix, air flow, size of plants and irrigation frequency.

Element	Minimum ppm	Maximum ppm
Nitrogen (NO_3 & NH_4)	60	100
Potassium	60	100
Calcium	30	50
Magnesium	15	30
Phosphorus	30	50
Sulfur	15	25
Boron	trace	< 0.8
Iron	> 0.5	2
Manganese	> 0.2	2
Zinc	1	2
Copper	trace	< 0.2
Molybdenum	trace	< 0.05

At a very practical level, if you are using a balanced low urea commercial fertilizer at a reasonable rate (say 50 –100 ppm nitrogen), your likely only serious mineral nutrition concerns are calcium and magnesium levels (which are related to also to your water analysis), and the pH of your irrigation mix. If you are using a pure water source then to a certain extent your resolution of the calcium and magnesium levels is somewhat easier, you simply have to supply them at the level you want. Several commercial fertilizers are available that provide one or both of them, but many have neither. Your choices are to select one of the fertilizers that contain sufficient levels, or to feed calcium nitrate once every 2-3 weeks and Epsom Salts (magnesium sulfate) at another feeding every 2 – 3 weeks. Even some of the fertilizers that have these two elements in them contain them at sub optimal levels for use in pure water, so a periodic feed of calcium nitrate and Epsom Salts may still be indicated even with them. If you are working with water with higher concentrations of these elements you may need to choose a fertilizer that does not contain them to maintain as much balance as possible in your program. As discussed earlier, if you have extremely high water salinity, you may have to fertilize at well below the sub optimal levels to avoid salt build up problems for your plants roots.

Water/ fertilizer pH is another commonly overlooked area, and an area where I think many folks could drastically improve their plants health. Various elements are available at different levels depending on the pH of the solution they are dissolved in, with some becoming virtually unavailable if the pH goes too far out of range. We use a base line pH in the 6.6 range for our irrigation mix, and use calcium supplements on the mix of strongly calcicolous plants and those associated with ultrabasic rock. This is explained in more detail in Use of Calcium Based Supplements for Paphs. Be aware that most municipal water supplies have artificially raised pH’s to reduce leaching of toxic substances into the water. Also, purified water is extremely susceptible to wide pH swings when fertilizer is added, having little buffering capacity (our RO with Peter’s Cal-Mag at 100 ppm N drops to about pH 4.3, with Jerry’s Grow Foliage formula at 1 teaspoon per gallon it gives us pH 6.4). Rain water has both the lack of buffering and the possibility of very acid pH to start with. Fertilizers differ in their alkalinity or acidity depending on composition. You may be able to match a fertilizer to your condition to arrive at an acceptable pH, for example an acidic fertilizer used with pH 8.0 municipal water may end up at a range in the high 6’s. It is important to know the pH of your final irrigation mix, and make adjustments if necessary to get it into an appropriate range. We use potassium hydroxide to raise our pH, phosphoric acid is commonly used to lower pH. Vinegar is commonly mentioned as useful for lowering pH, however we do not have experience with it. It is also possible to use a limited amount of potassium silicate to raise your pH, follow label directions to avoid using too high a level. Do not try to raise the pH levels of fertilizer concentrates that contain calcium or magnesium and phosphorus, you may cause precipitates to form. The pH adjustment of these fertilizers must be made in the diluted form.

The charts below summarize additional information regarding mineral nutrition. The relative numbers of atoms in plant tissue is a generalized approximation based on molybdenum being 1, to give a rough’ idea of the relative needs of the plants for each of these elements, note that it is based on a number of atoms basis, not weight basis. It illustrates the large differences in the plant's needs for macro versus micronutrients, and also helps illustrate the higher needs for calcium and magnesium, which are often overlooked, and are present in reasonable quantities in only about 1/3 of the commercial fertilizers I've surveyed.

The elements tranlocatability in the plant is also important in disgnosing deficiencies. If the element is translocatable, that is the plant can remove it from tissue in one area and transport it for use in another, then symptoms of deficiency typically appear in the older tissue as the plant mobilizes the element from the more expendable older tissue to the newer growing areas. Conversely, if it is not translocatable, then the deficiency will show more in the new growing areas of the plant. Another diagnostic indicator to pay attention to is the location of the symptoms, are they marginal, interveinal or generalized on the leaf? Again, I'd like to point out that the most likely cause of a mineral deficiency (unless you are not fertilizing at all) is the loss of the roots of the plant, leaving it unable to take up the needed nutrient levels.

Element	Symbol	Form Available to Plants	Trans locatable	Deficiency Induced by Excess of (Antagonism)	Most readily available pH	Unavail- able pH range	Relative No. Atoms in Plant Tissue
Hydrogen	H	H_2O					60,000,000
Carbon	C	CO_2					35,000,000
Oxygen	O	O_2, H_2O					30,000,000
Nitrogen	N	NO_3^-, NH_4^+	yes	Potassium Phosphorus	6.0 – 8.0	<4.5, >9.5	1,000,000
Potassium	K	K^+	yes	Nitrogen Sodium	6.0 – 10.0	<4.5	250,000
Calcium	Ca	Ca^{++}	slightly	Potassium Sodium Magnesium	6.5 – 9.0	<4.5, >10.5	125,000
Magnesium	Mg	Mg^{++}	yes	Potassium Sodium Calcium Zinc	6.5 – 9.0	<4.5, >10.5	80,000
Phosphorus	P	$H_2PO_4^-$, HPO_4^{--}	yes		6.5 – 7.8	<4.8	60,000
Sulfur	S	SO_4^{--}	no		5.8 – 10.0	<4.5	30,000
Boron	B	BO_3^{---}, BO_7^{--}	no	Calcium	5.0 – 7.5	<4.0, >8.0	2,000

Iron	Fe	Fe^{+++}, Fe^{++}	no	Potassium Phosphorus Zinc Copper	4.0 – 7.5	>10.5	2,000
Manganese	Mn	Mn^{++}	no	Potassium	5.0 – 7.5	>9.5	1,000
Zinc	Zn	Zn^{++}	no	Potassium Phosphorus	5.0 – 7.5	<4.0	300
Copper	Cu	Cu^{++}, Cu^{+}	no	Potassium	5.0 – 7.5	<4.0	100
Molybdenum	Mo	MoO_4^{--}	slightly		6.2 – 10.0	<4.5	1

Signs of Deficiency or Excess of Mineral Elements

Element	Primary Functions in Plant	Signs of Deficiency	Signs of Excess
Nitrogen	Growth of green (leaf and stem)portions of plant.	Reduced growth, vigor. Chlorosis of older leaves first, premature leaf drop	Soft growth, spindly growth, leaf curl, reduced flowering, symptoms of Potassium deficiency
Potassium	Root growth, sugar and starch production, cell membrane integrity	Dwarfing, chlorosis of older leaves first, leaf curling	Deficiency symptoms of nitrogen, magnesium, calcium, iron, zinc, copper, manganese.
Calcium	Cell wall formation, cell division, enzyme catalyst, neutralization of toxic metabolites	Poor growth, deformed newer leaves, chlorosis of newer leaves, blackened areas at leaf ends and new growths with a leading yellow edge, stunted, shortened roots, dead root tips.	Symptoms of magnesium deficiency
Magnesium	Chlorophyll and protein production, carbohydrate metabolism, enzyme activation	Interveinal and marginal chlorosis starting in the older leaves, increase in appearance of anthocyanin in leaves, necrotic spotting	Symptoms of calcium deficiency
Phosphorus	Constituent of nucleic acids, coenzymes NAD and NADP required for photosynthesis, respiration and many metabolic processes, and the energy compound ATP. Essential for root growth, flowering and seed production	Older leaves are affected first, an increase in anthocyanin pigment and a dark blue green coloration, sometimes with necrotic areas, and stunting.	Symptoms of nitrogen, zinc, iron deficiencies.

Sulfur	Protein formation, photosynthesis, and nitrogen metabolism	Root stunting, general chlorosis starting with younger leaves	
Boron	Sugar transport, DNA synthesis	Death of meristematic tissue, root stunting, no flower formation	Interveinal leaf necrosis
Iron	Component of cytochromes and ferrodoxin, synthesis of chlorphyll	Interveinal chlorosis of newer leaves	
Manganese	Enzyme activation in respiration and nitrogen metabolism	Interveinal chlorotic and necrotic spotting	Stunting, necrotic spotting of leaves
Zinc	Trytophan synthesis, enzyme activation	Smaller, distorted leaves, stunting, interveinal chlorosis of older leaves, white necrotic spotting, rosetting	Symptoms of magnesium or iron deficiency
Copper	Enzyme component, electron carrier protein in chloroplast	Stunted, misshapen growth.	Symptoms of magnesium or iron deficiency
Molybdenum	Nitrogen and potassium metabolism	Chlorotic interveinal mottling, marginal necrosis, folding of the leaf, no flower formation	

Nitrogen Source	Residual pH Effect
Urea	acid
Ammonium nitrate	acid
Ammonium chloride	neutral
Ammonium sulfate	acid
Diammonium phosphate	acid
Calcium nitrate	basic
Potassium nitrate	basic
Dried blood	acid
Dried fish meal	acid
Raw bone meal	acid

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