BEGINNER'S SERIES

Orchid Culture — 7 — Nutrition

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A LIVING PLANT is an awesome chemical phenomenon. It absorbs simple compounds from the environment and combines them into its own intricate chemical structure using the energy from photosynthesis. Yet plants need more than the carbon, oxygen and hydrogen they derive from air and water to exist. Other elements drawn in by the roots from the surrounding substrate are constituents of countless essential plant compounds — or help drive the processes which create these compounds.

THE NUTRITIONAL ELEMENTS

Essential elements for plants are usually divided into two groups. Those needed in relatively large quantities are called the macronutrients. Included in this group are nitrogen (N), sulfur (S), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg). Elements used by plants in comparatively small amounts are called micronutrients. Iron (Fe), manganese (Mn), boron (B), molybdenum (Mo), copper (Cu), zinc (Zn), chlorine (Cl) and cobalt (Co) are frequently included in this category.

With the exception of iron, the function of these micronutrients in plants is not clearly understood. Generally they are thought to have a stake in the catalytic systems which drive metabolic processes in plants. Whatever their role, micro-nutrients are no doubt needed in only minute quantities. If these elements are present in concentrations of any magnitude, many plants will exhibit toxic reactions. Also toxic to plants in greater-than-minuscule quantities are aluminum, arsenic, fluorine, lead, mercury, silver and nickel. Sodium, particularly at the high concentrations typically found in water treated by a water softener, has a well-documented toxic effect on orchids *(see* Davidson, 1978).

Nitrogen, judging from studies in the chemical composition of orchids (Poole and Sheehan, 1973), is in greatest demand in actively growing tissue. Here and elsewhere nitrogen is ultimately incorporated into proteins, chlorophyll, and many other important organic compounds which make up plant tissue. Because it is so essential to a plant's continued growth and health, deficiencies in nitrogen often produce dramatic responses in plants. If deprived of this major component of tissue, plants will mature small and stunted. Chlorophyll synthesis will also decline, causing leaves to yellow. This is a condition called chlorosis.

Sulfur, like nitrogen, is a structural component of the amino acids which make up plant proteins. Because it is so prevalent in the environment, plants rarely, if ever, are deficient in sulfur.

Phosphorus has a vital role in plant respiration and metabolism, providing the means by which the stored energy of carbohydrates can be converted and utilized. Plants deprived of phosphorus lack readily available energy and will respond with reduced growth. The high levels of sugars which accumulate because of reduced respiration favor the formation of red pigment (anthocyanins, themselves sugar derivatives), another symptom of phosphorus deficiency.

Potassium is found in especially high concentrations in actively growing plant tissue, like nitrogen. Unlike nitrogen and phosphorus, however, potassium does not constitute part of any organic compound considered crucial to plants. Its precise role has yet to be discovered, though it is thought to have a catalytic function in plants; that is, it may provide the impetus for any number of important metabolic activities. Potassium is considered to be involved in the synthesis of proteins from amino acids. Similar to deficiencies in nitrogen and phosphorus, a lack of potassium can cause a disruption in the growth processes and various degrees of stunting.

Calcium is a vital constituent of cell walls in plants, and therefore is necessary for continued cell division and growth. Because it is immobile in plants, older leaves can be high in calcium while young, rapidly expanding leaves are seriously deficient. Growing tips of leaves and fruits have been known to blacken and rot under calcium deprivation.

Magnesium is the mineral constituent of chlorophyll. Thus any deficiency in this element causes a chlorotic response in plants. Older leaves are more likely to exhibit this condition because available magnesium is readily redistributed in plants and tends to be translocated to the newer, more demanding leaves.

Iron deficiency can also cause chlorosis, not because it is part of the chlorophyll molecule, but because it is indispensable in its synthesis.

A LITTLE CHEMISTRY

To understand some of the rationale behind modern-day fertilizing practices, a basic understanding of the chemistry involved in plant nutrition is required. First of all, despite current trends in human affairs, plants have little direct interest in organic *(i.e.,* chemically complex) foods. Instead, nutritional elements are taken up through the roots in a watery "soup" of simple, electrically charged elements or compounds called ions. Once inside the plant, these elements are then translocated and utilized, indirectly or directly, in the formation of complex, organic compounds. For example, nitrogen is most readily absorbed by plants in the form of the nitrate ion (NCV). Once within a plant, a series of reactions occurs leading to nitrogen's ultimate incorporation into amino acids, the building blocks of proteins. Phosphorus is principally absorbed as the H_2PO_4 ion; potassium, the simple K^+ ion.

What are some of the sources of these nutrient ions? In nature, they are the result of the weathering of minerals and the decay of organic matter (dead vegetation, etc.) on the soil surface. Microorganisms, largely unseen, are the major force bringing about the breakdown of organic matter. Water, with its tremendous power as a solvent, dissolves into solution ions from both these organic and inorganic sources. Not surprisingly, naturally occurring water is far from pure, percolating as it does through chemically active soils. Rather, it is a solution containing ions, many of which have nutritional value to plants, some of which do not.

NUTRIENTS IN WATER SUPPLIES

Most orchids today are watered "out of the tap" with treated water from municipal supplies. Making water safe to drink and pleasant to use does alter its ion content somewhat. Yet many of the nutritional ions found in untouched water supplies are still present in treated "city" water. Calling the municipal water department for an analysis will verify this in your particular area. In mine, a recent analysis indicated significant levels of elements needed by plants, including sulfur, calcium and magnesium. Many of the micronutrients listed earlier were also present, in minute quantities. Not occurring in substantial concentrations, however, were the macronutrients nitrogen, phosphorus and potassium. In the local water-treatment process, the *pH* was raised from 6.3 to 8.8, in large part to remove high levels of iron present in the existing water supply. Iron is an element considered undesirable in municipal waters largely because it has a terrific staining potential. Even after processing, some iron remained dissolved in the local municipal water.

A *pH* of 8.8, according to most of the literature, is beyond the recommended range (pH 5-8). Even so, orchids grown with so basic a water supply do not seem adversely affected. How much of a concern should water *pH* be? Strictly speaking, *pH* is a measure of the hydronium ion (H_3O^+) concentration in a solution. A pH below 7 indicates an acid solution, one high in hydronium ions. A p*H* of 7 indicates a neutral solution, one with equal concentrations of hydronium ions and hydroxide (OH") ions. Pure water has a p*H* of 7. A basic solution has a pH higher than 7, and a greater concentration of OH^- ions than H_3O^+ ions.

Any relevance pH might have to horticultural practice revolves around the fact that it can affect the concentration and form of nutritional elements in solution, and hence their availability to plants. For instance, iron, as suggested by the previous discussion, begins to fall out of solution in the form of an insoluble precipitate at a />H higher than 7, rendering it unavailable to plants. This can actually be a blessing, because iron, along with aluminum and manganese (and others), is far more likely to be present in toxic quantities to plants at *pH* values of 5 or less, when it is most soluble. On the other hand, calcium and magnesium are more readily dissolved and available in a somewhat basic solution (pH 8) than an acidic one (p*H* 5).

Aside from this indirect effect, it is unlikely that />H will have any adverse, direct effect on your orchids — unless you choose to water with household ammonia (pH 11.5) or freshly-squeezed orange juice *(pH* 3.5)! Otherwise, conventional water supplies are rarely found to be dangerously acidic or basic.

POTTING MEDIA AS A FACTOR IN NUTRITION

Another factor should be considered with regards to *pH* and orchid growing — the potting medium. Most organic potting media have an acidifying effect on the water which runs through them and is retained. To a great extent, potted orchid roots absorb this retained water, and its pH and nutrient content merits more attention, perhaps, than the p*H* and nutrient content of the water supply.

Orchids and their roots do not alone inhabit the potting mix! Everyone who grows orchids in an organic medium knows very well, when repotting time rolls around, that it decays into a relatively fine, dark material. This is humus. What brings about this decay are countless microorganisms in the medium, probably a range of fungi (since they favor acidic media, while bacteria do not) Microorganisms break down the complex, organic compounds of the medium into simple combinations, particularly ones containing nitrogen and sulfur. What they cannot digest remains as humus. In this way, microorganisms release any number of nutritional elements — eventually.

Unfortunately microorganisms, like plants, need nitrogen. In soils, this causes a well-known phenomenon called "nitrate depression", which is most pronounced when woody matter (with a high carbon-to-nitrogen ratio) is added. With the addition of undecomposed organic matter to a soil, microbial activity increases dramatically. As the population of microorganisms expands, the demand for nitrogen increases, and there is a corresponding drop in nitrates. Plants in such an active soil cannot compete and are thus deprived of nitrogen. Gradually the microorganisms digest what they can of the organic matter and humus remains. As the supply of food dwindles, their activity and numbers decline, making at last available the nitrogen which was digested and withheld. The plants present can then profit from the increased nitrates available, and from the conditioning effect the resulting humus has on the soil.

Orchids grown in a predominately organic mix usually reap few benefits from such microbial activity, because before the final stage of decomposition is reached and nitrates are released, it is time to repot. Humus by itself is too water-retentive and fine-particled to provide the airy conditions which orchid roots require to survive and function. Priceless in conventional soils, humus is typically — and necessarily — discarded in orchid culture! An orchid root, then, can spend its entire life in a competitive medium fighting, in effect, a relentless and losing battle with the microorganisms present for the available nitrogen. This is why supplemental nitrogen is regularly given in proportionally large amounts to orchids potted in bark mixes. These woody mixes have the high carbon-to-nitrogen ratio which encourages nitrogen competition.

There do exist, in nature and in potting media, a number of fungi which are of immediate and constant benefit to orchids. They regularly infect orchid roots, increasing the effective root surface area, which in turn enhances both water and nutrient absorption. This association of fungus and root is called mycorrhiza.

WATER AND NUTRIENT ABSORPTION

While a small amount of active water absorption is suspected to occur in plants, the overriding amount is believed to be passive, taking place without the expenditure of energy. Transpiration is considered to cause a "tension" at the roots, resulting in the easy uptake of water when available. Water absorption then occurs unless there is a high concentration of ions in the water solution surrounding the roots.

Water in solution generally moves towards regions of lower water concentration, a tendency called osmosis. Ions lower the water concentration of a solution. When the solution in contact with a root has a lower concentration of water than the root itself, the tendency of the water is to move out of the root, not in. A root under these extreme conditions is usually overwhelmed by the contrary osmotic pressure. Not being able to absorb water, it is likely to die and blacken.

Nutrient ion absorption in plants, in contrast to water absorption, is thought to be primarily active in nature, requiring energy from respiration: "Since the active uptake of ions requires respiratory energy, it is not surprising to find that ion uptake is markedly reduced under conditions of oxygen deficiency . . . Likewise in waterlogged or otherwise poorly aerated soils, the absorption of mineral salts is greatly retarded." (Meyer, *et al.,* 1973, pages 303-304).

How nutrient ions are absorbed is yet to be totally understood. It is known, however, that most absorption takes place in the terminal parts of roots through intimate association with the substrate. Plants are also known to absorb mineral nutrients far in excess of their present requirements.

CONCLUSIONS

Many of the elements essential for orchid survival and growth become available through the ongoing decay of inorganic and organic matter. Water dissolves and conveys these elements in simple ionic form to the actively-absorbing orchid root. Once absorbed, they fulfill a variety of vital metabolic functions. Yet for reasons of scarcity, or intense competition for what little is available, nitrogen as well as several other nutritional elements have to be supplemented for adequate growth and flowering in cultivation.

Proper fertilizing practice takes into account the factors discussed here. But because of space limitations in this issue, just how these factors figure into orchid fertilizing will have to be discussed in the upcoming October BULLETIN. — *84 Sherman Street, Cambridge, Massachusetts 02140.*

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