Dialogues with Hugh: No1 - The 'Food' of Orchids

Noel Grundon FAOC

POPULAR literature about fertilisers and their use by orchids contains some facts (i.e. truths) and some fables (i.e. half-truths), but often they contain many furphies and fallacies. Many of the furphies and fallacies are not by intent to mislead, and might be attributed to overzealous advertising or incomplete statements of the whole truth. The aims of these dialogues are to explain some facts about fertilisers and their use in orchid growing, and to dismiss some fallacies, furphies and fables commonly seen in the popular literature.

To the readers, the major question will be answered early in each dialogue, to be followed by a more technical explanation of why that answer has been given. I make no apology for the frequent use of technical terms and chemical notation for the symbols of the elements and chemical salts; this is necessary to be unambiguous in what is being explained.

The 'food' of orchids – The Essential Elements

It is a fallacy that fertiliser labels list all the elements essential for completion of the full life cycle of a plant from seed germination, through plant growth, to development of flowers, fruit, and viable seed.

The first truth to understand is that orchids, and all plants do not 'eat' solid food. Many hundreds of millions of years ago, single and multi-celled organisms that 'ate' complex organic compounds such as starch, sugars and proteins as found in solid foods evolved into animals. The organisms that 'ate' simple chemical salts that were dissolved in water evolved into plants, including the higher plants such as orchids.

If a fertiliser label lists only three elements, such as nitrogen (N), phosphorus (P), and potassium (K), are these the only elements needed for growth and flowering of orchids? If another fertiliser label lists N, P, and K and unspecified "trace elements", is it a better fertiliser? Or are we paying for unneeded 'orchid food'? What is the 'food' that orchids require for growth? What do plants 'eat'?

Although the nutritional requirements of orchids have not been studied extensively, all available information suggests that orchids have the same or similar requirements for elemental nutrients as other higher plants. Readers interested in consulting the technical literature on the nutritional requirements of orchids and plants in general can refer to articles listed in the Reference section of this dialogue.

It is fair to state that a plant will contain traces of all the elements in its environment. Chemical analysis of plant material does not prove that an element is essential for plant growth — it only shows that the element is present in that plant material. To define essentiality of an element for plant growth, the following three criteria must be met before an element can be classified as essential (Arnon and Stout 1939):

1. The plant must be unable to complete its lifecycle in the absence of that ele ment.
2. The element must be directly involved in a metabolic process within the plant.
3. The function of that element within the plant can not be replaced by another el ement.

To prove essentiality of an element, critically controlled sand and water culture experiments are undertaken in which particular elements are selectively omitted. The number of essential elements is likely to increase with improvements in analytical chemistry, and methods of purification of chemical salts.

To date, 24 elements are considered to be essential for growth and development of most, but not all higher plants. They are divided into two main groups: (1) Essential non-mineral elements; and (2) Essential mineral elements. The latter group can be sub-divided further into: (a) Essential macronutrients, which are those elements needed in relatively larger amounts; (b) Essential micronutrients (often called the 'trace elements'), which are those elements needed in relatively smaller amounts; and (c) Beneficial elements, which are those elements that if needed at all, are required in extremely small amounts and for which no firm function has yet been shown in many higher plants.

The following mnemonic lists the non-mineral elements and the macronutrient mineral elements essential for growth of higher plants: C HOPKINS CaFe Mg (i.e. C. Hopkins café manager. [Iodine (I) is included to facilitate spelling of Hopkins and because some algae accumulate it].

The essential non-mineral elements are: carbon (C) which is obtained from air as carbon dioxide; hydrogen (H) which is obtained from water; and oxygen (O) which is obtained from water and directly from air as oxygen gas.

The essential macronutrient mineral elements are: phosphorus (P); potassium (K); nitrogen (N); sulphur (S); calcium (Ca); and magnesium (Mg).

The essential micronutrient mineral elements include: iron (Fe); boron (B); manganese (Mn); molybdenum (Mo); zinc (Zn); copper (Cu); and chlorine (Cl).

The beneficial mineral elements include: nickel (Ni); vanadium (V); silicon (Si); sodium (Na); aluminium (Al); cobalt (Co); selenium (Se); and gallium (Ga).

What roles do each of the essential mineral elements play inside a plant cell?

The metabolic functions played by each of the macro- and micro-nutrient mineral elements in an orchid's growth and development are:

Nitrogen (N) is a constituent of amino acids, the building units of proteins. It is part of chlorophyll and enzymes. As such, nitrogen has an over-riding effect on growth and flower development, and a dominant effect on other nutrients in the plant. It is especially high in the young tissues.

Phosphorus (P) functions in the movement and storage of energy within the plant. Consequently, it has a controlling role in photosynthesis (the conversion of light energy into chemical energy, sugars and starch) and the use of that energy through respiration. It also plays an important role in cell division and protein formation, promotion of root development and regulation of maturity. A large proportion of plant phosphorus is found in seeds and the growing points.

Potassium (K), although needed in large amounts, has an unclear role in plant metabolism. From studying the effects of potassium deficiency, it is obvious that it performs many vital functions in cell organisation, permeability, water relations, in both carbohydrate and protein metabolism, and in photosynthesis. It activates several enzymes, controls pH within the cell and is needed to open stomata.

Calcium (Ca) is found in high concentrations in the walls of the cells where it appears to stiffen the wall. It is important for the growth and functioning of roots, in cell enlargement, as an activator of some enzymes and in chromosome structure. It helps to balance the effects of an excess of other elements, particularly trace elements.

Magnesium (Mg) is the central atom of every chlorophyll molecule. It is an important activator of several enzymes and concentrates in seeds.

Sulphur (S) forms a part of several important amino acids, and as a result, all plant proteins contain sulphur. It is a part of several enzymes that function in carbohydrate, protein and lipid formation. Sulphur compounds also give certain plants characteristic flavours and odours, e.g. garlic and onions.

Iron (Fe) is necessary for the synthesis of chlorophyll and is part of several important enzymes. It functions in photosynthesis, nitrate reduction and nitrogen fixation by legumes.

Manganese (Mn) is required for the activity of several enzymes including the reduction of nitrate prior to protein formation, in photosynthesis, carbohydrate metabolism and oxidation systems within the plant.

Boron (B) is important in the movement of sugars, in cell wall structure, and is closely related to some functions of calcium.

Zinc (Zn) is needed for the development and activity of the growth controlling hormones auxin and indole acetic acid. It is needed for important enzyme systems in nitrogen metabolism and respiration.

Copper (Cu) is an activator of a number of enzymes associated with carbohydrate and nitrogen metabolism and cell wall development, and plays a role in pollen formation; it is present in high concentrations in the chloroplasts in leaves.

Molybdenum (Mo) is required for the reduction of nitrate prior to protein formation.

Chlorine's (Cl) function in plant metabolism is not well understood in many plants, but it may play a role in photosynthesis in some plants.

Nickel (Ni) is an essential element for many bacteria, and has been shown to be involved in nitrogen metabolism of some higher plants.

Sodium (Na) is an essential mineral element in salt-loving plants such as halophytes, but its role in many higher plants is not well established where it can sometimes replace part of the requirement for potassium.

Silicon (Si) essentiality has been demonstrated for unicellular organisms such as diatoms, but has not been established for many higher plants, although it has been shown to be beneficial for many species, including rice.

Cobalt (Co) is an essential mineral element in fixation of nitrogen by Rhizobium and Bradyrhizobium bacteria in the root nodules on legumes, but there is no evidence that cobalt plays a role in the metabolism of higher plants in general.

Selenium (Se) is accumulated by some higher plants and may have an essential role in the metabolism of such species, but its requirement by many higher plants has not been demonstrated.

Aluminium (Al) is accumulated by some species tolerant of low soil pH, but there is no convincing evidence that aluminium is an essential mineral element even in such accumulators, where there is some evidence that the beneficial effects of aluminium are secondary, brought about by alleviation of toxicity caused by other mineral elements.

The requirement for **Vanadium (V)** and **Gallium (Ga)** has been established in some lower plants such as algae and fungi, but reports on the stimulation of growth of higher plants are rare and vague.

Complete fertilisers – How complete are they?

No fertiliser lists nor claims to supply all 21 of the essential macronutrient, micronutrient and beneficial mineral elements. Therefore, claims to be a 'complete fertiliser' are a fallacy and should be read as a publicity blurb. Fertilisers can be:

(1) A single chemical salt, such as ammo nium sulphate [(NH4)2SO4]; or

(2) Mixtures of many simple chemical salts, such as mixtures of ammonium sulphate, calcium nitrate [Ca(NO3)2] and potassium chloride [KCl]; or

(3) Mixtures of complex organic com

pounds such as proteins, urea, amino acids and other organics; or

(4) Mixtures of complex organic com pounds and simple chemical salts, as is often found in many organically-based fertilisers such as Hoof & HornTM or Fish EmulsionTM.

By reading the label carefully, growers can find out how many of the essential mineral elements any fertiliser will supply. But to the elements listed on the fertiliser label, you will need to add those elements that: (a) occur as impurities in the fertilisers or in the water used to dissolve the fertiliser; and (b) the elements provided by the breakdown of components of the potting medium. Some of these impurities and inadvertent additives might be essential for plant growth, especially should they be micronutrient mineral elements or beneficial mineral elements.

Very few of us use pure water to water our plants; we commonly use town/city or underground water that will contain some dissolved chemicals from the river or groundwater that is the source of most town or city waters. In contrast to the 'super-pure' conditions required to investigate the essentiality of mineral elements for plant growth, fertilisers and town/city waters are very 'dirty' or impure and will contain many other elemental impurities than those listed on the fertiliser label. Because the essential micronutrient mineral elements and beneficial nutrient elements are needed in very small amounts, many of them may be adequately, or even completely, supplied as impurities in the fertilisers, or in the town or ground water we use to water our plants. Because of such impurities in the fertilisers and water, some fertilisers that supply all six of the essential macronutrient mineral elements and the essential micronutrients may go close to being a complete fertiliser.

Balanced nutrition

Orchids, like other plants, require a balance in their diet of mineral elements. Just as they require a minimum amount of an essential element to grow normally, plants can also be adversely affected if the supply of any one element or group of elements is too high or too low.

We read of different ratios of nitrogen (N), phosphorus (P), and potassium (K) needed for maximum vegetative growth or for boosting flowering. But what is the correct ratio of the essential elements that provides for balanced nutrition throughout the annual life cycle of the orchid?

Early studies into the nutritional needs of plants assumed that you can provide balanced nutrition for maximum growth and development by analysing the concentrations of elements in a plant, and then supplying the elements in that ratio.

The concept that you can achieve balanced nutrition by supplying the essential

Table 1. Ratio of concentrations required for healthy plant growth of some macronutrients and micronutrients relative to the concentration of Molybdenum (Mo)[1]

Macronutrient	Nitrogen	Potassium	Calcium	Magnesium	Phosphorus	Sulphur
Ratio	140,000	100,000	50,000	20,000	20,000	10,000
Micronutrient	Iron	Boron	Manganese	Zinc	Copper	Molybdenum
Ratio	1,000	200	500	200	60	1

[1] Adapted from Table 1, page 1: Grundon, N.J. (1987)

nutrients in the ratio that they are found in a plant is a furphy!

For higher plants, the approximate concentration of the micronutrient element Molybdenum (Mo) required for healthy growth is about 0.1 parts per million (Grundon, 1987). When this concentration for Mo is given a value of 1, Table 1 shows the approximate orders of magnitude in which some of the other nutrient elements are required for healthy plant growth.

However, we know from analyses of orchids (and other plants) that the concentrations of the essential elements can differ greatly between different species, and between different parts of the same plant. Other factors that can cause differences in these concentrations include age of tissue, potting medium, fertiliser regime, and complex interactions between the elements and the plant. Table 2 illustrates these differences in the concentrations of some essential macronutrients for various plant parts of Cattleya Culminant.

An adequate supply – but not necessarily a 'truly' balanced supply – may be better

Table 2. Concentrations of some macronutrients in *Cattleya* Culminant[2]

Plant part	Concentration of element (Percent dry weight)				
	N	P	K	Ca	Mg
New leads	3.1	0.21	1.55	0.22	0.34
1-year old leaves	2.0	0.1	1.35	0.71	0.49
7-year old leaves	1.7	0.25	0.13	2.20	0.81
1-year old pseudobulb	1.8	0.20	1.29	0.41	0.45
7-year old pseudobulb	4.6	0.66	0.33	0.16	0.29

[2] Extracted from Table 5-22, page 204: Arditti, J. (1992).

Like all plants, orchids will absorb the elements they require in the amounts needed for growth and development at each stage of their life-cycle. With certain genera, and at different times of the year or growth cycle, varying the ratios of the essential elements may produce better growth. For example, during spring or when the rate of new vegetative growth is at its maximum, a product with a high ratio of nitrogen to other macronutrients may be more beneficial. When the new vegetative growth matures and flowering commences, the ratio of nitrogen may be reduced, partly because little new growth is being produced as flowering takes place, and the nitrogen stored in the leaves and pseudobulbs is often adequate for flower production.

At all times, it is most important that an adequate amount of the essential elements be supplied. Thus, while an N:P:K ratio of 25N:5P:10K may be a beneficial ratio to provide 'balanced nutrition' during maximum vegetative growth, the amount of nitrogen provided must still supply all the nitrogen needed for maximum growth of the orchid plant; if insufficient nitrogen is supplied growth will be limited by the supply of nitrogen, not by an inappropriate or unbalanced ratio of N:P:K.

Because many genera have little capacity to store appreciable quantities of the essential elements for future use, a continuous sup-