A FRESH LOOK AT PLANT NUTRITION

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It is often said that "money is the root of all evil". From my observations in growing plants and in horticulture, the person who first wrote that had not heard of fertiliser.

I am regularly asked to comment and advise on why people's plants are not growing well, and what we use in the nursery to get our plants to grow. We even sell our blend of fertiliser to the general public in an effort to assist. Modern high-quality, blended, slow-release fertilisers have taken much of the skill away from the art of plant nutrition. If a plant does not grow well with a handful of Osmocote, Nutricote, Magamp, or whatever, then it is declared impossible to grow, which is indeed unfortunate.

The correct use of fertiliser in plant nutrition is the difference between complete success and total crop failure. I am convinced the average nursery could double its output with correct plant nutrition. Nearly all fungal and bacterial diseases are a result of poor nutrition. The first sign that all is not well with plant nutrition is when the plants stop growing. When any visible signs of nutritional problems become evident, the plant is already chronically malnourished and prone to disease. Plant growth is regulated by the availability or not of the least available essential nutrient. Too much fertiliser is a far greater menace than too little. For example, we have proved conclusively when pricking out seedlings that if there is no fertiliser whatsoever in the mix there are never any losses. Pricking out losses increase with the increase in total dissolved salts.

The ideal for young seedlings would be to have no fertiliser in the mix and to liquid-feed them approximately two weeks after planting. I am also convinced when I see the high losses at pricking out of micropropagated explants that it is because the nutrition level is too high. Excessive total dissolved salts is evidenced by the burnt leaf tips and die-back, which can lead to the collapse and death of the plant.

To understand the nutritional needs of plants, *The Essential Elements of Life* must first be defined. These are:

Atomic No.	Chemical Symbol	Element
1	H	Hydrogen
5	B	Boron
6	C	Carbon
7	N	Nitrogen
8	O	Oxygen
9	F	Fluorine
11	Na	Sodium
12	Mg	Magnesium
14	Si	Silicon
15	P	Phosphorus
16	S	Sulphur
17	Cl	Chlorine
19	K	Potassium
20	Ca	Calcium
23	V	Vanadium
24	Cr	Chromium
25	Mn	Manganese
26	Fe	Iron
27	Co	Cobalt
28	Ni	Nickel
29	Cu	Copper
30	Zn	Zinc
34	Se	Selenium
42	Mo	Molybdenum
50	Sn	Tin
53	I	Iodine

Life is not possible without each of these inorganic elements being available in the correct proportions. Each of these elements is highly toxic, and all of them are lethal in excess. Other elements are found in plants in addition to those above. These can include:

13	Al	Aluminium
80	Hg	Mercury
82	Pb	Lead
48	Cd	Cadmium

These elements are considered to have no part in general plant metabolism, but may in fact benefit plants in other ways. For example, aluminium compounds are very good fungicides, and a high aluminium content in plants may confer resistance to fungal infections. The aluminium-rich clays in our area definitely give a growth response. However, this is no evidence that it is in itself a plant nutrient. I believe more work needs to be done on clarifying the place of aluminium in plant responses. Mercury is a lethal element with well known natural fungicidal properties. Many early fungicides were made out of this metal. High lead levels have been recorded in plants, especially in gardens around old wooden houses that were painted with lead compound paints. These levels can reach toxic proportions in vegetables grown in lead contaminated soils.

Two of these elements, cobalt and selenium, are held to be not necessary for plant growth. However, cobalt is the central atom in the Vitamin B_{12} molecule, an animal protein. Cobalt is essential for bacterial health, particularly rhyzae-bacteria in legumes. Legumes cannot be grown without adequate cobalt. Selenium is not deemed to be plant food. However, it is an element required for neurological development in animals. I do not believe that there should be any differentiation between plant and animal nutrition when it comes to trace minerals, particularly in the production of horticultural crops, as these plants are required for animal food anyway. Selenium has been recorded in a number of plants at levels up to 3,000 parts per million. *Astragalus racemosus* is a selenium accumulator plant. The presence of selenium in this American plant is interesting, and leaves open the question of the place of selenium in plants' needs. I would like to point out that 5 parts per million in the dry matter of stock-food in considered lethally toxic. Therefore, 3,000 parts per million makes this plant extremely poisonous. However, it possibly could be considered as a very good organic source of selenium, to be used in selenium-deficient areas.

Hydrogen, carbon, and oxygen are the magic triad of elements of the photosynthesis carbohydrate miracle, and fortunately are adequately supplied naturally with good ventilation and proper watering. Extra carbon dioxide is sometimes provided with CO_2 enrichment of the glasshouse atmosphere. However, for the most part these three elements require no further concern.

This leaves 23 elements which need to be available at all times in the correct proportions to ensure optimum and balanced growth. It is a sad fact that if you mix all of these elements together nasty reactions take place. Nitrate reacts adversely with calcium; copper reacts badly with molybdenum; and a number of other adverse reactions can take place.

The principle of plant nutrition in modern nursery potting mixes must be totally divorced from the needs of plants grown in soil in the open ground. In soil every effort is made to have the nutrients readily available for the plant. The current practice of using silica sand in nursery potting mixes is a practice which defies logic. Sand has no nutritional value; it has no cation exchange capacity; it leaches badly; it is excessively heavy; and in sand it is almost impossible to stabilise a steady supply of plant nutrients. Furthermore, practically all the sand that is used in our local nurseries is dredged out of rivers, which are the major source of the pathogenic water-borne fungi which create havoc in most nurseries.

The ideal potting mix requires that there be little or no nutrient available at potting up, and from then on be available in ever-increasing amounts as the plant grows in size, until it is ready for planting out, when maximum nutrient availability should be attained. In reality, the reverse is the case. Potting mixes normally have maximum availability at potting up, and nutrients become steadily less available as plants grow older, until such time as they are depleted and a side dressing is applied. This is, in fact, a highly unsatisfactory situation. Nature ensures that plants receive a steady supply of minerals from the natural weathering of rocks; from the accumulation of organic compounds in the soil; from acid rain which provides a steady stream of nitrates and sulphates; and from wind-evaporated sea spray which deposits countless tonnes of minerals over the land every day, further enriching the soil and contributing to plant growth. The long-term nutrient supply of potting mixes are best provided by the use of finely ground, non-activated mineral rocks. For example, calcium can be best provided by finely crushed oyster shell, limestone rock, and marble; iron would be best provided by crushed iron ore; and trace minerals of all kinds can be readily provided with crushed and finely ground mineral-rich rock, such as volcanic basalt and granite. Superphosphate is a menace in potting mixes, due to the "super" availability of phosphoric acid. Finely ground rock phosphate is excellent. The natural acids in the water and potting mix slowly release these minerals over a long time, allowing for a steady supply.

We have found that nutrients can be stabilised in sand by adding in clay, and we now advise our customers when planting in sand to mix friable clay in with their sand, so that the nutrients attach themselves to the clay instead of leaching out with the first shower of rain. Five percent friable clay added to an organic potting mix will not only supply a host of trace minerals, but will also provide cation exchange capacity. Free nutrients can attach themselves, giving stability to the minerals in the potting mix, and thereby preventing leaching.

A few years ago we tried growing some plants in charcoal, believing this would be an ideal sterile medium for the plant export trade. However, it was a total failure, because the plants would not grow at all. Recently, while judging at the finals of the School Science Fair in Auckland, I saw that a young girl had demonstrated that charcoal locked up nutrients and totally suppressed plant growth. If wood charcoal is presaturated with trace minerals, a steady supply is then available to the plants throughout the life of the potting mix.

It can be readily demonstrated how important a steady supply of trace minerals is to a plant, by mixing up the total complement of minerals into a paste, using either petroleum jelly or lanolin (sheep wool oil) as a base. If a small patch of this paste is smeared on to tree trunks, it will be slowly absorbed through the bark into the tree, giving a dramatic improvement in plant growth and health. I have never seen mature trees respond so dramatically to any treatment as to this simple procedure.

In conclusion, long-term stable potting mixes containing all of the elements, can be achieved by going to every effort to ensure that the minerals are retained in the mix, but using the following techniques:

1. Use stable mineral sources, such as rock phosphate and finely ground natural mineral ores in place of silica sand.
2. Mix sulphates, etc. with fine acidic clay.
3. Use the unique properties of activated charcoal, which locks up compounds, making them less prone to leaching.