# The Living Plant
**by "the Botanist"**

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**AN INTIMATE KNOWLEDGE** of plant functions is by no means essential to successful chrysanthemum cultivation. Many successful growers know little of such matters, and at the other extreme students of plant biology can make poor plantsmen. No one will deny, however, that a knowledge of elementary fundamentals of the various factors affecting growth is desirable. We should at least appreciate how a plant is constructed and know something of the factors governing its development. The following notes cover in brief the most important aspects.

**PLANT CONSTRUCTION**

A chrysanthemum plant-leaves, stems and roots alike-is composed of microscopic cells, each cell being bounded by a cell wall. In infancy these cells are completely filled with the living plasma of the plant (called "protoplasm"), but as the cells mature this substance recedes to line The cell walls, and the central area becomes filled with plant sap.

This sap, i.e. water and the solutions it contains, is able to pass through both the cell walls and the protoplasm to form a continuous network from the rootlets to the tips of the leaves. With age the cells become devoid of protoplasm, but many continue to perform valuable functions. Whilst those in lower leaves may eventually die and play no further part in plant maintenance, those in the stems and in the main roots continue to assist the plant. Some make up the corky outer covering of the older stems and insulate the inner "living" tissues against temperature changes and excessive loss of moisture; some form fibrous strands which strengthen the stems; others develop into channels for moisture and food transmission.

A chrysanthemum plant is an intricate system of cells and tissues, some "alive", some "dead", but all contributing to the vital functions of the plant. A plant is not, however, "solid", but is equipped with a continuous network of air spaces making contact with all but the infant and reproductive cells. The function of this air system is to supply oxygen for respiration and carbon dioxide for the manufacture of plant foods, and to provide for the removal of waste gases. Minute openings in the lower leaf surfaces (called "stomata") provide the necessary link with the atmosphere. These stomata have the power of opening and closing, opening by day and closing by night. Broadly speaking, they can also be said to tend to close when a plant is flagging and when the air is dry, and to open when the atmosphere is humid.

**IMBIBITION**
Though leaves are capable of absorbing small amounts of liquid (and any fertilising elements dissolved in the liquid), the bulk of a plant's nutritional requirements are taken up by the roots. The main roots of a plant branch into countless rootlets, just as the branches of a tree branch into numerous twigs. The forepart of each rootlet consists of a mass of rapidly multiplying cells, known as the "root cap", and as these cells multiply the rootlet lengthens and the root cap literally grows into the tiny air spaces between the mineral particles of the soil. Situated just behind the growing point of each rootlet is a circlet of "root hairs", and it is these root hairs which largely absorb the soil solution. The life of each root hair is short, but as they die new ones are constantly forming on the younger cells just behind the extending root cap. Thus the roots of a growing plant are constantly penetrating, and drawing sustenance from, a wider and wider area of soil. Broadly speaking, the roots take up the soil solution by a process known as "osmosis". This is a process whereby a stronger solution will "attract" a weaker solution through a semi-permeable membrane. Nature has arranged that the outer tissue of the root hairs is semi-permeable and that the concentration of the solution within the plant is stronger than than of a normal soil solution. Thus the weaker soil solution passes into the root hairs and is subsequently transmitted through the network of conductive tracts to stems and leaves in readiness for the processing of plant foods. There is no evidence, however, that the entry of mineral nutrients depends directly on the amount of water entering the plant; nutrients can still enter if transpiration (and thus the flow of moisture through the plant) is virtually at a standstill.

**FOOD MANUFACTURE**
Neither the air taken in by the leaves nor the mineral solution absorbed by the roots is in itself a plant food. They are only the ingredients, and need processing before they can be utilised for plant development. It is in the leaves-in special layers of cells containing "chlorophyll"-that the manufacture of vital sugars and other substances takes place. Briefly, air passes through the stomata, carbon dioxide is separated from the other constituents within the chlorophyll cells (by a process known as "photosynthesis") and is utilised to form plant sugars, which in their turn are combined with the nutritive ingredients taken up by the roots to form more complex plant foods. The foods so manufactured are transported to the growing points along the internal conductive channels.

**PLANT REQUIREMENTS**
The development and health of a plant is influenced by many factors. To secure the best results we must understand and heed these factors. Chief among them are: light, air, moisture, warmth, hygiene and food.

**Light**
The photosynthetic process (the manufacture of plant foods) depends on light, Without light, growth will cease. Plants grown in conditions of low light intensity are usually weak and drawn; the extra vigour produced under conditions of good light is utilised to produce sturdiness rather than height. Chrysanthemums should, therefore, be grown in full light and should be well spaced at all stages of growth. Light is in nature closely linked with warmth-day temperatures are usually higher than night. This fact should be borne in mind where artificial conditions are provided, e.g. in the greenhouse and frames. Light can play another role in the development of the chrysanthemum. Chrysanthemums are in some cases "short day" subjects, and many refuse to bloom until day-length is of appropriately reduced duration. They are usually started into growth in the lengthening days of spring, continue development in the long days of summer, form buds as day-length begins to decrease, then flower in the shorter days of autumn (the date depending on the inherent characteristics of

each cultivar.) Buds formed too early frequently delay their opening, and run up a long "neck" until conducive conditions in terms of day-length are experienced.

**Air**

As we have seen, the carbon fraction of the atmosphere is utilised by plants for the production of growth materials. In addition, the oxygen of the atmosphere is vital to their very existence, for, like human beings, plants must "breathe". In other words they must enjoy a supply of oxygen to support the continuous process of respiration occurring in each living cell. But a plant has no lungs, and no bloodstream in which to circulate the oxygen it needs. Instead it has internal passages with openings (stomata) in the leaves. These air passages are a necessary part of the structure and function of the plant, but although they adequately supply stems and leaves with oxygen, they are not able to supply all the oxygen needed by the roots. The roots themselves depend largely on oxygen supplied externally from within the soil. It is therefore essential that the soil in which chrysanthemum roots operate be "open" and aerated. The air "breathed" by a plant should, as far as possible, be free of dust, fumes and smoke. It should not be excessively dry nor excessively moist. Air should circulate freely through the foliage to aid transpiration and to dispel surplus moisture, but briskly-moving air in the form of draughts and strong winds can multiply transpiration to such a degree that tender tissues become damaged. Plants recently potted or planted are especially vulnerable, and it is sometimes necessary to protect them by windbreaks.

**Moisture**

In physical make-up a chrysanthemum plant is over three-quarters liquid, yet the moisture retained is but a minute fraction of the total taken up by the roots. Most of the liquid imbibed is shortly transpired to the atmosphere through the stomata of the leaves. The chain of liquid is, as it were, a highway for the food ingredients supplied by the soil. Too little moisture results in hard, stunted plants; too much induces soft growth, and in great excess impairs root activity by excluding air from the soil and drowning the feeding root hairs. It is by ensuring satisfactory moisture retention in the soil or compost and by thoughtful watering that the moisture content of a plant is maintained at the desired level. The rate of transpiration depends on whether the stomata are fully or only partly open; also on temperature, humidity of the atmosphere and wind velocity. The warmer and drier the air the more moisture transpired by the plant; likewise with increasing wind velocity-just as moisture is drawn more quickly from washing on the clothes line on a warm, dry and windy day. The moisture-depleting effects of a dry atmosphere should especially be watched where newly-rooted plants have just been removed from the propagator. Such plants frequently have thin cuticles and "soft" foliage, and for a time they are liable to suffer leaf damage if exposed to an arid atmosphere.

**Warmth**

For vigorous growth a plant requires a reasonable temperature level. Below such a level growth slows down, until at very low temperatures it ceases altogether. Growth also becomes slower at high temperatures, and ceases in very high temperatures. Beyond these extremes a plant is in danger of destruction. Small chrysanthemum plants develop steadily in a temperature as low as 40 deg. F. In the early stages a temperature of 60 deg. F, would, in fact, be undesirable where conventional outdoor methods of cultivation are employed. But later, as development proceeds and light becomes more intense, naturally higher temperatures will promote optimum development. Very high summer temperatures are, however, still undesirable. Chrysanthemums prefer cool rather than hot conditions. As mentioned earlier, when plants are in the greenhouse and frames, temperatures should be co-related, as far as possible, to light intensity, avoiding violent ups and downs between day and night levels. Plants will tolerate reasonable temperature changes, but drastic fluctuations are undesirable. Little can be done to maintain a steady level in the open, but in the greenhouse, and to some extent in the frames, violet changes can be avoided by ventilation, shading and artificial heat. This is particularly important with greenhouse chrysanthemums in flower. High day temperatures followed by low night temperatures contribute to petal damping. A somewhat lower temperature by night is, however, desirable at all times, say in the region of ten to fifteen degrees. Allowance should be made for this where possible.

**Hygiene**
To grow plants sturdily in light, airy surroundings is to be partway to avoiding serious debilitation by pests and diseases. Inspect plants frequently for signs of infection. Insist on tidiness both in the greenhouse and on the plot, and keep weeds down. These measures, coupled with any necessary sprays and dustings, should prevent serious outbreaks.

**Nutrients**
Plants rely on correct nutrition as the basis of healthy development. Their nutrient supply is dependent in particular on the physical structure and chemical constituents of the soil or compost. Too much can be just as harmful as too little. The amount of nutrient a plant can utiuise depends upon its rate of growth, which again depends on such things as light and warmth. An unbalanced diet is just as undesirable. The increase of one nutritive element relative to the others can easily lead to poorer rather than improved results.

**NUTRITIONAL ELEMENTS**
A word on the elements concerned with plant nutrition. To begin with, the "big four": nitrogen, phosphorus, potassium and calcium.

**Nitrogen.**
This is the element mostly concerned with the development of leaves and stems. Is necessary to the synthesis of proteins, alkaloids, chlorophyll and other complex substances. Of all the plant food elements it is the one most readily leached from the soil, and the one most likely to need replenishing. Where nitrogen is in short supply growth is stunted, with small yellowy leaves and thin wiry stems. The whole plant is dwarfed and hard in appearance; leaves take on autumn tints and fall prematurely. In cases of excess, leaves and stems grow to enormous size; leaves become bloated and dark green in colour, and stems are soft and structurally weak. The plant is more vulnerable to pests and diseases, and when blooms appear damping is probable. Excess can lead to coarse, rank growth, at the expense of bloom quality.

**Phosphorus.**
Of especial value in ensuring a strong root system and in building up plant tissues. An important cell catalyst. Much concerned with the advance of a plant toward maturity and with the flowering function. It is inherently abundant in some soils, especially those containing appreciable amounts of clay. Counters the effect of excessive nitrogen. Shortage means a poor root system, with outdoor plants suffering in times of drought, with small leaves with a dull purplish hue. Flowering is delayed and blooms are small. Excess is not normally serious, for the bulk of phosphorus in the soil is "locked up" and released only gradually. Where abundantly excessive, however, growth may be stunted and hard.

**Potassium.**
Potassium ("potash") balances the effect of nitrogen and prevents soft, rank growth. It is the "sunshine element", in that it has the effect of hardening and ripening. Not a constituent

of any important plant substance, but appears to have an influence on the efficiency of such functions as the formation of proteins and starch. Differs from most other elements by existing within the plant always in soluble form. Where adequately supplied, stems are harder and stronger, colour is intensified, and the overall quality and texture of blooms is improved. Serious shortage is likely only in very light, clay-deficient soils. Shortage can result in soft growth and blooms of poor texture. Leaves develop pale edges, with these symptoms soon spreading inward. In severe cases the discoloured areas wither. Moderate excess does little harm, for potassium is stored in the soil and only slowly released into solution. Great excess could, however, produce unduly hard growth, with lower leaves developing yellow patches. Where a soil is adequately supplied with manure and lime it is unlikely that a shortage of potash will be experienced.

**Calcium.**
The function of calcium (lime) in plant nutrition is complex. Plays a part in the functioning of the cell nucleus, and is necessary to the healthy functioning of the apices of both roots and stems. But calcium is more than a plant "food". It acts as a soil cleanser, influences the flow of other essential elements, and controls the balance of soil acidity (referred to as "soil reaction"). On application to the soil, calcium replaces some of the potash held in store by the clay particles, which then becomes available to the plant. It converts phosphorus in excess of immediate needs into a gradually available form not readily washed out by rain, and applied in moderation releases magnesium, iron and trace elements held by the soil particles. It is necessary to the well-being of beneficial bacteria, which produce valuable nitric acid and break down organic animal and plant residues into humus and plant "foods". The average annual loss of lime from a medium soil is said to be in the order of an ounce to an ounce and a half of hydrated lime per square yard (approximately two ounces of carbonate of lime), with a tendency to greater leaching from sandy soil and less from clay.

The symbol pH is used to represent the reaction of a soil. Values are indicated within the range 00 (extreme acidity) to 14.0 (extreme alkalinity). A value of pH 7.0 is neutral. Chrysanthemums thrive best in a soil which is slightly acid-in the region of 6.5. Calcium deficiency is indicated by stunted growth, with small yellowy blotched leaves. Leaf edges turn yellow and wither. Excess means tall plants, but weak and soft tissues. The real danger of excess, however, lies in interference with supplies of potassium, phosphorus, magnesium and iron. Lime should never be mixed with manure, basic slag or super-phosphate, either in store or at the time of application.

**Magnesium.**
Another very important element. Essential to the formation of chlorophyll. Usually abundant in clay soils, but with a tendency to shortage in light soils, from which it is easily washed out by rain. Serious shortage is unlikely, however, where adequate supplies of manure or vegetable compost are applied to the plot, or where good quality loam is used as the basis of a potting compost. Deficiency is indicated by leaves turning very pale green between the veins, starting in the older leaves and progressing up the plant. Pale brown areas of dead tissue may appear. Leaves tend to curl upward and may develop brilliant autumn tints. Bloom will be pale in colour. Excess is seldom so extreme as to upset the balance of growth.

**Iron.**
Although iron is not a constituent of chlorophyll, the production of chlorophyll proceeds only in its presence. Most soils contain ample supplies, but this is not always in a form readily available to the plant-sometimes due to excessive alkalinity, i.e. over-liming. Deficiency leads to pale chlorotic foliage, starting with the younger leaves. Pale brown areas of dead

tissue do not appear, as is the case with magnesium deficiency. The likelihood of excess can be discounted for practical purposes.

**Other Elements.**
Several other elements are required by a plant for healthy development, but only in minute quantities. They are accordingly known as trace elements, namely sulphur, copper, zinc, manganese, boron and molybdenum. They are invariably present in both soils and composts in adequate quantities, and for normal purposes can be conveniently forgotten. Of the foregoing elements those most likely to need replenishing are nitrogen, phosphorus, potassium and calcium.

**AIMS AND IDEALS**
At all times try to match your plants against the ideal, and if they fall short in any way try to ascertain why. Leaves should not be excessively dark in colour, bloated and brittle to the touch (as in nitrogen excess), nor should they be thin, pale and small (as in starvation). The ideal foliage is sizeable for the cultivar without being huge, though leaf size and colour varies with the cultivar. Stems should be thick and firm without being "gouty" and sappy. Try to keep plants moving steadily forward without checks and many of your troubles will be over. Where defects do develop ask yourself why. Note whether peculiar leaf symptoms apply to just one plant, one cultivar or the whole collection.

It is unlikely that the cause is nutrient deficiency or excess if the symptoms are confined to one plant or one cultivar. Ask yourself whether the defect could be connected with air, light, water, warmth, food, pests-or what? Learn to read your plants for the presence of pests, as well as for physiological defects.

A stunted and nibbled appearance in shoot tips can be due to capsids; thrips can cause shoots to become "blind"; white moult cases and "gum" deposits on the leaves are an indication of the presence of aphids under the leaves above. Keep an eye open, too, for the tell-tale frass of caterpillars and earwigs, especially when the blooms are opening. So often we are unaware of the presence of pests until such signs lead us to make a thorough inspection.

It is good experience to visit exhibitions and nurseries to assess standards whenever the opportunity arises. To see plants growing is especially helpful. The difference in growth and foliage between cultivars receiving identical culture is remarkable, and many fears for the health and adequacy of one's own plants are allayed on the spot. So many apparent defects are simply cultivaral peculiarities. It is sometimes said that you cannot produce good foliage and good blooms, and there is an element of truth in this. Too much nitrogen is indeed undesirable, for it can produce coarse, lush foliage at the expense of bloom quality. It is possible, however, to produce good foliage and good blooms if we pay attention to the balance of fertilising elements applied and watch the condition of growth as the season proceeds.

Excess of one element can be just as harmful as deficiency; so, too, can balanced excess of all the main elements. A spartan diet in the vegetative period can lead to small blooms of poor colour; an excessive diet in the flowering period can lead to a general reduction of bloom quality. In general, aim at sturdy and healthy development, with plants moving steadily forward throughout the entire vegetative and bud development cycle, but slowing down on a less nutritive diet during the period of flower development.

Purple Chempak Rose