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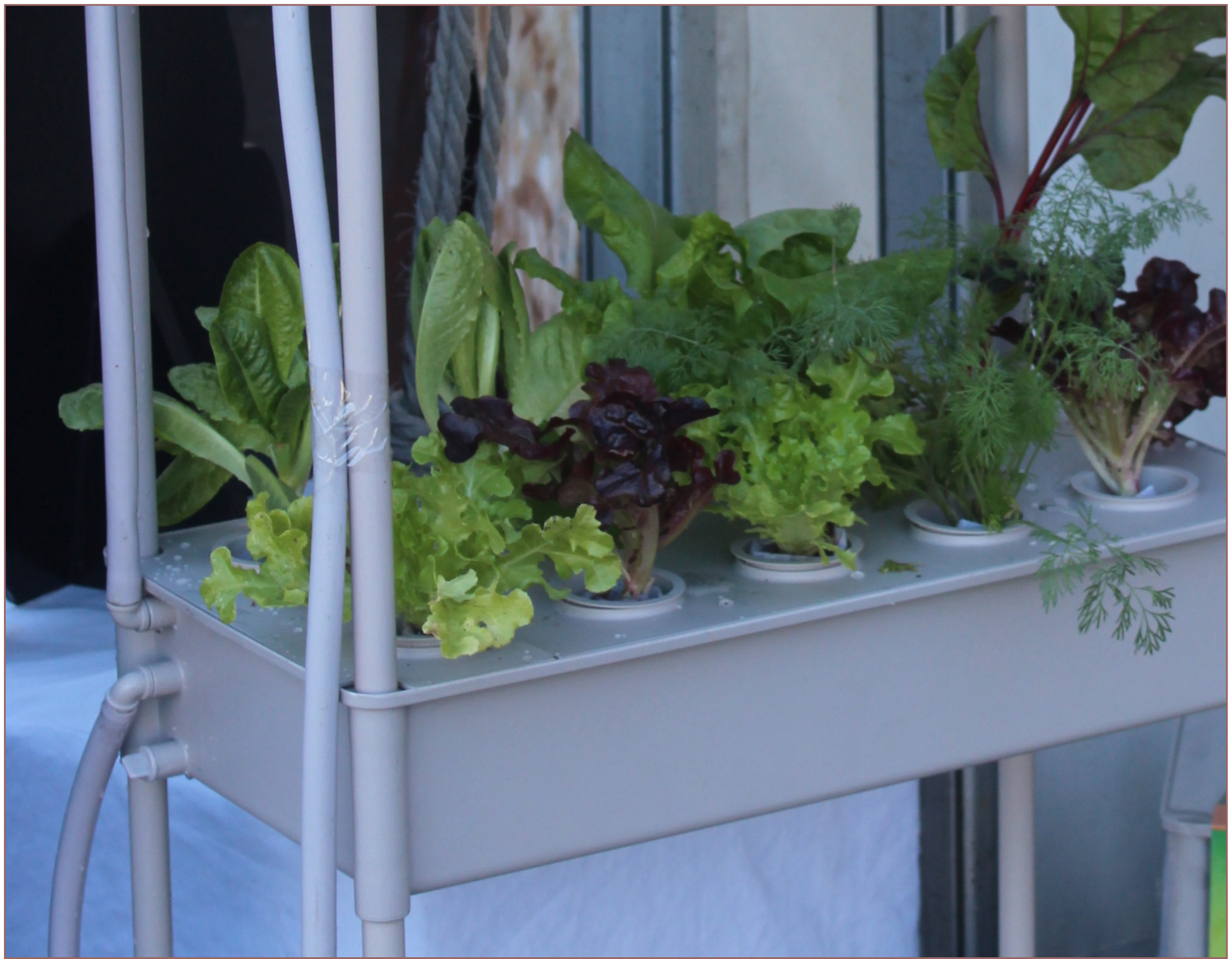
LESSON 1 INTRODUCTION

Plants, like any living thing, need food to grow. In nature, such plant food comes from the soil. If we grow a plant using tissue culture or hydroponics, there is no soil as such, meaning the nutrients must be supplied artificially.



Hydroponics

Artificial Growing

Artificial growing provides the advantage of having total control over the nutrients the plant does and does not get. This also provides an opportunity to add other things into a chemical solution (e.g. hormones to regulate growth, chemicals to control pathogens). It also presents the challenge of trying to balance what is supplied and how it is supplied.

Artificial growing can be more complicated, but if managed really well, it provides opportunities that do not exist when you grow plants in soil.

Suggested Tasks:

Throughout this course you will be provided with suggested tasks and reading to aid with your understanding. These will appear in the right hand column.

Remember: these tasks are optional. The more you complete, the more you will learn, but in order to complete the course in 20 hours you will need to manage your time well. We suggest you spend about 10 minutes on each task you attempt, and no more than 20 minutes.

Plants obtain nutrients two ways:

1. Through the roots – mostly mineral salts dissolved in water are absorbed through roots.

2. Through foliage – mostly carbon dioxide and oxygen gasses are absorbed through foliage.

Note: Oxygen and carbon dioxide can be absorbed through roots to some extent. Water and other nutrients can be absorbed through foliage too.

Other than Carbon (C), Oxygen (O), and Hydrogen (H), plants need a range of macro and micronutrients in order to grow well. The six macronutrients (needed by plants in larger amounts) are: Nitrogen (N), Phosphorus (P), Potassium (K), Magnesium (Mg), Calcium (Ca), and Sulphur (S).

Micronutrients (or trace elements) are taken up in much smaller (even minute) amounts and include Iron (Fe), Zinc (Zn), Manganese (Mn), Copper (Cu), Boron (B), Molybdenum (Mo) and Chlorine (Cl).

Most soils have ample quantities of calcium and magnesium and therefore fertilisers used in general horticulture are almost completely made up of nitrogen, phosphorus and potassium (NPK). In hydroponics though, it becomes necessary to add large amounts of magnesium and calcium.

Tissue Culture

Tissue culture is a method of propagating and growing plants from small pieces of plant tissue, sometimes so small that magnification is necessary when handling them. The tissue used does not contain plant parts like roots, stems and leaves but rather just cells from roots, stems or leaves. Or it may contain undifferentiated meristematic tissue (like stem cells from a human). Plants cultivated this way will require both a mixture of nutrients to feed them and other chemical additives: vitamins, carbon, sometimes hormones (growth regulators to encourage cell differentiation), sometimes specific reagents to restrict growth so as to stimulate them to grow all the different types of cells needed to become a complete plant (i.e. roots, stems and leaves). This makes the culture medium and medium formula used the most crucial aspects of successful tissue culture; the medium formulae vary depending on the purpose of the tissue culture.

Because a plant grown this way is incomplete, and very tiny, it is particularly vulnerable to diseases; hence it needs to be grown under laboratory conditions until it is large enough to resist disease, absorb nutrients through developing roots and continue to grow without a high level of assistance.

Tissue Culture

Hydroponics

Hydroponics involves growing plants without soil; but it is different to tissue culture in that the plants have fully differentiated tissues (i.e. stems, roots and leaves) from the start; and the plants are larger and more able to grow without the level of protection and human intervention provided for tissue culture in a laboratory.

Both tissue culture and hydroponics share one thing in common – the grower is taking control over supplying nutrients to the plant. In doing so, the grower has the potential to manage the plant growth more effectively that what is possible when growing is soil.

Nevertheless, every plant species is different and has different nutritional requirements. Therefore, the optimum nutrition required by each type of plant will be different. The nutrients made available by soil, or by feeding plants can have a big impact on the status of a plant in many different respects:

- Vigour
- Tolerance to different types of adversity (e.g. environmental extremes, disease)
- Type of growth (e.g. fruit, flower, foliage, roots)
- The quantities of different chemicals found in the plant tissues

The nutrients which a plant absorbs and incorporates into its tissues will affect its chemical composition. Food crops, for example, can become more or less nutritious. Plants may develop more or less of one type of tissue (e.g. leaves, flowers, fruit).

How Plants Uptake Nutrients

To gain a better understanding on how to formulate and supply nutrients to plants in the rates that are needed for good, healthy plant growth in hydroponics – you need to know, in a general sense, how plants uptake and use nutrients.

Nutrients available to the plant vary depending on the chemical and physical nature of the environment, the species being grown and its stage of growth. Plants obtain a substantial portion of their oxygen from the atmosphere. The remainder of nutrients, including hydrogen, required for plant growth absorbed from soluble elements in water.

Light intensity, temperature and water supply determine how effective plants are at using available nutrients. Nutrients and water absorbed are translocated through the plant dependent on the relationship with the membranes and the solution, and the concentration of nutrient ions around a plants root zone.

Plant nutrients can be supplied, broadly speaking, in three different forms:

1) Water-soluble simple chemical compounds: nutrients in these compounds are readily available to plants (i.e. the plant can absorb them quickly and easily).

2) Less soluble simple chemical compounds: the nutrients in these compounds can be used by plants without needing to undergo any chemical change, but because they don't dissolve so easily in water, they aren't as readily useable as the more soluble compounds. The diminished solubility may be because of the nature of the compound (e.g. superphosphate) or may be due to something else (e.g. slow-release fertilisers, such as Osmocote, which are made by incorporating the simple chemicals inside a semipermeable bubble where nutrients move slowly out of the bubble). This second group of nutrients when placed in soil will last longer than the first group of water-soluble nutrients.

3) Complex chemical compounds: these require chemical changes to occur before the nutrients can be absorbed by plants. They include organic manures and fertilisers which need to be broken down by soil microorganisms into a form which the plant can use. They also include other complex fertilisers which need to be affected by natural acids in the soil, or heat from the sun, to become simple compounds which the plant roots can use. Complex chemicals release their nutrients gradually over a long period of time, depending on the range of chemical changes needed to take place before the plant can use them. Plants grown in soil derive their nutrients from all three types of compounds. The availability of these compounds varies according to not only the group they come from but also according to factors such as heat, water, soil acids and microorganisms present. As such, it is impossible to control the availability of nutrients in soil to any great degree.

Prior to their absorption into root cells, nutrients reach the surface of roots by three mechanisms: mass flow, diffusion, and root interception.

Mass flow: this is the most important of these mechanisms quantitywise, and is the movement of plant nutrients in flowing soil solution.

Diffusion: this is movement by normal dispersion of the nutrient from a higher concentration (such as near its dissolving mineral source) through soil water to areas of lower concentration of that nutrient. It is different to osmosis which is where solvent molecules will move through a *semipermeable membrane* from a region of low solute concentration to a region of high solute concentration.

Root interception: this is the extension (growth) of plant roots into new soil areas where there are untapped supplies of nutrients in the soil solution.

All three processes are in constant operation during growth. The importance of each mechanism in supplying nutrients to the root surface for absorption by the root varies with the chemical properties of each nutrient. Nevertheless, mass flow, because of the large amounts of water flowing to, and absorbed by, roots as water is transpired from the plant is the dominant mechanism and supplies about 80% of most nutrients to root surfaces.

The mechanisms of absorption into the root cells are not well understood. The cell walls are porous, and the soil solution can move through some or all of the cell walls, causing intimate contact of the soil solution with the outer membranes of the cells. For a nutrient to cross a cell membrane into the cell, it is believed that each nutrient