How to grow herbs and vegetables more efficiently:

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Every plant grower knows the need to achieve optimum productivity, whether in a greenhouse, field, garden, hydroponics, or aquaponics system.

So how can you do better? How can you improve on tried and tested growing practices? The answers concern the better understanding, working with, improving on, and managing the growing conditions of your plants. It does not matter whether you are growing aquaponically or hydroponically with a soil-less substrate, or traditionally in a more conventional way. The principles are the same.

Start with the basics. Through its leaves, a plant takes in light and carbon dioxide (CO_2) from the atmosphere. Primarily through its roots, it takes in water and nutrients as ions from the soil or growing environment. It converts light and CO_2 into chemical energy (as sugars), and releases oxygen (O_2). The plant uses these sugars, the water, and nutrients for its growth.

Just like our own biological system, the growth and development systems of a plant is complex. However, it is well understood. It is also highly efficient, having been refined by nature over countless growing generations.

The key factors to manage:
It is particularly important to watch and respond to the key factors listed below. They are essential to growing successful plants or better crops.

- Environment
  Humidity range, clean air, proper CO_2/ oxygen (O_2) ratio, adequate air circulation, light-sunlight or plant lamps, support.
- Plant Food
  Sufficient nutrients in the root zone and in an available form for the plant.
- Temperature
  Of the soil, media, environment, and water.
- Water
  Sufficient levels, good quality and drainage.
- pH level
  Allows uptake of essential ions.

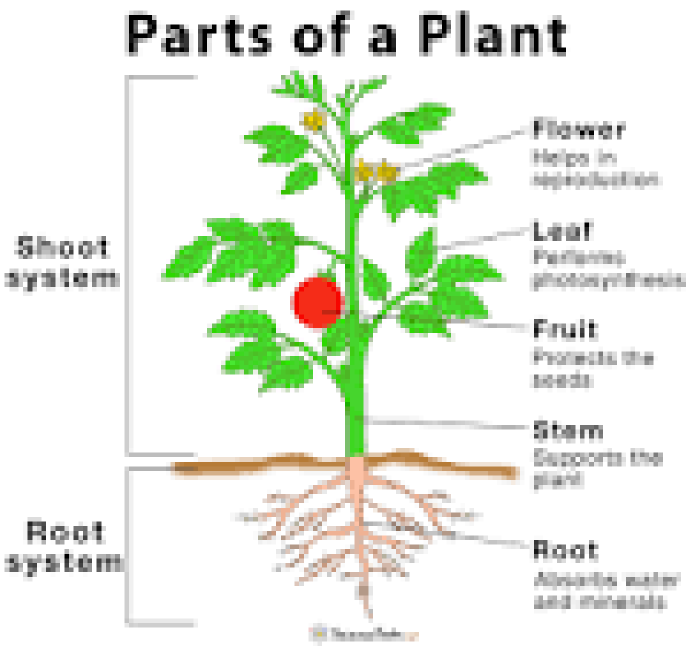
Understand the basic structure of plants:
Plants are essential for any ecosystem. They provide all the energy for the ecosystem because they can get energy directly from sunlight. They use a process called photosynthesis to use energy from the sun to grow and reproduce. They also need nutrients from the soil.

Before considering how plants grow without soil, it is necessary to understand, as far as possible, how they grow in their normal environment – soil. To do this, however, a basic knowledge of what constitutes a plant is the first requirement.

An ordinary plant has three main parts, namely:
- the root system,
- the stem, and
- the leaves.

In addition, there is the flower for reproducing the species. Without the aid of a magnifying lens, it would not be realized that the various main parts are built up of cells. These are the structural units of the plant body like the human cells, which build up our own body.

Plant cells are filled with a fluid known as *protoplasm*, which is responsible for the life of the plant. This protoplasm is complex and not yet fully understood by science. Mineral substances, fats, proteins, and sugars are necessary constituents of this life-giving protoplasm.



The root system:
Roots serve the purpose of anchoring the plant in its growing medium (normally soil), as well as the vital role of absorbing water and the mineral salts present in the soil. Roots branch profusely, giving rise to a complex reticulation system. Tiny root hairs stick out of the root, helping the absorption process. These fine hairs have semi-permeable cell walls. This means that they have the selective property of allowing certain minerals and water to pass through them. The fine rootlets normally intertwine around the soil particles, and by the phenomenon known as osmosis absorb water when the plant requires it.

The stem:
This is usually the least specialized part of the plant. Stems are the main support structure of the plant. They also function as the plant's plumbing system, conducting water and nutrients from the roots to other parts of the plant, while also transporting food from the leaves to other areas. Stems can be herbaceous, like the bendable stem of a daisy, or woody, like the trunk of an oak tree.

Leaves:
Most of the food in a plant is produced in the leaves. Leaves are designed to capture sunlight, which the plant then uses to make food through a process called photosynthesis. In the presence of sunlight, carbon dioxide from the air combines with water to form simple sugars. The remarkable green substance responsible for this transformation is known as chlorophyll.

The second significant role the leaf plays is one of air-conditioning. By means of numerous little pores, called stomata, situated on the underside of the leaf, water vapour evaporates into the atmosphere, thereby cooling the plant on a hot day. This is known as transpiration.

The stomata also allow carbon dioxide and oxygen to diffuse into the leaf during photosynthesis and respiration, respectively. Respiration refers to the function of breathing analogous to our own breathing. Respiration, which is accompanied by the intake of oxygen and breakdown of sugars into their original components, carbon dioxide and water vapor, takes place at a slow but steady rate

all the time. Photosynthesis occurs only in the presence of light of sufficient quantity and quality.

Flowers:
Flowers are the reproductive part of most plants. Like most living organisms, the plant has its male and female parts. Flowers contain pollen and tiny eggs called ovules. After pollination of the flower and fertilization of the ovule, the ovule develops into a fruit.

Most plants have male and female parts in the same flower, e.g., the tomato. Some have a mixture of separate male and female flowers on the same plant, e.g., the cucumber. Still others have male and female flowers on different plants, e.g., the pawpaw.

Reproduction may also take place asexually. An example is the propagation of the species by means of leaf, stem, or root cuttings.

Fruit/seeds:
Fruits are developed parts of flower ovaries that contain seeds. Seeds are the reproductive structures of plants, and fruits serve to help disseminate these seeds.

Plant nutrition:
Just like us, plants need to secure food sources. Through photosynthesis, they convert energy, but that is not enough to sustain them. They need specific nutrients. However, it is not as simple as feeding nutrients in any old form or amount. Plants need appropriate soluble nutrients in the correct quantities. Highlight this in your mind. It is key to everything else.

There are four main things to consider:
1. The nutrient quantity of each plant needs for each stage of its life, cycle, e.g., generative, or vegetative.
2. All plant species have different nutrient requirements.
3. The ratio of nutrients, as the nutrients, can "interact" with each other and enhance or prevent the plant from absorbing them.
4. And, whether the nutrients we add are available to the plant.

With complete nutrient mixes at hand, it is easy to reach for this or that plant food product. However, just as in people, an

unbalanced diet in plants leads to nutrient deficiencies and toxicities. You can see this in stunted growth and damaged or yellow leaves. The primary means of nutrients uptake is through the roots. Nutrients are carried up by water when dissolved. In fact, plants can only absorb nutrients in their dissolved form as ions.

Managing pH is vital to ensure nutrients remain soluble and available to the plant. You need to control the pH of the root zone environment and the Nutrient solution or fertilizer you are using.

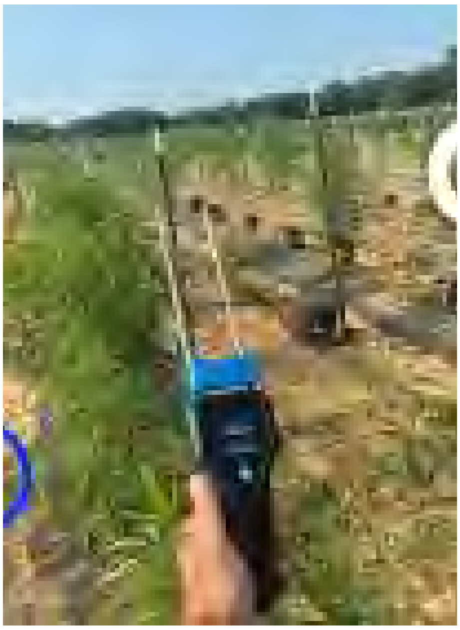
Essential plant nutrients:

- Essential nutrients:
  Plants need most, if not all, of at least 17 different elements for optimum growth and health.
- Non-mineral nutrients:
  Obtained from air and water Carbon (C), hydrogen (H), and oxygen (O).
- Primary macro-nutrients:
  Required in the greatest quantities. Building blocks of critical cellular components.
  Nitrogen (N), phosphorus (P), potassium (K).
- Secondary macro-nutrients:
  Also required in large amount and assist the transport and function of the primary macronutrients.
  Calcium (Ca), magnesium (Mg) and sulphur (S).
- Micro-nutrients:
  These are only required in trace amounts, but still just as important!
  Baron (B), chloride (Cl), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn), molybdenum (Mo), nickel (Ni), silicon (Si), and cobalt (Co).

The last two mentioned – silicon and cobalt – are not technically essential nutrients, but when used do improve growth and plant health.

What else do plants need?

- Light – key reactant for converting energy, through photosynthesis, into a usable form.
- Oxygen – a by-product of photosynthesis, but also absorbed by the roots. They do not undergo photosynthesis but still, require oxygen.
- Water – carries the soluble nutrient ions from the root zone (the area close to the roots) into the root due to transpiration. The plant roots need to be in a moist environment.
- Transpiration – the process by which the plant loses water through the leaves by evaporation, which pulls more water in through the roots.
- Temperature – the temperature of the environment affects the plant's internal temperature and how much water exchange is required to cool it down. This goes hand in hand with the humidity of the environment. Temperature can affect specific nutrient absorption.
- Humidity – the amount of water present in the atmosphere, and how easy it is for the plant, to lose water by evaporation. With



high humidity, there is a lot of water in the atmosphere, so it is hard for the plant to lose water and vice versa.

Control of pH and nutrient availability:
Quick science: the nutrients that a plant takes up are present in their purest and simplest form as ions. To be available to the plant they need to be soluble (dissolved in water) and have a positive or negative electrical charge.

The pH value we measure is also based on ions: specifically, hydrogen ions (H^+). The amount of H^+ present determines the acidity or alkalinity of whatever you are measuring. The pH is a ratio between H^+ and hydroxyl groups (HO^-). If more hydrogen ions are present, the pH will be acidic (0-7), and if there are less H^+ relative to OH^-, the pH will be alkaline (7-14).

The hydrogen and hydroxyl ions that determine the pH play a particularly vital role in nutrient availability. They can interact and bind to nutrient ions and make them drop out of solution in an insoluble form – meaning the plant is unable to recognize and absorb them. If this happens, you get nutrient wastage, and you may have equipment blockages.

Each nutrient ion has a pH range within which it will be soluble (available to the plant). Outside this range, the ions could interact or change their chemical form and become unavailable. Known as "nutrient lockout", it is a leading cause of nutrient deficiency, especially with nutrients such as iron and molybdenum.

Nutrient lockout is not easy to reverse. Take care to prevent this from happening.

Water quality requirements:
Not all water is equal. Do not assume any water you use will benefit crop health. You might be surprised at the levels of physical, chemical, and microbial contaminants discovered in a survey of commercial horticultural operations.

Pure water (H_2O) is composed of equal parts the hydrogen ion (H^+) and hydroxyl ion (OH^-) and nothing else. A balance of H^+ and OH^- produces a neutral pH of 7. Pure water contains no other minerals, microbes, pathogens, or other contaminants. Monitoring water quality can help determine how pure your water is, meaning how close it measures to pH 7 and an EC value of zero or close to zero. In our world today there are few sources of pure water, therefore growers should establish a water monitoring and treatment program that enhances the ability of water to hydrate and transport essential minerals and plant available nutrients to the plant. Irrigation management can be improved with an awareness of its contents, to determine the level of treatment needed and help you prevent problems further on.

Thus, pure water is used as a reference point in growing systems because there are no contaminants interfering with water treatment and has nothing present that could be detrimental to the plant growth or to the

performance of any of the added nutrients.

Making sense of Electrical Conductivity (EC):

Measuring electrical conductivity is one of the most important things to do during growing. Why EC? Simple. The electrical conductivity of a nutrient solution is a vital measure of the total available nutrients in the sample. When nutrients (or other salts) dissolve in water, they split into ions. For example, potassium nitrate dissolves into a potassium ion and a nitrate ion. Each ion carries an electrical charge (potassium carries a positive charge and nitrate a negative charge).

The ions enable water to conduct electricity. Without these ions, water is not a good conductor. The more ions present, the better the water conducts electricity.

The central fact is this, only nutrients that are in an ionic form are available to be absorbed by plants. So, measuring the electrical conductivity of the water is a really effective way of measuring the strength of your nutrient solution. It does not give information about individual nutrients. However, it is an incredibly useful guide to its overall strength. In general, if your EC is exceptionally low, your plant probably doesn't have enough "food". If your EC is extremely high, you may run the risk of burning the roots or toxic build-ups.

Conclusion:

The essential nutrients that the plant requires for healthy growth are always in the same form. For example, nitrogen can be available to the plant to absorb as ammonium (NH^{-}), and nitrate (NO^{-}) and potassium is always present as K^{+}. This is because plants have evolved highly selective and sophisticated transport mechanisms to recognize nutrients in these forms and only absorb these. The plant will not selectively absorb nutrients based on their origin, organic or not. It only responds to a particular nutrient form. This response does not change, whether it is an organic or direct application. Plant growth and health depend on having sufficient nutrients available in their appropriate form.

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Some pictures are from Google images.