ICARDA

Arabian Peninsula Regional Program

**Handout**

# Establishment of Soilless Culture (Hydroponics) closed system under Protected Agriculture

# Handout for
# Establishment of Soilless Culture (Hydroponics) closed system under Protected Agriculture

Soil is the most available growing media and plants normally grow on it. Soil main functions are to provide anchorage, nutrients, air and water to the plants rooting system. However, soils do pose serious limitations for plant growth, at the time. Presence of disease causing by soil organisms and nematodes, unsuitable soil reaction, salt accumulation due to irrigation, unfavorable soil compaction, poor drainage, degradation due to erosion, etc. are some of them.

In greenhouses, agricultural practices in soil will increase the soil-born pathogens such as Nematodes and accumulate salinity. Moreover, the present conventional growing system in soil, wastes a lot of fresh water due to run off and deep percolation. In arid countries, rapid evaporation from the soil surface may also lead to salinity problems.

To address such problems, ICARDA developed, simplified and introduced soilless culture techniques which are applicable at the growers' field in the Arabian Peninsula.

## Why Soilless Culture?

In the absent of soil in hydroponics systems, soil related constrains are likely disappeared which prevent the expensive soil sterilization process and application of hazardous agro-chemical in greenhouses.

Hydroponics offers opportunities to provide optimal conditions for plant growth and therefore, higher yields can be obtained compared to conventional soil base agriculture.

Soilless techniques also offer a way of improving water-use efficiency and obtaining better water and fertilizer management in crop production.

The advantages of soilless culture over normal soil bed systems include:

1. Provide very efficient use of water by reclaiming and reusing;
2. Shorter cropping cycle allows for more crops within the season;
3. Top quality crops grown out of the depleted or contaminated soil;
4. Increased production per unit area;
5. Reduction in labor requirement by more than 50%;
6. Increased job satisfaction among workers;
7. Better control of water and nutrients;
8. Elimination of the costly operations such as sterilization, soil cultivation, base fertilizers and weed control.

## What is Soilless culture?

Soilless culture or Hydroponics is a growing technique which plants were grown in nutrient solutions that supply all nutrient elements needed for optimum plant growth. Number of inactive media such

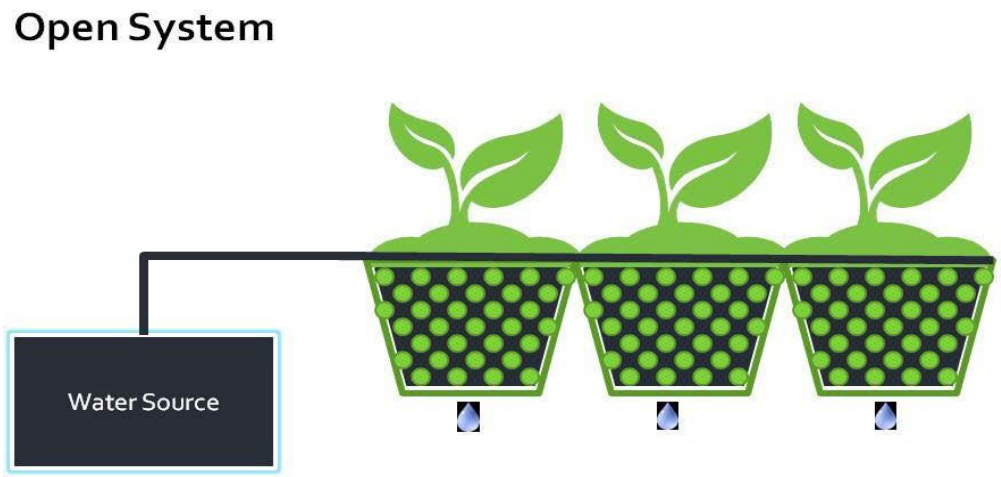
as gravel, vermiculite, rock wool, peat moss, saw dust, coir dust, cocopite, etc might be used to provide mechanical support.

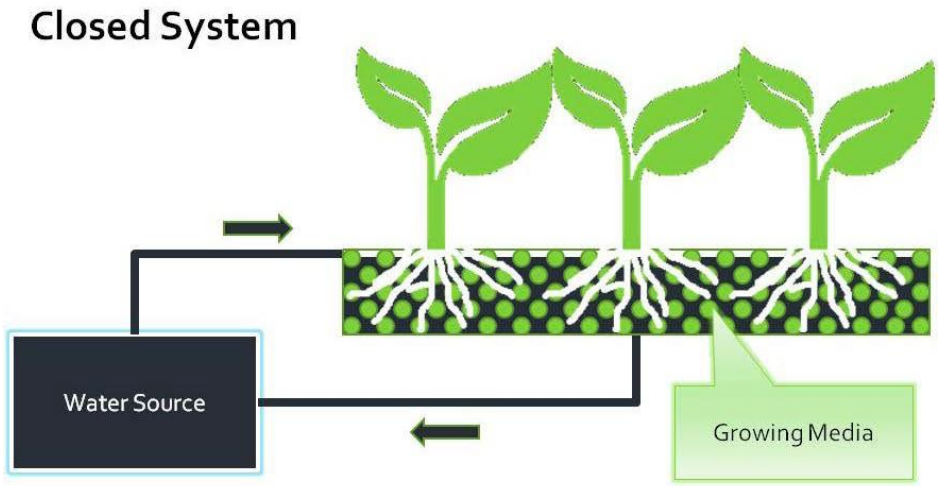
## Different soilless culture systems

There are two main types of soilless cultivation:

Open systems, where plants are grown in containers or channels filled with an inert medium. Water and nutrients are supplied through drip irrigation and the surplus nutrients and water is allowed to run off as waste. The substrate must be inert and have a high water-holding/ release capacity. Maintenance of appropriate water and nutrient levels within the substrate is essential to prevent plant stress.

Closed systems, where plants are grown in pipes or channels lined with polyethylene, with a film of nutrient solution circulating through the roots and back to a catchments tank. This provides good contact between the recalculating solution and air, sufficient to maintain the oxygen level required by the roots without additional aeration of the solution.



## Establishment of a close hydroponic system in greenhouse

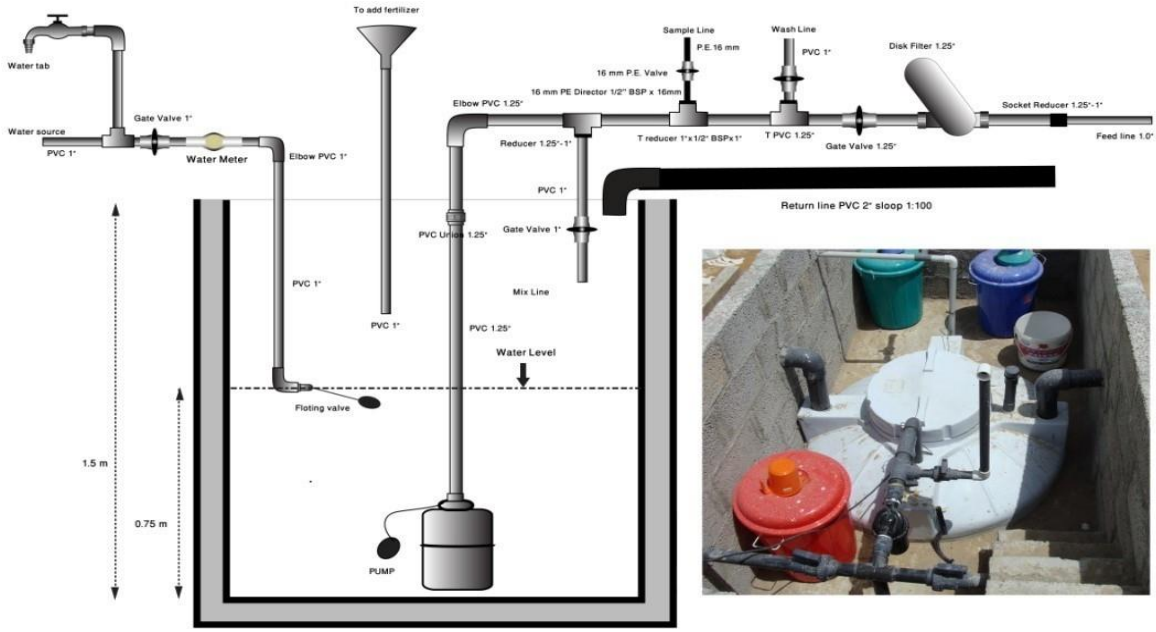
To establish soilless production systems different materials for growing canals can be used including PVC flooring sheets, PP or PE sheets, cement blocks lined with PE sheets, etc. the important issue here is to use locally available materials for establishment of the systems as well as reduce the required capital cost. However, the cement blocks are more available than the other materials, at the same time they are not very expensive and have higher life time inside greenhouses.

Number of the canals for the greenhouse is based on the plant density (please see under “Planting in Soilless System,”) area, width and high of the greenhouse.The following pictures illustrate different steps for establishment of a soilless production system using cement blocks. Then again, most of the steps are similar between different systems.

1- Level and compact the greenhouse soil. The slope (1:100) should be made toward the middle of the greenhouse


2- Fix the irrigation tank beside and middle of GH where the tank head stays 30cm under soil level. A $2m^2$ tank (500 US gallons) can cover two normal GH (8 x 36m). All the sharp age or big stone under the tank should be removed before putting the tank inside the hole.


3- Fit the connections for irrigation and collection lines. Solution will pump to system through 1¾“ or 1½“ pipes and return in 2-3” pipes. The water source should be connected with 1” pipe and a flutter. The flutter should be fixed in the middle of the tank.





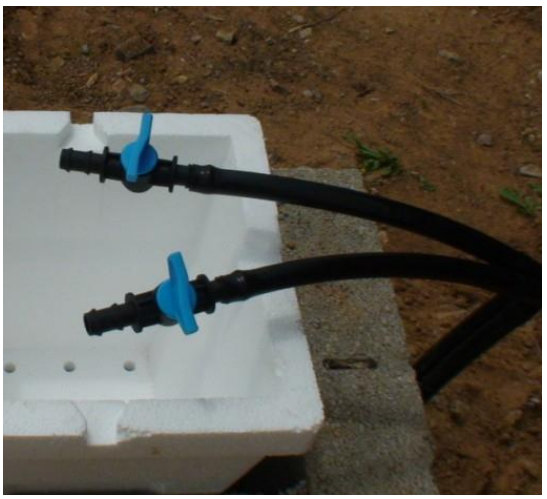

4- Set growing canals using cement block 10 x 20 x 40 cm. the inside width should be 21 cm. for 6 to 9m width GH 4 canals is enough. The space between first lines to GH walls should not be less than 1m if the greenhouse has Quonset shape. Consider a lateral ditch in the middle of GH for solution retune line which is a 2-3” PVC pipe.

5- Using plastic sheets and sink connection in middle of growing canals for connecting growing canals to solution return line. Cover the return line ditch by soil, complete growing canals

6- Fix the slob inside canals. Remove stones that could tear the plastic sheet. Line the growing canals with black PE sheet. The sheet should set completely on the bottom of the canals while the edge of it reached to corridors and covered by soil/gravel.


7-cover the bottom wholes of the Polystyrene pots with a fine mesh and fill them with growing media. Put them in growing canals with about 30cm center to center. The bottom of pots should not touch the canal. The growing media can be different inactive medium based on available materials. Similarly the Polystyrene pots can be replaced by any available containers. In some cases media can be used directly inside the canals, although this is not recommended.


8- Use 2 dripper lines (4l/h) for each growing canal. The dripper space should be 30 cm. the lines should connect to feed line using 1" HPVC pipe. Fix 16mm PE valves at the beginning of each dripper line.




8- Fix the submersible pump inside the tank. To select the correct pump please check with distributor agents. Install electric panel beside tank and connect pump to automatic switch or controller. It is recommended instead of timer use automatic hydroponics controller, although it is more cosrly.



9- Connect irrigation and return line to pump and tank. Use a fine mesh as filter for return line. Wash the tank. Connect the tank to water source and full the tank. Do not use salty water. Run the water and test the system.



## Planting in soilless system

Use polystyrene foam (PED) pots filled with growing media to plant the seedling. The growing media could be perlite or mixture of 50% perlite and 50% peat moss. Before planting, start pump and run the system for 1 hour. Each pot (23.5x23.5 cm) can accommodate 2 plants. Number of plants and pots should be calculated based on the greenhouse areas and crop density. For example cucumber plant density in greenhouse should be 2.5 to 3. In a greenhouse with 240$m^2$ (8x30m) number of plant will be 600-720 or 150-180 plant per growing canal which needs 74-90 pots in each row. The seedling should not be at the far corner of the pots otherwise the roots will not have enough space.

It is better to use seed starting pots or seed trays. The important point is that during the planting the seedling itself should not be touched. After the planting seedling the system should run continually for at least another 1-2 hours, before starting the routine irrigation timing program.




## Solution Management

While optimum nutrition is easy to achieve in hydroponics, incorrect management of the nutrient solution can damage the plants and lead to complete failure. The success or failure of a hydroponic depends primarily on the strict nutrient management program. Carefully monitoring and manipulating the nutrient solution pH level, temperature and electrical conductivity and replacing the solution whenever necessary are the key issues.

The required nutrition should add to the solution using liquid fertilizer such as the Kristalon. To balance and maintain the PH and EC of the solution at the level suitable for the plant growth, Nitric Acid and Calcium Nitrate would be used. The solutions should be kept in three different stock containers. Use different colors for the containers. The following table is showing the density of each stock solution for Number of vegetable crops. PH and EC of the solution should be measured and corrected on daily bases by PH and EC meter. The PH and EC were maintained 6-6.5 and 2500-3000 during the production period.

Table 1 - Stock Solutions for some vegetable crops in soilless production system

| | Tomato | Cucumber | Lettuce |
|---|---|---|---|
| **Stock Solution 1** | | | |
| Water | 40 L | 40 L | 40 L |
| Ca(No3) | 11 kg | 9.5 kg | 11 kg |
| EDDHA (Fe) 6% | 600 g | 600 g | 600 g |
| **Stock Solution 2** | | | |
| Water | 40 L | 40 L | 40 L |
| Kristalon Red 12-12-36+1+TE (Purity 60%) | 14 Kg | 12 Kg | 10 Kg |
| MgSo4 | 1.2 kg | 1.2 kg | 1.2 kg |
| Microplex | 400 g | 400 g | 400 g |
| **Stock Solution 3** | | | |
| Water | 40 L | 40 L | 40 L |
| Nitric Acid | 2 L | 2 L | 2 L |
| EC | 1st week 2500<br>2nd week 3000<br>3rd week 4000<br>4th week 5000<br>6th week 3000<br>Keep 2500 in summer season | 2500-3000 | 2500-3000 |
| PH | 5.0-6.0 | 5.0-6.0 | 5.0-6.0 |

For adding the nutrition; first put the pump on manual to run continuously; then shutoff the feed line and open the pump return gate valve; add the solutions as requirement and measure and balance the PH and EC; then open the feed line and close pump return.

## Important management issues regarding the stock solution management:

1- The fresh water using for the irrigation should be good sweet water with PH about 7 to 7.5. The formulation for fertigation is based on water with PH 7 to 7.5. Using water with low PH which normally comes from RO unit reduces the solution PH less than 5 and negatively affect the plants.

2- The fertigation solution should be completely refresh and tanks to be cleaned and washed every 15 days. The old solution should not be considered as wait water which is a very fertile for field crops and date palm.

3- The gate valve connecting the fresh water to the tank through the floating valve should always kept open. This will adjust the PH of the solution. If you have problem with overflow, please adjust the water level inside thank using floating valve.

## Enhance the nutrition management in Hydroponics using Intellidose automatic controllers

Maintaining the suitable PH and EC of the nutrition solution is the key of success in soilless production systems. Controlling the PH and EC manually, although possible, is not very effective and the situation between two measurements cannot be monitored and enhanced. The Intellidose is an automatic hydroponics solution controller. All on-demand dozer has the job of adding fertilizers and/or pH correction fluid to the reservoir tank repeatedly until the set point(s) are reached. It also has alarm so that a siren will sound if the EC or pH wanders too far from the set point. In addition it has shutoff systems to stop injection after receiving the set point. Therefore, the plants can continually receive the optimum fertilizer through nutrition solution. This has a very positive impact on yield and fertilizer efficiency. In some cases using Intellidose increase the production up to 50%.

## Intellidose automatic controller's parts and setup

The main part of an Intellidose automatic controller are including

1) Intellidose Controller
2) Triple peristaltic pumps
3) Sample pot, EC and PH probes

Installations of the IntelliDoes units are very simple. The diagram below shows a typical installation chart.

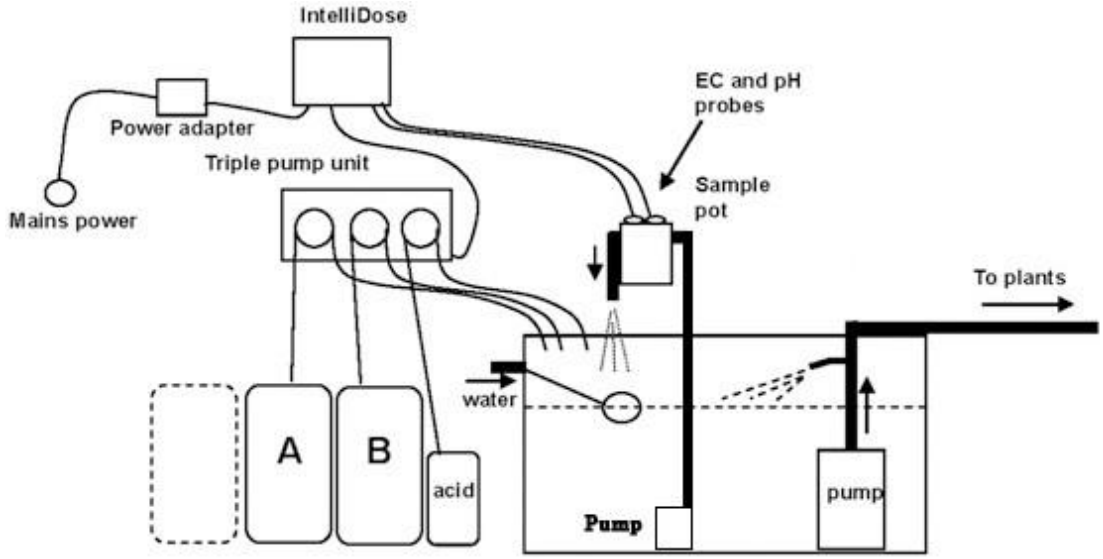



Figure 1 - Simple Installation of Intellidoes automatic controller using Triple Prestatltic pumps

## Setting from the controller key pad

Operation of the keypad is similar to a cell phone. The two keys at the bottom of the display are “soft keys”. This means that their function at any particular time is shown on the screen above them. After switching on you will find that the right hand key has the label “menu” on the LCD above it and the left hand key is unused at this point. To the right of the LCD screen are two arrow keys. These are for moving down or back up, through the menus and when you are in a screen which allows you to edit a numeric value they are used for incrementing or decrementing the values. They are also used to select between different options.

On first pressing the “menu” button, you will find yourself in the main menu. Use the down arrow to move down through this and you will find the following items

**DOSING**
**CALIBRATION**
**OVERRIDES**
**IRRIGATION**
**ALARMS**
**CLOCK**
**CONFIGURE**

If you wish to make a change to, say, Dosing, you would move down to Dosing and then press the “enter” key in order to enter the Dosing sub-menu where you can adjust PH and EC dosing set point, time and interval of injections. Now again by pressing the down and/or up arrows move through this sub-menu to find the item that you wish to change and then press enter to

access this item. After making any changes the soft keys will allow you to either save the new setting or to cancel and exit out of that screen.

The setup and adjustment of the system will be explained during the practical sessions.

## Crop management

Crop management and training in the soulless culture is almost the same as crop management and training of the cash crops under protected agriculture. Implementing the Integrated Production and Protection Management (IPPM) techniques with soilless culture will help to significantly reduce the negative effect of pest and diseases.




# COPPER


**DEFICIENT** Stunted growth, distorted younger leaves, growing tip dies.

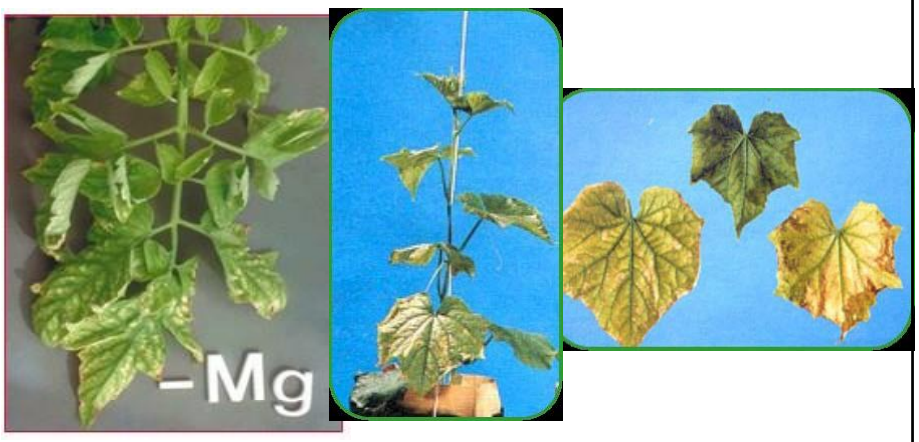
**EXCESS** Induces iron deficiency

# CALCIUM


**DEFICIENT** The tips of the shoots and roots turn brown and die. Causes blossom end rot in tomatoes and tip burn in lettuce.

**EXCESS** Causes either magnesium or potassium deficiency symptoms.

# MAGNESIUM




**DEFICIENT Yellowing of older leaves between veins. Severe deficiency produces death of older leaves and *chlorosis (paling or yellowing of leaves from insufficient chlorophyll) of the entire plant.***
**EXCESS *No specific symptoms***

**Treatment** use Magnisal® in a nutrient solution containing 30 ppm Mg.

# SULFUR


**DEFICIENT** Light yellowing most pronounced in the younger leaves. Very similar to nitrogen deficiency. Roots longer that usual, stems become woody.
**EXCESS** Premature leaf death.

# IRON


**DEFICIENT** Yellowing, inter-veinal chlorosis of younger leaves.
**EXCESS** No symptoms.

# MANGANESE


**DEFICIENT** Stunted growth, inter-veinal chlorosis of younger leaves.
**EXCESS** Older leaves develop small brown spots surrounded by a yellow chlorotic zone

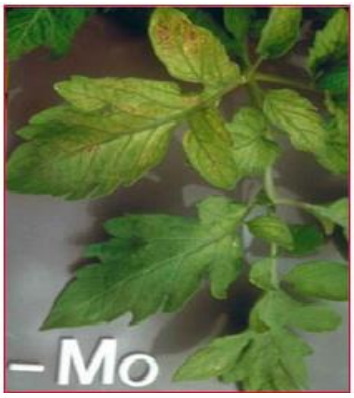
# BORON


**DEFICIENT** Growing points become abnormal, becoming stunted and dying. Leaves and stems become brittle.
**EXCESS** Leaf tips become yellow, then scorched and eventually leaf falls off.

# ZINC


**DEFICIENT** Inter-veinal chlorosis of young leaves, plant growth stunted leaves die and fall off.
**EXCESS** No common symptoms.

# Molybdenum




**DEFICIENT some mottled spotting along with some interveinal chlorosis. An early symptom for molybdenum deficiency is a general overall chlorosis, similar to the symptom for nitrogen deficiency but generally without the reddish coloration on the undersides of the leaves..**

**EXCESS At high concentrations, molybdenum has a very distinctive toxicity symptom in that the leaves turn a very brilliant orange.**

# PHOSPHORUS


**DEFICIENT** Slow growing, stunted and dark green plants. Older leaves may show purple coloration - occurs in older leaves first.
**EXCESS** Causes iron and/or zinc deficiency.

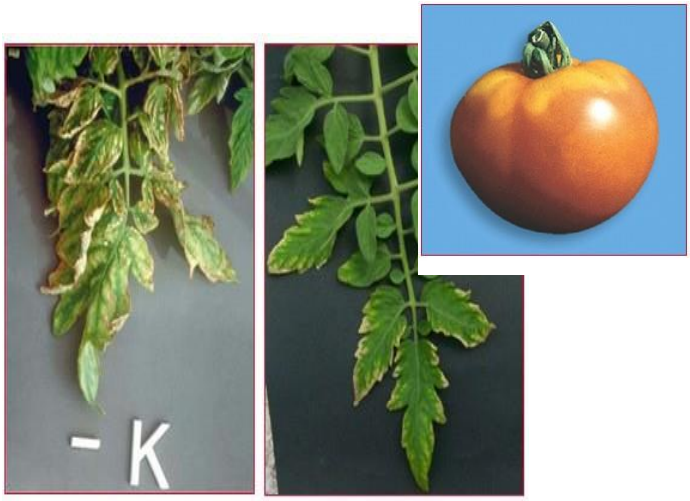
# PHOSPHORUS

# NITROGEN


**DEFICIENT Plants are slow growing, weak and stunted. Leaf colour light green to yellow seen on older leaves first. Plants mature early, reducing yield.**

**EXCESS Plants are dark green, soft, succulent foliage. Fruit and seed crops may fail to yield.**

# POTASSIUM




**DEFICIENT** Scorch along margins of older leaves.
**EXCESS** Causes magnesium deficiency.

# Botrytis Gray Mold (Fungus)

**How to Control Disease**

- Keep humidity below 90%.
- Avoid overhead watering.
- Inspect leaves and remove faded flowers.
- Improve air circulation

**Where to Look**

Look for light-tan or gray spots on infected leaves. These areas become covered by a brown or gray fuzzy mass of fungus growth and the leaf collapses and withers. Other sites of infection include dying flowers and the calyx area of fruit.

# Leaf Mold (Fungus)

**How to Control Disease**

- Use disease resistant varieties of seeds.
- Leaf mold can be kept under control if there is good air ventilation and air circulation.
- Keep humidity

**Where to Look**

Look for pale-green or yellowish areas with irregular margins on upper leaf surfaces. Beneath the yellow spots areas of olive green velvet growth are visible. Infected leaves become yellow-brown and drop prematurely.

# Early Blight (Fungus)

**How to Control Disease**

- Practice crop rotation.
- Remove and destruct all crops from previous crops.
- Practice staking, mulching, and timely application of fungicides (if necessary).
- Use disease tolerant varieties of seeds.

**Where to Look**

Look for characteristic circular brown leaf spots up to 2 inches in diameter. Spots contain dark rings with a common centre, giving a target-board appearance. Symptoms appear on leaves, stems, and fruit.

# Bacterial Wilt (Bacterial)

**How to Control Disease**

- Control cucumber beetles, as they transmit the bacteria.
- Remove all infected vines - wilted vines can not be saved.
- Control weeds in and around greenhouse as they can easily help transmit bacteria

**Where to Look**

Symptoms of the disease first appear on a single leaf which suddenly wilts and becomes dull green.