

NUTRIOPHYSIOLOGY

21.1 FOLIAR NUTRITION

Foliar nutrition of mineral nutrients by means of sprays offers methods of supplying nutrients to higher plants more rapidly than methods involving root application. Foliar nutrition consists of spraying dilute nutrient solutions on foliage in order to feed the plants with required nutrients in short time.

21.1.1 Mechanism of uptake: In terrestrial plants the uptake of solutes by the surfaces of leaves and other aerial parts is severely restricted by the external wall of the epidermal cells. This wall is covered by a layer of wax and cutin and contains pectin, hemi cellulose and cellulose. The direct penetration of solutes from the leaf surface through open stomata into the leaf tissue is unlikely because a cuticular layer also covers the surface of guard cells in stomatal cavities. Further more ion uptake rates from foliar sprays are usually higher at night, when the stomata are closed, than during the days, when the stomata are open.

The movement of solutes across the cuticular layer takes place in cavities or channels called **ectodesmata** by process of diffusion. Ectodesmata extend through the outer epidermal cell walls from the inner surface of the cuticle to the plasma membrane. When a substance reaches the plasma membrane of an epidermal cell it will be absorbed by mechanisms similar to those which operate in root cells.

21.1.2 Advantage of foliar nutrition: The advantage of foliar nutrition is high recovery rate while the limitation is the smaller amounts of nutrients that can be supplied at a given time. It is very essential not to exceed the specified concentration of fertilizer solutions, for the foliar spray to avoid the risk of leaf scorch. Fertilizers when used in excess concentration damage the leaf tissue causing necrosis.

The technique has great practical utility under certain conditions.

- a) **Correction of visual symptoms:** Nutrient deficiencies observed during early stages of crop growth can be corrected by foliar sprays.
- b) **Low nutrient availability in soils:** in calcareous soils, for example, iron availability is very low and iron deficiency (Lime induced iron chlorosis) is widespread. Foliar spray is much more efficient than the soil application of expensive iron chelates.
- c) **Decrease in root activity during reproductive stage:** As a result of sink competition for carbohydrates, root activity and thus nutrient uptake by the roots decline with the onset of the reproductive stage. Foliar sprays containing nutrients can compensate for this decline.

Usually micronutrients, which are required in low rates, are foliar sprayed. Urea sprays are used for supplying nitrogen. Ammonium phosphate fertilizer is also used to spray to improve seed setting in multicut fodder legumes like Berseem.

21.2 HYDROPONICS

The method of growing plants in aqueous nutrient solutions is known as hydroponics culture or hydroponics. The growing of higher plants with their roots in dilute solutions of mineral salts instead of in soils has led to a vastly increased understanding of plant nutrition. The use of water culture technique for growing plants permits precise control of the supply of nutrient ions in the root environment. The first recorded use of water culture technique was in the year 1699 by **John Woodward**. Latter the process of growing plants in water culute was named as hydroponics by **Gericke** 1930.

The water culture technique is extensively used to grow certain high value crops (eg. Tomato, lettuce and strawberry) in glass houses during off seasons in metropolitan areas of developed countries. In addition, vegetables are grown in plastic houses in a few coastal desert regions, where sea water is desalinated and supplied to roots in precisely the amounts required by the growing plants.

21.2.1 TYPES OF SOLUTIONS CULTURE:

The three types of solution culture are

1. Static
2. Flowing
3. Mist system

In static system, the plant is supported in such a way that its roots are immersed in culture solutions containing nutrient elements. The solution is kept oxygenated by bubbling air through it from a compressed air line. This system is mostly used for experimental purpose. In flowing systems, the solution move continuously allowing its composition to remain relatively constant at the root surface. The nutrient film technique, where roots grow in films of solution constantly moving down inclined troughs is a commercial version of the flowing system.

In mist system, roots hang in the air and are sprayed intermittently with a nutrient solution.

21.2.2 SAND CULTURE:

In a modification of the solution culture technique, plants are grown with their roots anchored in a solid inert aggregate, such as sand culture technique. The added advantage of this solid medium culture is that the roots grow in a natural medium and no other means of support needs to be provided.

Most important form of solid culture techniques is sand culture. Sand culture is sometimes referred to as slop culture, drip culture, or intermittent renewal. Plant nutrients are supplied with solutions, as in water culture. The major difference is that the plants are grown in silica sand or other inert material (perlite, vermiculite, peat etc.). The solution is applied to the sand and then allowed to drain off. In this way plant nutrients are supplied, aeration is provided, and the roots of the plant are supported. Additional support may be required for the aerial portions of the plant,

especially tomatoes and cucumbers. Sand should be medium to coarse in size (.0.25 mm-2mm).

Perhaps the most limiting aspect of solid media is that access to roots is achieved only with major damage.

21.2.2.1 Types of solid medium culture

Based on the addition of nutrient solutions to the solid culture the following three systems are categorized.

1. **Slop culture**:- Nutrient solutions are poured over the surface of the solid medium.
2. **Drip culture**:-Nutrient solutions are dripped on the surface.
3. **Sub irrigation**:- Nutrient solutions are forced from the bottom of the container to come up to the surface of the solid medium.

Methodology

Stock solutions are prepared separately from inorganic salts containing the essential elements for normal plant growth. **Hoagland and Arnon** (1950) formulated two nutrient solutions which have been very widely used and the term “**Hoagland solution**” has become a household word in laboratories devoted to plant nutrition all over the world. Hoagland solution II contains ammonium ions as well as nitrate and as a result it is a better buffered one. pH of the nutrient solutions will be in the range of 5 to 7. The final nutrient solution is prepared by adding the correct proportion of stock solutions and diluted with deionised water. The containers are filled with nutrient solution and covered with aluminum foil or thick non transparent paper in order to eliminate light incidence and algal growth in containers.

Week or ten days old seedling are taken, the roots are submerged in the nutrient solution and the stem projected through an opening cut in the container lid. To ensure the stem to be held rigid, the opening is stuffed with some inert padding material such as cotton. The nutrient solution is well aerated periodically by employing an air-pump and change once in few days depending on undesirable pH changes and the growth rate of the plants.

For commercial cultivation, large shallow tanks (nutrient film technique) are used. The nutrient solutions are replenished often enough to maintain their concentrations. Nutrient solutions are made to flow over the plant roots from a recirculating tank .

Use in Agriculture

1. To grow plants in the laboratory for experimental purpose such as studies involving nutrient physiology, herbicide physiology, radio tracer technique for ion uptake and movement etc.
2. Commercial cultivation of high value crops in glass houses during off seasons in metropolitan areas.

3. Deficiency and toxic symptoms of mineral elements can be developed and studied with different crop plants.

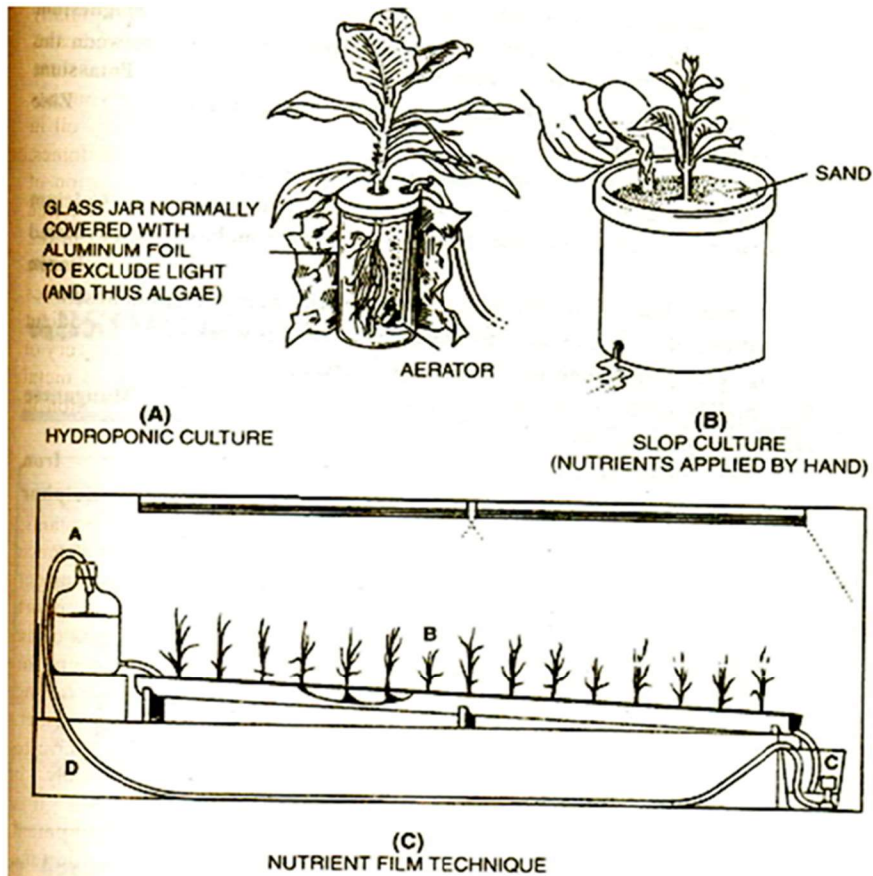


Fig Three methods for growing plants with nutrient solutions : (a) hydroponic culture, (b) slop culture using sand, (c) nutrient-film technique. A contains nutrient solution that supplies to plants B. Plants can be supported. Unabsorbed solution flows to C having a pump to force solution through tube D back to A.