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हाइड्रोपोनिक कृषि उत्पादन प्रणाली — आवश्यकताएँ

Draft ***Indian Standard***

HYDROPONIC FARMING PRODUCTION SYSTEM - REQUIREMENTS

ICS 65.020.99

Agricultural Systems and Management Sectional Committee, FAD 22	Last date of comments: **19 April 2024**

FOREWORD

(Formal clause will be added later)

New technologies are coming up every day in the world. As the world population is growing, the agriculture industry is also developing new techniques to grow food in lesser space and by saving water. The hydroponic growing system is a step towards this. Growing plants in water culture or sand culture without soil are procedures that have been used by physiologists studying plant nutrition and by other plant scientists for more than a century. With land being limited and a rising population in need of proper housing facilities, a method of farm production that enables production without land use can be of great value for India where agriculture still serves as a primary livelihood source for a majority of citizens.

Hydroponics is the technique of growing plants using a water-based nutrient solution rather than soil, and can include an aggregate substrate, or growing media, such as vermiculite, coconut coir, or perlite etc. Hydroponic production systems are used by small farmers, hobbyists, and commercial enterprises. Hydroponics was a successful technique used to supply fresh vegetables in many countries and has been considered as the future of farming to grow foods for astronauts in space by NASA. Hydroponics enables urban farming in the sense that it can be used to cultivate plants on roofs and even in bedrooms.

Hydroponic production system has been identified as one of the priority subjects under Standards National Action Plan 2022-27 developed after multiple stakeholder consultation. Considering the above, this National Standard for Hydroponic Farming Production system has been taken up for development in order to provide required guidance to the farming community and all concerned stakeholders. This standard will provide recommendations on requirements for substrates, structures, nutrients, maintenance and also the basis for development of conformity assessment scheme in future in order to evaluate the hydroponic farming production system.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1 SCOPE

This standard covers the guideline for operation of hydroponic systems including requirements of substrates, nutrient solution and structure design.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
IS 6911 : 2017	Stainless steel plate, sheet and strip - Specification (*second revision*)
IS 10151 : 2019	Polyvinyl chloride (PVC) and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water - Specification (*first revision*)

3 TERMINOLOGY

3.1 Hydroponics

Technique of growing plants using a water-based nutrient solution rather than soil, and can include an aggregate substrate, or growing media. Hydroponics is soil-less farming. The word hydroponics comes from the root words ‘hydro’, meaning water, and ‘*ponos*’, meaning *labour*, literally “working water.”

3.2 Substrate

The physical medium that supports plants by the stem and keep them under appropriate growing conditions by providing an aseptic environment with good oxygenation, and an adequate flow of the nutrient solution

3.3 Electrical Conductivity (EC)

An estimation of the total concentration of ions in a solution. Low values of EC indicate a scarcity of nutrients in the form of ions; on the other hand, too-high values may lead to salt stress in the plant thus, EC should be kept within a target range because it significantly affects growth and crop quality.

4 TYPE OF HYDROPONIC SYSTEMS

4.1 Floating Root System or Deep Water Culture (DWC)

The hydroponic system, where the root of the plant is immersed in the nutrient solution, while the rest of it is supported above water level using polystyrene, cork bark or wood, among other materials. A schematic diagram and design of a typical DWC is given in Fig. 1 for guidance.

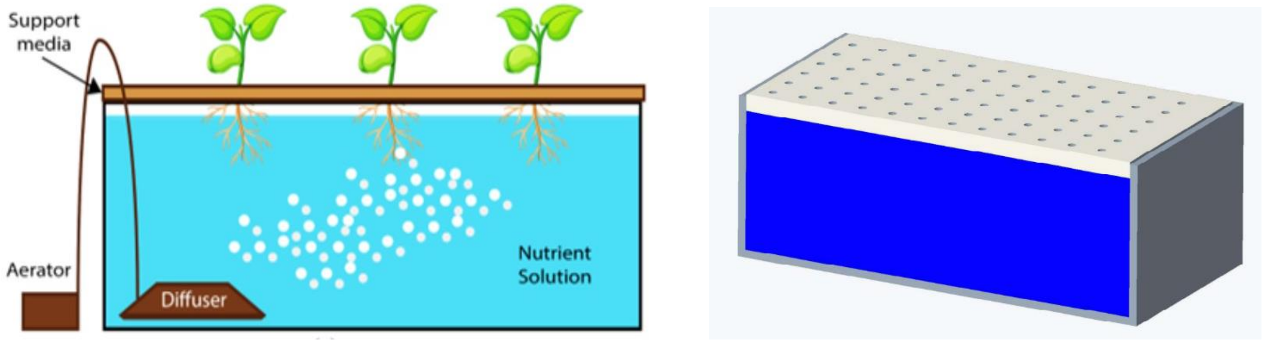

FIG. 1 FLOATING ROOT SYSTEM OR DEEP WATER CULTURE (DWC)

4.2 Drip Irrigation

The hydroponic system, where the nutrient solution is pumped directly to the roots of the plants with regulated flow. The solution is administered at predetermined time intervals and, for closed systems, the leftover solution is returned to the storage tank. This method is best suited for tomato and pepper-like crops. A schematic diagram of a typical drip irrigation based hydroponic production system is given in Fig. 1 for guidance.

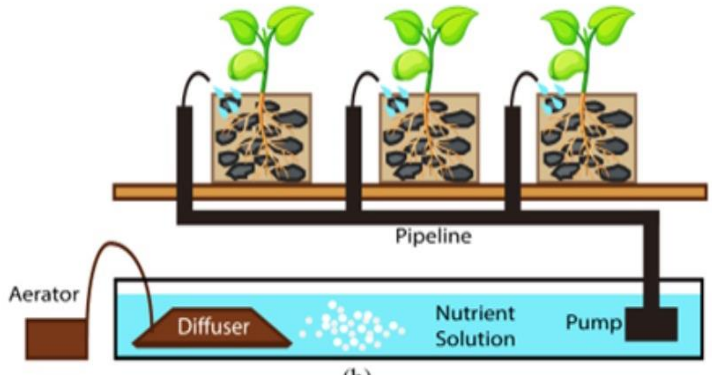

FIG. 2 DRIP IRRIGATION BASED HYDROPONIC

4.3 Aeroponics

The hydroponic system, where the plants, with their roots hanging down in the air, get their nutrients from periodic spraying by a system of sprinkles. The main advantage of this technique is that it does not require an airing system as oxygen is carried along with the sprayed nutrient solution. Tubers and root vegetables are ideal to grow using aeroponics. A schematic diagram of a typical aeroponic production system is given in Fig. 3 for guidance.

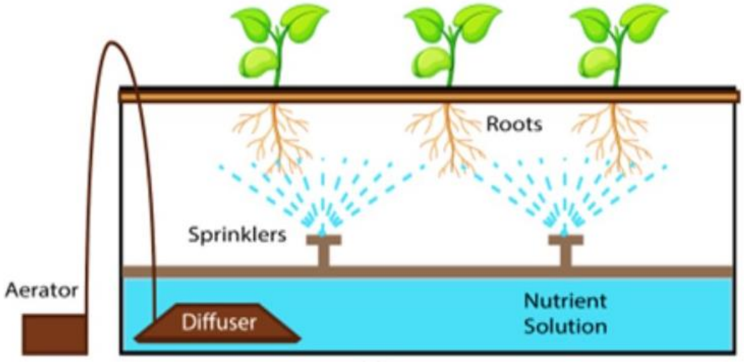

FIG. 3 AEROPONIC PRODUCTION SYSTEM

4.4 Nutrient Film Technique (NFT)

It is like the floating root system, except that the plant roots are not completely submerged in the nourishing solution, but in a liquid stream flowing through a piping system. Although NFT requires smaller amounts of nutrient solution than the floating root system, it requires additional energy and components to operate. The excess solution returns to the storage tank by gravity and the flow of nutrient solution can be continuous or periodic. A schematic diagram and design of a typical Nutrient Film Technique (NFT) is given in Fig. 4 for guidance.

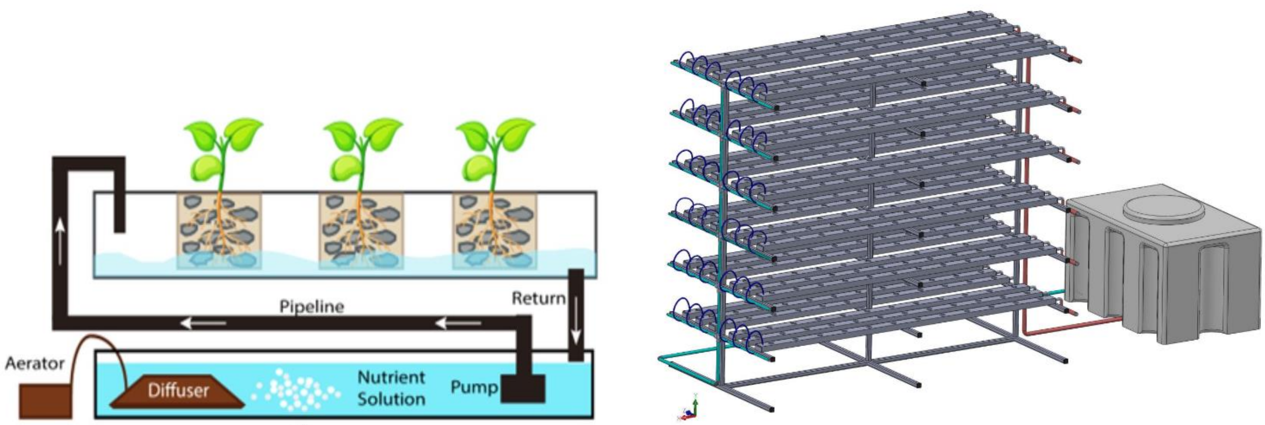

FIG. 4 NUTRIENT FILM TECHNIQUE (NFT)

4.5 Ebb and Flow

The hydroponic system, where plants are placed in a tray, which is periodically filled with nutrient-rich water pumped from a reservoir below. The system uses gravity to return the water to the reservoir and reuse it. A schematic diagram and design of a typical Ebb and Flow based hydroponic system is given in Fig. 5 for guidance.

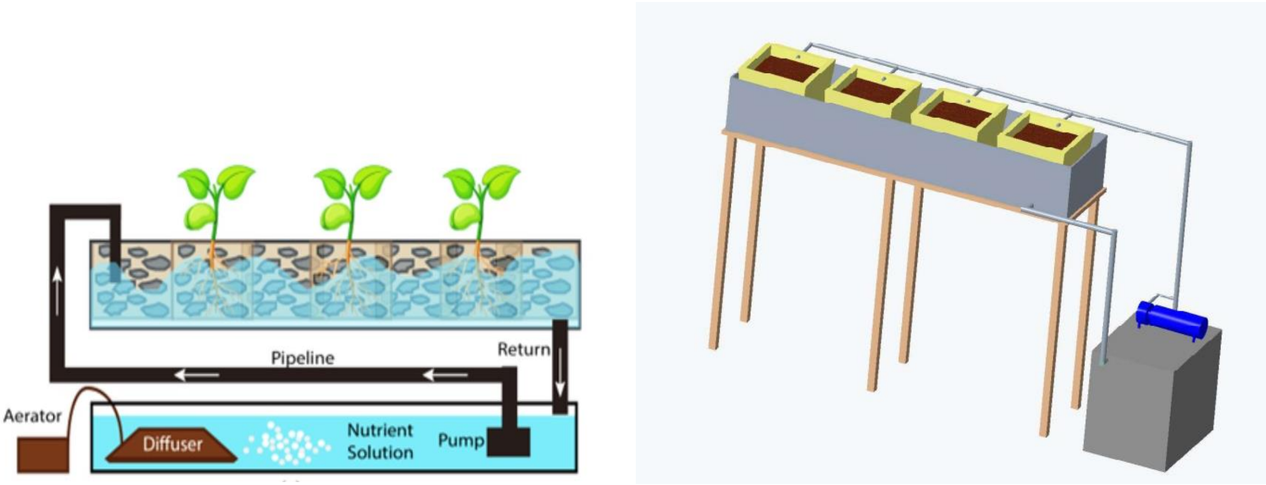

FIG. 5 EBB AND FLOW

4.6 Aquaponics

This technique exploits the symbiosis of flora and fauna to achieve an efficient system in which fish feces is used for the nutritional requirements of the plants. The absorption of nutrients by plants, combined with the microbial process of nitrification and denitrification, allows the recycling of water from the fish tank, forming a balanced micro-ecosystem. A schematic diagram of a typical aquaponic production system is given in Fig. 6 for guidance.

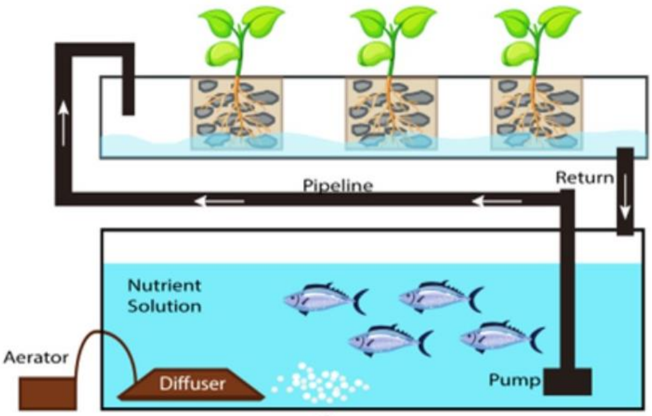

FIG. 6 AQUAPONICS

4.7 Wick Pot System

A passive system (which means there are no moving parts), in which the nutrient solution is drawn into the growing medium from the reservoir with a wick. The wick pot system is by far the simplest type of hydroponic system. A schematic diagram and design of a typical wick pot hydroponic system is given in Fig. 7 for guidance.

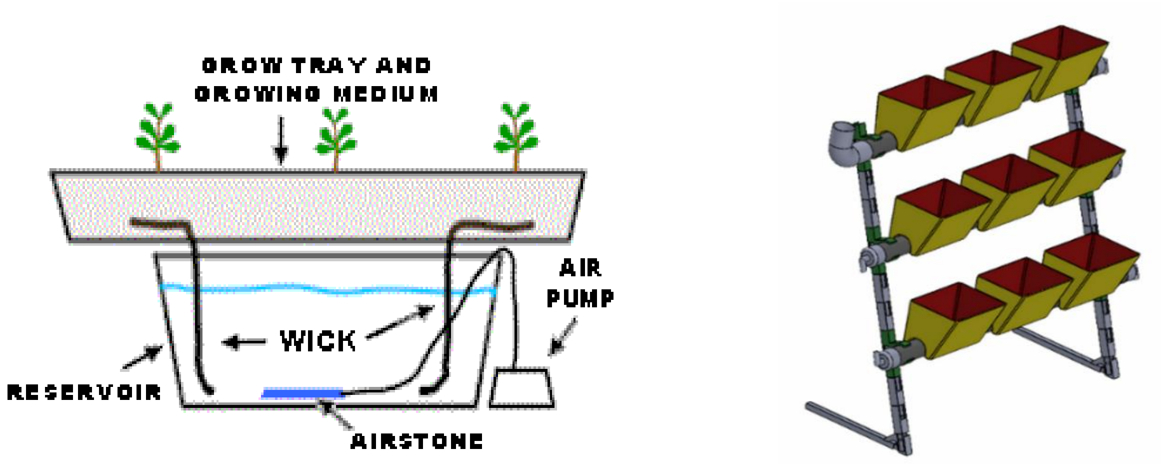

FIG. 7 WICK POT SYSTEM

4.8 Vertical Farming

The type of hydroponic farming where, plants density is increased by arranging the systems in vertical pattern with sustainable fabricated frames and supporting structures. This technology involves artificial lighting if necessary to provide sufficient grow light in absences of sunlight or shade. Design of two typical vertical farming structure is given in Fig. 8 for guidance.

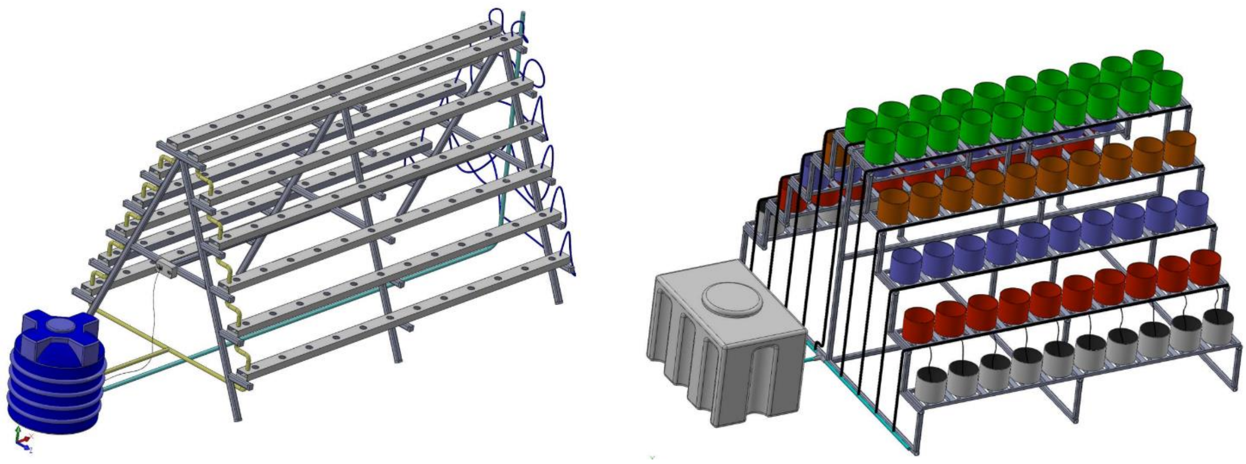

FIG. 8 VERTICAL FARMING

5 TYPES OF SUBSTRATES USED IN HYDROPONICS

5.1 General

Soil-less hydroponic culture involves growing plants in different types of solid media. In this type of culture, a growing medium is used to anchor the plants and provide support. The growing medium or substrate is an inert material that does not contain any nutrients but provides physical support to the plants.

5.1 Types of Substrates

5.1.1 *Peat Moss*

Peat moss is considered the most common substrate and widely used at global level. It is a decomposed organic material available in humid locations of the globe called peat moss mines. This material is used separately or mixed with other substrates such as vermiculite or sand.

Peat moss is characterized by:

a) Large capacity to absorb water about 8 folds of its weight at saturation level and drains surplus water.
b) Low acidity level.
c) High percentage of organic matter (94-99%).
d) High porosity (95-98%)

5.1.2 *Rice Husk*

The characteristics of rice husk are:

a) Very light weight.
b) Provides necessary aeration for roots of different plants.
c) Has a medium capacity to hold water.

5.1.3 *Coconut Fibers (coir)*

Characteristics of coconut fibres are:

a) Possibility of use for more than one year without any change in its physical characteristics.
b) Its decomposition is slow therefore, it would not deteriorate quickly.
c) Has the capacity to hold water.
d) Can provide enough airing to the substrate.

5.1.4 *Vermiculite*

It is dehydrated iron, aluminum and magnesium silicate, which is obtained from metallic chips from mica mines in Africa, Australia, and America. The material to be used as a substrate obtained by treating the raw element with a temperature of 1000 centigrade. The humidity transforms to vapor which creates an increasing pressure inside its layers, which in turn fragments to small light pieces of good porosity and characteristics appropriate to soil-less agriculture.

Some characteristics of vermiculite are:

a) High capacity to hold water.
b) Contains magnesium and potassium in an absorbable form for the benefit of plants.

It may be noted that vermiculite is a good water absorption material and therefore, continues to be wet most of time; hence, it is preferable to mix it with other materials to reduce such permanent wet condition so that it would be more appropriate for plant growth.

5.1.5 *Perlite*

This is a volcanic stone originated from volcanic lava of color graded from grey to white and consists of Aluminum Silicate and Sodium and Potassium, which is grinded and heated to high temperature from 900-1000°C.

Characteristics of perlite are:

a) A material of stable physical consistence with no capacity of cationic alternation.
b) A lightweight material.

It has good drainage capacity with a very lower water holding capacity. Therefore, irrigation is preferred several times per day to ensure the availability of required water and nutritional elements needed by the plants. It is a substrate of good airing conditions. Perlite is widely used either separately with good results or in a mix with other substrates like peat moss to grow several vegetable crops, seeds, flowers, and indoor ornamental plants.

5.1.6 *Expanded clays*

Heating montmorillonite clay minerals to approximately 690ºC forms expanded clays. The pottery like particles formed are six times as heavy as perlite. Expanded clays have a relatively high cation exchange as well as water holding capacity. This material is a very durable and useful amendment.

5.1.7 *Rockwool*

The use of rock wool has quickly spread in agriculture, particularly in Europe where it is used to produce many vegetable and ornamental crops. It is a fiber produced from volcanic rocks and contains Diabase (60%), Limestone (20%) and Coal (20%). This mix is heated to very high temperature for melting together. The melted material is transformed to fine threads of 5-micron diameter after treatment with a fast centrifugal machine and cooling. The threads are then compressed and divided into the required sizes. During the cooling process, the phenol material is added to help sticking the rocky wool into a substrate of good porosity.

It is important to choose the right growing medium for the hydroponic system based on the type of plants to be grown, the size of system, and the budget. Regular maintenance of the growing medium is also important to ensure that it remains free from disease and pest infestations.

6 DESIGN AND DIMENSION REQUIREMENTS

6.1 The raw materials of the structure of the hydroponics production system shall be food-grade and lead Free polyvinyl chloride (PVC) Channels conforming to IS 10151 or stainless steel of designation SS 304 (Austenitic X04 Cr19 Ni9) or SS 316 (Austenitic X04 Cr17 Ni12 Mo2) conforming to IS 6911.

6.2 The system shall have provision for automatic fertigation with automated dosing for nutrient and *p*H along with EC sensor and *p*H sensor.

6.3 The design and dimension of different hydroponic structures should be as per the requirements of production volume, type of plant and recommendations issued by concerned government authorities.

7 REQUIREMENTS FOR SUBSTRATES USED IN HYDROPONICS

7.1 While using the substrates in hydroponic systems, consideration should be given to physical as well as chemical properties along with presence of nutrients. The substrates to be used in hydroponic system shall confirm to the requirements given under Table 1.

TABLE 1 IMPORTANT CHARACTERISTICS OF SOIL-LESS SOLID MEDIA SUBSTRATES

(*Clause* 7.1)

Sl No.	Parameters	Requirements
(1)	(2)	(3)
i)	EC, dS/m, *Max*	1.50
ii)	*p*H	5.5-6.0
iii)	Nitrates, mg/l	50-70
iv)	Ammonium, mg/l	3-6
v)	Phosphorous, mg/l	3-5
vi)	Potassium, mg/l	50-100
vii)	Calcium, mg/l	50-80
viii)	Magnesium, mg/l	20-30
ix)	Sodium, mg/l, *Max*	90
x)	Chlorides, mg/l, *Max*	90
xi)	Sulphates, mg/l	40-90
xii)	Iron, mg/l	0.5-1.0
xiii)	Boron, mg/l	0.2-0.4
xiv)	Copper, mg/l	0.05-0.1
xv)	Zinc, mg/l	0.1-0.2
xvi)	Manganese, mg/l	0.2-0.4

7.2 The characteristics of substrates should be suitable for a particular hydroponic growing method or condition to obtain the maximum output.

7.2.1 Ebb and flow type hydroponic system should be used for substrates such as expanded clay, gravel, coarse sand, pumice, or rock-like material which are reasonably heavy so that it will not float away; drain reasonably well (although hold some moisture).

7.2.2 Drip irrigation systems type hydroponic system should be used for substrates which hold a reasonable amount of moisture and have high percentage of air-filled pores.

7.2.3 For warm climates, materials such as coconut fiber, ground bark, rockwool, or stonewool which are heavy media types and hold more water and are slow to heat up should be used.

7.2.4 For cooler climates, materials such as perlite, pumice, sand, and expanded clay should be used.

7.3 Sustainability Criteria for Choosing Substrates

Selection of substrate the user/practitioner should consider not only the chemical, biological or physiological aspects of substrates intended for hydroponic farming, but also their economic, social, and environmental viability. Additionally, one should also determine the carbon footprint to measure their environmental impact.

8 REQUIREMENTS FOR NUTRIENT SOLUTION

8.1 The chemical composition of the nutrient solution depends on specific crop and plant development stage. Some examples of soluble fertilizers used in hydroponics are ammonium nitrate (NH_4NO_3), calcium nitrate ($5[Ca(NO_3)_2 \cdot 2H_2O]NH_4NO_3$), phosphoric acid ($H_3PO_4$), nitric acid ($HNO_3$), etc.

8.2 Depending on their growth stage, plants require different formulations. During the vegetative stage, the plant grows foliage until ready to flower or root ripening. Therefore, the vegetative growth stage requires a nutrient solution which should be rich in phosphorous to build strong roots. Finally, during fruit ripening stage, the plant required a nutrient solution which should be low in nitrogen and high in potassium concentrations.

8.3 The active lifetime of the solution is of the utmost importance and will depend on timely adjustments made to the *p*H, electrical conductivity, and water level. In order to ensure that, the following measures should be taken:

a) To exclude changes in the nutrient solution, the volume level in the storage tank shall remain constant, replenishing the water absorbed by the plants and lost by evapotranspiration; in order to avoid the change in concentration of the salts which will affect the healthy growth of the plants.
b) The nutrient solution in the storage tank should be replaced in a frequency of every 2 to 3 weeks.
c) The tanks shall be thoroughly cleaned and disinfected before replacement process.

8.4 Characteristics of Nutrient Solution

The nutrient solutions used in hydroponic production system should have a specific characteristic which might vary from crop to crop.

8.4.1 *p*H *in Hydroponics Nutrient Solutions*

The *p*H for nutrient solution in hydroponics shall be between 5 to 7 as most of the nutrients remain soluble within this range.

> Note : If *p*H > 7, the solubility of Fe and $[H_2PO_4]^-$ decreases, giving rise to Ca and Mg precipitates, among other chemical reactions between nutrient solution components, hindering the absorption of iron, boron, copper, zinc, or manganese. On the other hand, if *p*H is below 5, the adsorption of nitrogen, phosphorus, potassium, calcium, magnesium, and molybdenum is inhibited.

8.4.2 *Electrical conductivity (EC)*

This parameter does not provide specific information regarding the concentration of each element in the nutrient solution; hence, after measuring EC, it is essential to add fertilizers in concentration amounts that the plants can absorb. The required ranges of EC and *p*H should be as per requirements given under Table 2 for respective crops.

TABLE 2 OPTIMUM RANGE OF ELECTRICAL CONDUCTIVITY (EC) AND PH FOR SOME POPULAR HYDROPONIC CROPS

(*Clause* 8.4.2)

Sl No.	Crops	*p*H	EC (mS/cm)
(1)	(2)	(3)	(4)
i)	Asparagus	6–6.8	1.4–1.8
ii)	Basil	5.5–6	1–1.6
iii)	Bean	6	2–4
iv)	Banana	5.5–6.5	1.8–2.2
v)	Broccoli	6–6.8	2.8–3.5
vi)	Cabbage	6.5–7	2.5–3
vii)	Celery	6.5	1.8–2.4
viii)	Carnation	6	2–3.5
ix)	Cucumber	5–5.5	1.7–2
x)	Eggplant	6	2.5–3.5
xi)	Lettuce	6–7	1.2–1.8
xii)	Okra	6.5	2–2.4
xiii)	Pak Choi	7	1.5–2
xiv)	Peppers	5.5–6	0.8–1.8
xv)	Parsley	6–6.5	1.8–2.2
xvi)	Rose	5.5–6	1.5–2.5
xvii)	Spinach	6–7	1.8–2.3
xviii)	Strawberry	6	1.8–2.2
xix)	Tomato	6–6.5	2–4

NOTE : Most hydroponic nutrient solution formulations are more concentrated in elemental content than needed and frequently lack the proper balance among the elements, particularly the major elements K, Ca, and Mg in solution. Phosphorus (P) concentration in excess is probably the most frequently occurring phenomenon in most nutrient solution formulations, while Mg and Zn are the elements most frequently inadequate in concentration. Combined with the hydroponic growing method, the use factors, volume applied with each irrigation, and frequency of irrigations associated with a nutrient solution formulation are as important as the elemental content of a nutrient solution formulation. With increasing volume of nutrient solution applied with each irrigation and increasing number of irrigations, the more dilute the nutrient solution formulation should be. For the majority of growers, the most economical procedure is to make their own nutrient solution formulation, rather than selecting from the many prepared formulations since a majority of these formulations are not well suited for the commonly used hydroponic growing systems and selected crop plants.

8.5 The inclusion of an organic substance, such as humic acid, or other similar substances or an array of microorganisms into a nutrient solution will not benefit plant growth and has the possibility of an adverse effect. In addition, the inclusion of an organic substance in a nutrient solution is an invitation for root disease invasion. Therefore, above such practices should be avoided.

8.6 Recirculation (reuse) of a nutrient solution may require treatment, such as restoration to its initial volume by adding water, adjusting the *p*H and elemental content, removal of suspended material by filtering, and sterilization to inactivate disease organisms. The requirements for recirculated nutrient solution should be same as the original nutrient solution requirements.

8.7 The inclusion of nonessential plant nutrient elements in a nutrient solution formulation should not be practiced except for the element silicon (Si).

8.8 After making a nutrient solution formulation, the nutrient solution should be analysed to determine its element content concentrations. If the nutrient solution is being formulated using injector pumps, such an analysis is essential to ensure that the injector pumps are operating properly and the nutrient element concentrates are at their proper elemental concentration; either based on the formulation or compared to the desired range in concentration for optimum plant growth.

9 OTHER REQUIREMENTS

9.1 Rooting media

The physical and chemical characteristics of a rooting medium may either affect the nutritional status of the growing plant— by contributing to the nutrient element requirement of the plant or by participating in the interactions that may occur between the rooting medium and the applied nutrient solution. Some of the commonly used rooting media may contain sufficient quantities of a plant essential element so that element does not need to be included in a nutrient solution formulation. The elements that may be sufficiently supplied by the rooting medium are K, P, Mg, Cu, Mn, and Fe. With the drip irrigation hydroponic growing method, there occurs an accumulation of elements in solution and as precipitates. The monitoring procedure should be followed during such case are as follows:

a) Monitoring should be done for the EC of nutrient solution being discharged from the rooting medium or from an aliquot of solution being retained in the rooting medium.

b) When the EC exceeds that of the applied nutrient solution, the rooting medium should be leached with water.

c) Accumulation of what is known as “salts” can be minimized by reducing the elemental content of the nutrient solution and/or by alternating between a nutrient solution application and water only.

d) Accumulation of “salts” in the rooting medium should be treated as an indication of poor management of the use of a nutrient solution formulation.

e) Accumulation of elements in solution as well as precipitates can also occur in the rooting medium with the flood-and-drain method and in the root mass for plants being grown using the NFT method.

9.2 Plant growth and maturity

Insufficiency of an essential plant nutrient element may not appear as a visual symptom, although plant vegetative growth and product production (flowers and fruit) will be less than the potential. Therefore, the nutrient element content of the growing plant should be monitored to determine nutrient element sufficiency.

9.3 Grower skills

Although skill is needed on the part of a grower to manage a hydroponic growing system efficiently, there are also considerable common-sense aspects that can contribute to a grower’s success, even though the grower may be carefully following operating instructions. Experience can contribute to the ability of a hydroponic grower to grow plants at their genetic potential in terms of both vegetative growth and product yield.

9.4 Disease and insect control

A commonly occurring error is not to be prepared to deal with the occurrence of an insect infestation or disease occurrence as well as not seeking professional assistance for identification and recommendations for best control treatments. Avoidance is the best control measure, followed by knowing when to apply an effective control treatment. A regular monitoring of symptoms for disease and insect infestation shall be done.

9.5 Testing requirements

9.5.1 Source water shall be tested at least once in a year in order to ensure the required EC, *p*H along with the requirements provided under Table 3 is maintained.

TABLE 3 REQUIREMENTS OF WATER USED IN HYDROPONICS

(*Clause* 9.5.1)

Sl. No.	Parameters	Requirements
(1)	(1)	(3)
i)	EC, dS/m	0.5 – 2.0
ii)	*p*H	6.8 – 7.5
iii)	Bicarbonates, mol/m^{-3}	2.0 – 6.0
iv)	Nitrates, mol/m^{-3}	0.5 – 2.0
v)	Ammonium, mol/m^{-3}	0.1 – 1.0
vi)	Phosphorous, mol/m^{-3}	0.3 – 1.0
vii)	Potassium, mol/m^{-3}	0.5 – 2.5
viii)	Calcium, mol/m^{-3}	1.5 – 5.0
ix)	Magnesium, mol/m^{-3}	0.75 – 2.0
x)	Sodium, mol/m^{-3}	3.0 – 10.0
xi)	Chlorides, mol/m^{-3}	3.0 – 10.0
xii)	Sulphates, mol/m^{-3}	2.0 – 4.0
xiii)	Iron, mol/m^{-3}, *Max*	90
xiv)	Boron, mol/m^{-3}	30.0 – 100.0
xv)	Copper, mol/m^{-3}, *Max*	15
xvi)	Zinc, mol/m^{-3}, *Max*	30
xvii)	Manganese, mol/m^{-3}, *Max*	10

9.5.2 EC and pH of the Nutrient Solution shall be maintained as per required parameters as per growth & type of the plant and shall be monitored on daily basis.

9.6 Maintenance of hydroponic system

The following measures shall be followed in order to ensure effective maintenance of the hydroponic farming production system:

a) Water tank (Nutrient tank) should be kept clean and refilled with fresh solution once in every 10 to 15 days frequency.
b) Before transplant of sapling in pots (Net Pot / Wick Pot), pot should be clean with disinfectant.
c) For NFT channels it is mandatory to wash with disinfectant solution and water before starting new cycle.
d) All drip pipelines or PVC pipelines should be cleaned after every cycle of production.

10 CROP SELECTION FOR HYDROPONICS

Hydroponics is appropriate to grow variety of fruits and vegetables. Not all hydroponic growing systems are well suited for a particular use and/or plant species. A good example is the NFT growing system, which is not suitable for use with long-term crops such as tomato, cucumber, and pepper, as the root mass will fill the NFT trough and impede the flow of nutrient solution down the trough. The root mass becomes anaerobic, resulting in the death of some roots, which results in a reduction in plant growth or even possible death of the growing plant. Most hydroponic growing procedural recommendations are wasteful in their use of water and reagents. Therefore, application procedures need to be designed in order to obtain maximum utilization of applied irrigation water and the nutrient solution. This will require careful monitoring of water and nutrient solution use coupled with experimentation in terms of adjusting timing and quantity applied based on plant requirements for water and/or nutrient elements. Recommended list of plants along with most suitable type of hydroponic cultivation technique is given under Table 4.

TABLE 4 MOST SUITABLE PLANTS TO GROW BY HYDROPONICS

(*Clause* 10)

Type	**Common Name**	**Scientific Name**	**Cultivation Technique**
(1)	(2)	(3)	(4)
Bulb Vegetables	Garlic	*Allium sativum*	Drip irrigation, wick pot
	Onion	*Allium cepa*	NFT, Drip irrigation, wick pot
Leafy Vegetables	Lettuce	*Lactuca sativa*	NFT, DWC, wick pot
	Cabbage	*Brassica oleracea* var. *capitata*	NFT, DWC, wick pot
	Brussels sprouts	*Brassica oleracea* var. *gemmifera*	NFT, DWC, wick pot
	Mustard	*Brassica nigra*	NFT, DWC, wick pot
	Spinach	*Spinacea oleracea*	NFT, DWC, wick pot
	Chard	*Beta vulgaris* var. *cicla*	NFT, DWC, wick pot
	Celery	*Apium graveolens*	NFT, DWC, wick pot
	Parsley	*Petroselinum crispum*	NFT, DWC, wick pot
	Coriander	*Coriandrum sativum*	NFT, DWC, drip irrigation
Root Vegetables	Beetroot	*Beta vulgaris*	Drip irrigation, aeroponics
	Turnip	*Brassica rapa*	Aeroponics, drip irrigation
	Radish	*Raphanus sativus*	Drip irrigation, aeroponics
	Carrot	*Daucus carota*	Drip irrigation, aeroponics
Tuber Vegetables	Sweet potato	*Ipomoea batatas*	Drip irrigation
	Potato	*Solanum tuberosum*	Drip irrigation
	Asparagus	*Asparagus officinalis*	NFT, DWC
	Broccoli	*Brassica oleracea* var. *Italica*	Drip irrigation, NFT, wick pot
	Cauliflower	*Brassica oleracea* var. *botrytis*	Drip irrigation, NFT, wick pot
Fruit Vegetables	Zucchini	*Cucurbita pepo*	Drip irrigation, NFT
	Cucumber	*Cucumis sativus*	Drip irrigation, NFT

	Cantaloupe	*Cucumis melo*	Drip irrigation, NFT
	Watermelon	*Citrullus vulgaris*	Drip irrigation
	Green bean	*Phaseolus vulgaris*	Drip irrigation
	Squash	*Sechium edule*	Drip irrigation
	Chile	*Capsicum annuum*	Drip irrigation, wick pot
	Eggplant	*Solanum melongena*	Drip irrigation
	Tomato	*Solanum licopersicum*	Drip irrigation, NFT, wick pot
Pulse Vegetables	Pea	*Pisum sativum*	Drip irrigation, wick pot
	Bean	*Vicia faba*	Drip irrigation, wick pot
	Sweet Corn	*Zea mays*	Drip irrigation