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Cultivation of Crops under Hydroponics

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INTRODUCTION

The term "Hydroponics" was derived from the two Greek words "hydro" means water and "ponos" means labour and literally means "water work". The word hydroponics was introduced by Prof. William Gericke in the early 1930s; describe the growing of plants with their roots suspended in water containing mineral nutrients. Hydroponic farming is the practice of growing crops by using mineral nutrient solutions instead of soil to deliver water and minerals to the crop roots. Traditionally, the soil supports the crop's roots by helping them remain upright and ensuring the delivery of water and essential nutrients. In hydroponic farming, crops are supported artificially. Therefore, the nutrients are supplied by using various practices that bring mineral nutrient solutions to the crops.

Due to rapid urbanization and industrialization not only the cultivable land is decreasing but also conventional agricultural practices causing a wide range of negative impacts on the environment. To sustainably feed the world's growing population, methods for growing sufficient food have to evolve. Modification in growth medium is an alternative for sustainable production and to conserve fast depleting land and available water resources. In the present scenario, without soil cultivation might be commenced successfully and considered as alternative option for growing healthy food plants, crops or vegetables. Among these hydroponics techniques is gaining popularity because of its efficient management of resources and food production.

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Oat cultivation under Hydroponics	Strawberry cultivation under Hydroponics	Cabbage cultivation under Hydroponics

Advantages of hydroponic

- Hydroponically produced food, vegetable and fodder crops can be of high quality and need little washing of vegetables.
- Soil preparation and weeding is reduced or eliminated.
- It is possible to produce very high yields of fodder and vegetables on a small area because an environment optimal for plant growth is created. All the nutrients and water that the plants need, are available at all times.
- One does not need good soil to grow crops.
- Water is used efficiently.
- Pollution of soil with unused nutrients is greatly reduced

Disadvantages of hydroponics

- Hydroponic production is management, capital and labour intensive.
- A high level of expertise is required.
- Daily attention is necessary.
- Specially formulated, soluble nutrients must always be used.
- Pests and diseases remain a big risk.
- Finding a market can be a problem.

1. Basic requirements of hydroponics

1.1 Light

The requirement for light is just as essential for plants grown hydroponically as for those in soil. When plants are grown hydroponically out door one may rely mostly on solar radiation, while growing plants indoor it is necessary to provide artificial illumination. In the past, balance has been achieved by using a combination of fluorescent tubes and ordinary sodium lamps, so that both the blue and red ends of the spectrum were present respectively. Photo synthetically active radiation (400 nm - 700 nm) is essential is artificial lighting is required.

1.2 Temperature

A favorable temperature is just as important for crop plants in artificial culture as for those in soil. Temperature influences growth and development of crops. The optimum temperature is necessary for better growth and development of plants. The night temperature profoundly affects stem growth and fruit setting of tomato. Generally temperature range of 15 °C - 32 °C for cucumber and 18 °C - 27 °C for tomato and capsicum are optimum for crop production. For leafy European vegetables temperature range of 15 °C - 18 °C is optimum although they can tolerate as low as 7 °C temperature.

1.3 Water

Water is another requirement for plant growth that must be satisfied in hydroponics as well as in soil. Some of the water absorbed is used by the plant but most of it is lost by transpiration from the leaves. A significant amount may be lost by evaporation.

1.4 Aeration

In order to absorb water and nutrients, the roots require a certain amount of oxygen. Plants do not grow well in water logged soil devoid of air space and most plants do not grow well in water culture unless provision is made to aerate the solution by circulating it or by bubbling air into it. The solubility of O_2 in water is quite low (at 75º F about 0.004 per cent) and decreases significantly with increase in temperature.

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1.5 Anchorage

For plants growing in soil, sand or gravel culture anchorage is not a problem. However, when plants are grown in water culture, it is necessary to provide some means of support for the seedlings (like clay balls filled in the plastic mesh cups) and later the plants above the nutrient solution (stacking threads or wires) to allow plats to grow vertically.

2. Basic components for establishing hydroponic system:

The hydroponics has several basic components.

- Shallow fiberglass trays/ plastic trays (8 cm. deep) in which plants are grown (1.0 m x 0.5 m size or any other suitable size)
- A collection tank/nutrient solution storage tank. Capacity may vary from few liters to few hundred liters depending on the size of unit.
- A water pump which will circulate the nutrient solution from the reservoir tank to the growing trays through polyethylene tubes.
- A sequential timer to control the operation of pump.
- An aerator connected to reservoir through polyethylene tube, to aerate the nutrient solution to maintain the oxygen level in the nutrient solution.

3. Crops suitable for hydroponics

Table 2: List of crops that can be grown on commercial level under hydroponics

Type of crops	Name of the crops
Cereals	Rice (*Oryza sativa*), Maize (*Zea mays*)
Fodder crops	Sorghum (*Sorghum bicolor*), Alphalfa (*Medicago sativa*), Barley (*Hordeum vulgare*), Carpet grass (*Axonopus compressus*)
Vegetables	Tomato (*Lycopersicon esculentum*), Chilli (*Capsicum frutescens*), Brinjal (*Solanum melongena*), Green bean (*Phaseolus vulgaris*), Beet (*Beta vulgaris*), Winged bean (*Psophocarpus tetragonolobus*), Bell pepper (*Capsicum annum*), Cabbage (*Brassica oleracea var. capitata*), Cauliflower (*Brassica oleracea var. botrytis*), Cucumber (*Cucumis sativus*), Melon (*Cucumis melo*), Radish (*Raphanus sativus*), Onion (*Allium cepa*)
Leafy vegetables	Lettuce (*Lactuca sativa*), Kang Kong (*Ipomoea aquatica*)
Fruits	Strawberry (*Fragaria ananassa*)
Condiments	Parsley (*Petroselinum crispum*), Mint (*Mentha spicata*), Sweet basil (*Ocimum basilicum*), Oregano (*Origanum vulgare*)
Medicinal crops	Indian Aloe (*Aloe vera*), Coleus (*Solenostemon scutellarioides*)

Source: Maharana and Koul (2011)

4. Nutrient Solution

Nutrient solution for hydroponic systems is an aqueous solution containing mainly inorganic ions from soluble salts of essential elements for higher plants. An essential element has a clear physiological role and its absence prevents the complete plant life cycle (Taiz et al., 1998). Currently 17 elements are considered essential for most plants, these are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, copper, zinc, manganese, molybdenum, boron, chlorine and nickel. With the exception of carbon (C) and oxygen (O), which are supplied from the atmosphere, the essential elements are obtained from the growth medium.

The frequency and volume of the nutrient solution applied depends on the type of substrate used (volume and physical-chemical characteristics), the crop (species and stage of development), the size of the container, the crop and irrigation systems used and the prevailing climatic conditions. Plants should be fed daily. The best time to administer the nutrient solution is between 6.00 and 8.00 am, though water requirements will vary considerably throughout the day, and from one day to another. The solution should be applied to the roots, trying to avoid wetting the leaves to prevent damage and the appearance of diseases. Under no circumstances should plants be allowed to suffer from water stress, as this will affect their final yield. It is generally recommended that you apply only water to the plants once a week, in order to flush away any excess salts that have remained. Use double the amount of water normally applied, but without adding nutrients. Between 20 and 50% of the solution should be drained-off to prevent the accumulation of toxic ions and an excessive increase of electrical conductivity in the root area. The excess nutrient solution that is drained away from containers during daily watering can be reused in the next watering. At the end of the week, this liquid can be discarded (Berry & Knight, 2008).

pH and Electrical conductivity

The optimum range of pH of nutrient solution is 5.8 to 6.5 for hydroponic cultivation (Khan et al., 2015). If the pH range is higher or lower than the recommended range then the nutrient deficiency will be seen or toxicity symptoms will be developed. The pH values are different for different crops. The optimum EC range for hydroponics is between 1.5 to 2.5 dS/m. If EC is higher than optimum range then it will prevent nutrient motion pressure and if it is lower than optimum range than it will severely affect plant health (Hussain et al., 2014).

Table 1: Nutrient composition for hydroponic cultivation

Nutrients	**Quantity**
Macro nutrients	
Ca $(No_3)_2$	120 g / 100 l water
KH_2PO_4	20 g /100 l water
KNO_3	80 g /100 l water
$MgSO_4$	50 g /100 l water
Micro nutrients	
Boron	0.30 ppm
Manganese	0.20 ppm
Zinc	0.203 ppm
Copper	0.022 ppm
Molybdenum	0.015 ppm
Chelated Iron	
Iron	1 ml/l wate

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