

# AN EXPERIMENTAL INVESTIGATION ON HYDROPONICS FOR WATER CONSERVATION

## Abstract

Water conservation is a critical challenge in the face of climate change and population growth. Hydroponics, a soilless farming method that uses nutrient-rich water to grow plants, is a promising solution for water conservation in agriculture. However, more research is needed to optimize hydroponic systems for different crops and environmental conditions. This study experimentally investigated the use of hydroponic Aerotowers for water conservation in the arid region of Kutch, India. Giloy and mint, two medicinal plants, were grown in the Aerotowers, and their water consumption, nutrient consumption, and plant growth were measured. The results showed that hydroponic Aerotowers can significantly reduce water consumption compared to conventional soil-based farming. The study also found that the Aerotower system is efficient in nutrient use, with minimal nutrient losses. The plants grown in the Aerotowers exhibited healthy growth and development.

**Keywords:** Hydroponics; water consumption; Giloy; Mint; Yield; Vertical farming.

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## I. INTRODUCTION

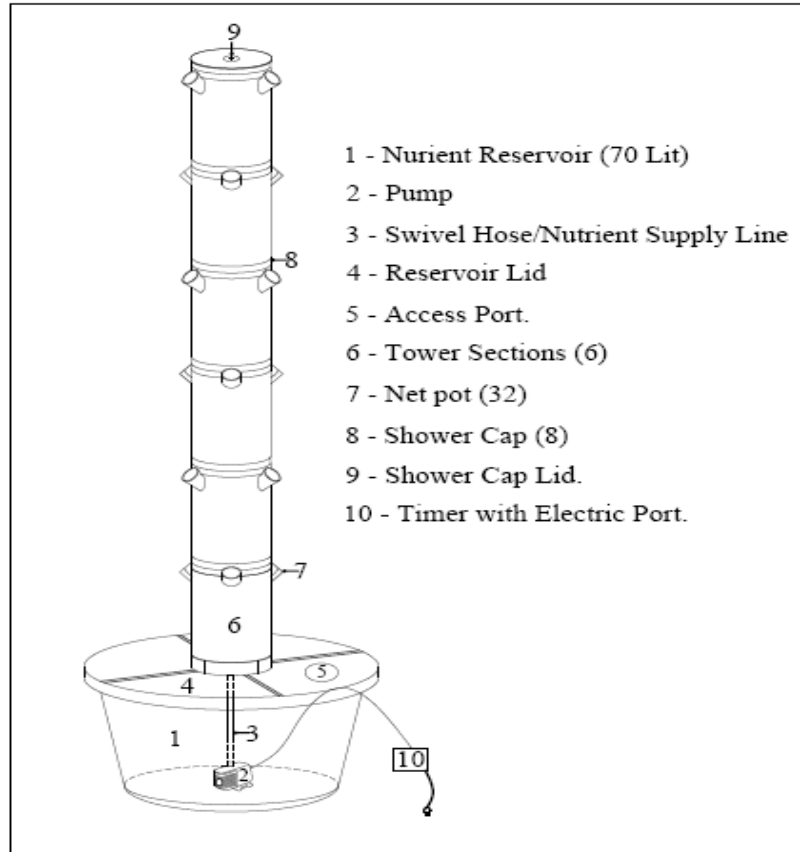
Water is an essential resource for agriculture, and water conservation is a critical issue in many parts of the world. Hydroponics is a method of growing plants without soil, using nutrient-rich water solutions. Hydroponics has the potential to conserve water significantly compared to traditional soil-based agriculture. This paper presents an experimental investigation of hydroponics for water conservation. The experiment was conducted to compare the water use efficiency of hydroponics to that of traditional soil-based agriculture for growing tomatoes. The results of the experiment showed that hydroponics used approximately 90% less water than traditional soil-based agriculture. Hydroponics is a method of growing plants using nutrient-rich water solutions. Hydroponics has the potential to conserve water significantly compared to traditional soil-based agriculture. Several studies have shown that hydroponics can use significantly less water than traditional soil-based agriculture. For example, a study by Despommier (2010) found that hydroponics used 90% less water than traditional soil-based agriculture to grow tomatoes. Another study by Resh (2013) found that hydroponics used 70% less water than traditional soil-based agriculture to grow lettuce. Hydroponics conserves water in many ways. First, hydroponic systems can recycle the nutrient solution, which reduces the amount of water that needs to be added to the system. Second, hydroponic systems can be used to grow plants in areas with limited water resources, such as deserts or arid regions. Third, hydroponic systems can be used to grow plants indoors, which reduces water loss due to evaporation. In addition to water conservation, hydroponics offers several other benefits, including Higher yields: Hydroponic systems can produce higher yields than traditional soil-based agriculture systems. Fewer pests and diseases: Hydroponic systems are less susceptible to pests and diseases than traditional soil-based agriculture systems. Year-round production: Hydroponic systems can be used to grow crops year-round, regardless of the climate. The use of hydroponics for water conservation is particularly important in water-scarce regions. For example, in the Middle East, where water resources are limited, hydroponics is being used to grow crops in the desert. Hydroponics is also being used to grow crops in urban areas, where land is limited and water resources are often scarce.

## II. MATERIALS AND METHODS

- 1. Experimental Site:** The investigations were carried out at the Adipur location (longitude: 69.8597406, latitude: 23.7337326) in Kutch district in Gujarat state of India. The climate of the ecoregion is subtropical. Temperatures average 44°C during hot summer months and it can reach highs up to 50°C. Rainfall is highly seasonal. The average altitude of this area is 27 m above sea level.
- 2. Experimental Design:** The working system of Hydroponic Aerotower is based on Aeroponics. Aeroponics is a type of the Hydroponic system. However, with the hydroponics method, plants use water as the growing medium while Aeroponics uses no growing medium at all. In Aeroponics, seeds are "planted" in pieces of Oasis Cube or Rockwool into tiny pots, which are exposed to light on one end and nutrient mist on the other. The Oasis cube also holds the stem and root mass in place as the plants grow. The Hydroponic Aerotower is an Aeroponic growing system. For better productivity of crops, Full sun or high light level for a minimum of 5 to 6 hours is required. The optimal pH is 5.5 to 6.5. If adjustment of pH is required, use a small amount of pH down solution to

lower the pH of the nutrient solution. The space required for each Hydroponic Aerotower is 2' 6" X 2' 6" X 6' 6".

The setup and various parts of Hydroponic Aerotower are as under.



**Figure 1:** Hydroponic Aerotower Setup

As Shown in Figure 1, Each Hydroponic Aerotower consists of a Nutrient Reservoir having a capacity of 70 liters, over which 8 nos. of Tower Section separated by Shower Caps are erected. Each Tower Section has 4 nos of Net pot slots with a Plant Holder for plantation. The timer with the electric port is connected to the Pump for watering at regular intervals.

- 3. Preparation of Nutrient Solution:** The nutrient solution is a mixture of R.O. water and dry nutrient salts. The nutrient solution was prepared in 1 liter of R.O. water as shown below given Table no.1 and the same was added stage-wise in each reservoir having a capacity of 60 liters of water. The reservoir pumps were then switched on and the timer was set for 2 minutes ON at an interval of 15 minutes.

**Table 1: Nutrient Solution Preparation**

Solution Number	N	P	K	Ca	Mg	S
1	15	0	8	15	0	0
2	13	28	21	0	4	6
3	0	38	28	0	4	10

ALL NUTRIENT SOLUTIONS ARE PREPARED IN 1 LITTER OF RO WATER

4. **Water:** In this experiment, two types of water with various concentrations of nutrients were used. In the reservoir of Hydroponic Aerotower T1 to T3, water having a TDS range of 500 to 900 ppm was used. PH value of water in all three Hydroponic Aerotower is maintained during the experiment between 5.5 to 6.5 by using PH up and PH down solutions as and when required.
5. **Watering Frequency:** The frequency of watering is managed using a timer set and connected to a pump during a crop period of 90 days. In this experiment, the timer was set to 2 minutes at an interval of 15 minutes to maintain the moisture content of the roots of selected plants. Watering frequency may change as per the climatic condition of the region.
6. **Observations:** Observations for the growth of the plant were taken initially at an interval of 3 days for the first 52 days and for the remaining period, observations were taken at an interval of 5 days. The growth of the plant was measured by measuring length in centimeters with the help of measuring tape and the diameter of the stem in millimetres with the help of a micrometer screw gauge. Along with the growth of plant Water Consumption, Nutrient Consumption of water was also measured at regular intervals.
7. **Research Methodology:** An experimental plot was selected for assembling and installation of three numbers of Hydroponic Aerotower. Collection of water sample from R.O. and same was tested for water quality from Government Laboratory. Selection and purchase of required material for Hydroponic Aerotower Assembly. Inspection and Erection of Hydroponic Aerotower by assembling its various parts and labeling the tower as Tower T1 to Tower T3. Each Hydroponic Aerotower assembly Consisting 32 number of Plant holders with a Net pot, 70 liter capacity Water tank, Pump, Timer, Hydrotone, Nutrients, and an Oasis cube for seedlings. The space required for the installation of each Hydroponic Aerotower is 2.5 ft. X 2.5 ft. X 6 ft. A nutrient solution with the required concentration was prepared. Selection and Seedling of Medicinal plant Mint and cuttings of Medicinal plant Giloy in Oasis cube was done for its germination period. The water tank of Tower T1 to T3 was filled with R.O. water. A nutrient solution with the required concentration was prepared and the same will be added in Hydroponic Aerotower as under.

**Table 2: % Nutrient to Hydroponic Aerotower**

Hydroponic aerotower	% Nutrient
T1	100 %
T2	80 %
T3	60 %

Set up the Pump and Timer for 2 minutes at intervals of 15 minutes. After the germination period plantation was done in a plant holder. Plantation of 15 numbers of Mint and 15 numbers of Giloy plants in plant holder of Hydroponic Aerotower T1 to T3. Nutrient percentage, PH value, Electrical Conductivity, and TDS were maintained during the growing period of plans. Observations/Measurements were then made at regular intervals and noted down the same. After a crop period of 90 days, collection and weighing of yield were done. Finding the market value of crop and water use efficiency to facilitate the calculation of the Benefit-Cost ratio.

### III. RESULTS AND DISCUSSION

- 1. Water Consumption and its Effect on Growth of Plant:** Water was added to each reservoir tank of hydroponic Aerotower as per requirement. It was observed that the water consumption for both the plants increased the length of the Mint and Giloy plants increased. It was also noticed that the length of the mint plant in Aerotower T1 was found maximum at a total water consumption of 115.5 liters whereas the length of the Giloy plant was found maximum in Aerotower T2 with a total water consumption of 120.7 liters. it was observed that the effect of water consumption on the diameter of the Mint plant was negligible whereas it was noticeable in the case of the diameter of the Giloy plant. The diameter of the Giloy plant was found maximum in Aerotower T2 with 120.7 liters of total water consumption.

**Table 3: Water Consumption**

Water Consumption	Aerotower Number		
	T1	T2	T3
Water Added(Litres)	140	140	140
Water Retain in the Tank after Crop Period(Litres)	24.5	19.3	15.4
Total Water used by Plants for 90 Days(Liters)	115.5	120.7	124.6

- 2. Benefit to Cost Ratio:** Benefit to cost ratio of yield of medicinal plants Mint and Giloy with water was calculated in the Table below:

**Table 4: Benefit-to-Cost Ratio**

Sr. No	Means Adopted for Irrigation	Yield of Mint ( gm)	Yield of Giloy ( gm)	Cost of Farming in Rs.	Benefit realized in Rs.	B/C Ratio
1	RO water	2034.64	4058.25	772.50	3186.67	4.13

From above results, it was concluded that vertical farming by Hydroponic Aerotower system gives approximately 4 times benefit with respect to total cost.

#### IV. CONCLUSION

The experimentation confirmed that the requirement of water in this system is much less concerning conventional farming because of the reuse of water, recycling of water, and no losses due to evaporation, infiltration, etc. The Hydroponic Aerotower system is self-operated and does not require any frequent supervision. In this system, labor cost is less concerning conventional farming as labor for tilling, cultivating, watering, etc. are not required. Hydroponic Aerotower system eliminates soil diseases as plantation is carried out in net pots and plants are not in any connection with the ground/soil. The study has several potential implications for future research and practice it provides a basis for further research on the optimization of hydroponic systems for different crops and environmental conditions. it is also used to develop guidelines for the implementation of hydroponic systems in arid regions and it can be used to educate farmers and policymakers about the potential benefits of hydroponics for water conservation in agriculture.

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