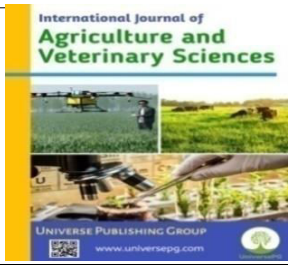
Publisher homepage: www.universepg.com, ISSN: 2663-7529 (Online) & 2663-7510 (Print)

https://doi.org/10.34104/ijavs.023.01090115

International Journal of Agriculture and Veterinary Sciences

Journal homepage: www.universepg.com/journal/ijavs



Vegetables Production (Tomato, Lettuce, Spinach and Capsicum) Through Utilization of Hydroponic Technology

Iffat Jahan Heera[1]* and Hasan Habibur Rahman[2]

[1]Department of Agriculture, Rabindra Maitree University (RMU), Kushtia-7000, Bangladesh; [2]Owner of HS Traders (Buyer and Vendor of Food Grain and Jute), Kushtia Sadar, Kushtia-7000, Bangladesh.

*Correspondence: iffatjahanheera@gmail.com (Iffat Jahan Heera, Lecturer and Program Coordinator, Department of Agriculture, Rabindra Maitree University (RMU), Kushtia-7000, Bangladesh).

ABSTRACT

In the present situation, Bangladesh needs food security which entails that each and every person must have physical and economic access to safe and nutritious food to meet dilatory needs. Scarcity of usable water for agriculture leads to production of lesser production of food which ultimately leads to hunger and malnutrition of a large number of people in our country. So, there is an utmost need for adoption of such technology in agriculture that can contribute towards water saving and have a positive impact on food production and availability. 'Hydroponics' is one such methodology of soilless cultivation and water use efficiency of this is much more than conventional system. Currently, hydroponics cultivation is gaining popularity all over the world because of its management of resources in a very efficient way and production of quality foods. Several benefits of this technique include less growing time for crops than conventional crop growing in soil, round the year production, minimum disease and pest infestation and elimination of several intercultural operations like weeding, spraying, watering, etc. which is labor intensive. Under hydroponics, by using different nutrient solutions and substrates such as coco coir, wood fiber, rice bran and water, production of leafy as well as other vegetables, 70%-90% water is saved. Some leading countries like Israel, France, Canada and Netherlands have adopted this technique at commercial level. On the basis of above performance, it is revealed that hydroponics can play a significant role in quality vegetable production. For this reason, an experiment was conducted at Rabindra Maitree University (RMU) in Kushtia Sadar, Kushtia district and the title states that "Vegetable production (Tomato, Lettuce, Spinach and Capsicum) through utilization of hydroponics technology".

Keywords: Vegetables, Tomato, Lettuce, Spinach, Capsicum, and Hydroponic technology.

INTRODUCTION:

Soil based cultivation is now facing difficulties due to different man-made reasons such as industrialization and urbanization. Also, sudden natural disasters, climate change and unrestricted utilization of chemicals for agriculture purposes cause the depletion of soil fertility and quality. That is why, scientists have developed a new alternative approach for cultivation system namely soil-less cultivation or hydroponics. Hydroponics is a method of growing plants in water based nutrient rich solution. The word hydroponics comes from the root's "hydro", meaning water, and "ponos", meaning labor, this method of gardening does not use soil.

Numerous plants, crops, and vegetables can be cultivated hydroponically. In comparison to natural soil-based horticulture, hydroponically grown items typically have greater quality yields, tastes, and nutritional values. This method of farming is economical, free of disease, environmentally benign, and gaining appeal both in developed and developing

nations. Along with advanced space research, it offers significant potential in many nations to bridge the gap left by a lack of suitable cultivable land. So, hydroponics would be a better technique to produce the different kinds of fruits, vegetables and fodder as well as meet the global nutrition demand with making advance future. In the future, hydroponics could be emerging techniques for the supplying of food to the worldwide population.

Hydroponics is a strategy that can deal with anybody effortlessly. Man can develop plants by hydroponics as their side interest or cultivating and at the same time, they can gather the new vegetables. This study aims to investigate the effects. Europe, America, Japan, Taiwan, China, Thailand, Singapore, Malaysia and Middle Eastern countries have been growing vegetables commercially using hydroponic methods for a long time. This method is now being extended in Bangladesh as well. In populous countries where there is little or no land for normal cultivation, it is possible to produce vegetables and fruits hydroponically on roofs or in greenhouses, silt tunnels, net houses (Professor Abu Noman Farooq Ahmed, 2023). In this method it is possible to produce vegetables and fruits throughout the year. Because no pesticides are used in the produced vegetables and fruits, these vegetables and fruits are safe and the market price is high.

Vegetables are an indispensable component of the human diet as they serve as major sources of vitamins and minerals necessary for human health. Vegetables such as Tomato, Lettuce, Spinach and Capsicum are in high demand owing to their nutritional and economic values due to their short growing cycle and high economic value in season and off-season production. The amount of arable land is decreasing day by day due to population growth in Bangladesh. It is possible to meet the increased demand of food in the country by growing crops in different mediums other than soil in hydroponic system.

Objectives of the study

The following specific objectives were formulated to give proper direction to the study:

1) To produce high quality vegetables by using local materials such as Coco Coir, wood fiber, Rice Bran and water comparing to soil.
2) To motivate people about hydroponics by maximum utilization of limited space.
3) To create awareness for growing healthy vegetables in home or roof top by hydroponics system.

Table 1: List of vegetables with Botanic Name which is used in experiment.

Type	Crops name	Botanical name
Vegetables	Tomato	*Lycopersicon esculentum*
	Capsicum	*Capsicum annum*
Leafy vegetables	Lettuce	*Lettuce Lactuca sativa*
	Spinach	*Spinacea oleracea*

MATERIALS AND METHODS:

The Nutrient Film Technique is one of the most widely used hydroponic systems. There are several other hydroponic techniques in use around the world. In this experiment, tomato, lettuce, spinach, and capsicum were grown using the nutrient film technique on four different substrates, including water, rice bran, coco coir, and wood fiber. Polyethylene plastic is used to line and construct the channels. Water is pumped through the channel in order to keep it flowing. Plants are suspended above solution with the roots dangling down into the solution. The channels are slightly sloped and the water is collected and reused by pumping it back to the holding tank. Plants with large root systems that can effectively reach down into the water can be grown using this technique (Turner, 2008). Occasionally, overgrown roots can block the channel and water must be filtered for debris before returning to the holding tank. Here used four vertical stands which contain four plastic seedling pots. Each pot filled with Coco Coir, Wood Fiber, Rice Bran and Water. Four types of vegetables such as Tomato, Lettuce, Spinach and Capsicum were produced in each pot. Each vertical stand requires nutrient solution creating by own. The five (05) most important minerals that listed in **Table 2** Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg). For example, they come at the ratio 10-10-10-10-10, meaning that each the nutrient is composed of 10% of the solution. The rest of 50% is water, and other substrate that assist the nutritional process (Bamikole and Adebowale, 2023).

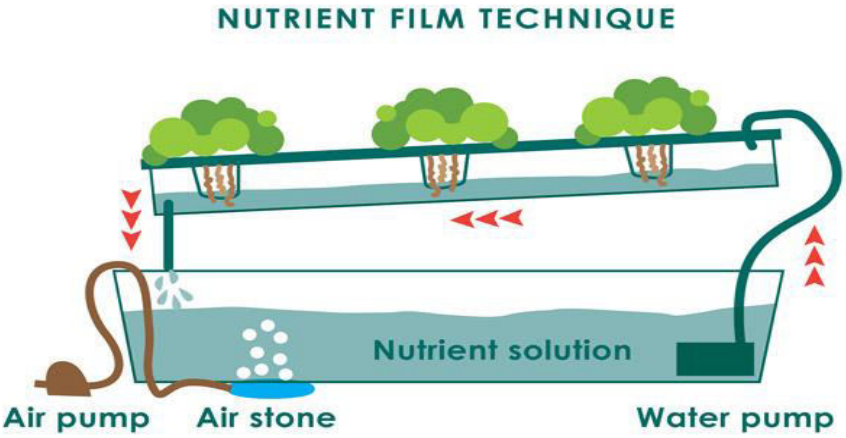


Fig. 1: Nutrient film technique.

Table 2: Here are the recommended nutrient solutions for vegetables.

Crop	Concentration in mg/l (ppm)				
	N	P	K	Ca	Mg
Tomato	190	40	310	150	45
Lettuce	180	40	280	130	40
Spinach	150	35	285	120	35
Capsicum	160	45	270	140	45
** Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg)					

The composition and concentration of the nutrient solution are dependent on culture system, crop development stage and environmental condition (Coic, 1973; Steiner, 1973). Extra four pots with soil were used for comparing the Hydroponic techniques.

Description of the research work:

Experimental Site: The experiment will be conducted at Agronomy Field and Horticulture Farm in Rabindra Maitree University, RC Roy Street, Kushtia-7000, Bangladesh.

Plant / Crop: Vegetables (Tomato, Lettuce, Spinach and Capsicum)

Total no. of Vegetable Items: Four (04)

Total no. of Substrate (Growing Support Materials): Four (04) such as Coco Coir, Wood Fiber, Rice Bran and Water

Total no. of Vertical Hanger: Four (04)

Total no. of Vertical Hanger Pot: Sixteen (16)

No. of Soil filled pot: Four (04)

Source of Seed Collection: The seed of (Tomato, Lettuce, Spinach and Capsicum) collected from Horticulture Research Center, Kushtia-7000.

Time duration of the Experiment: 4 month's (September 2022 to December 2022).

RESULTS AND DISCUSSION:

After completion of this experiment there were able to produce high quality vegetables such as Tomato, Lettuce, Spinach and Capsicum in minimum space utilization of RMU Campus by Hydroponic Technique. Comparing to soil the yield of above vegetables were much better in Hydroponics. Hydroponic research on Tomato, Lettuce, Spinach and Capsicum vegetables Life cycle on hydroponic is very short compared to traditionally grown on soil. Hydroponic Tomato can be harvested after 60 to 70 days of production; Hydroponic lettuce can be harvested after 35 to 40 days of production; Hydroponic Spinach can be harvested after 45 to 50 days of production; Hydroponic Capsicum can be harvested after 90 to 100 days of production. Lettuce can be successfully grown in NFT system & more than 8 crops per year can be grown efficiently in this system (Touliatos *et al.,* 2016).

Data collection

Data was collected on following parameters:

1). Plant height (cm), 2). Number of leaves (pc) per plant, 3). Number of flowers (pc) per plant, 4). Number of fruits (pc) per plant, 5). Weights (gm) of per fruit, 6). Yield per pot (gm).

Table 3: Morphological Change of Tomato, Lettuce, Spinach and Capsicum of Plant by using Potting Soil, Coco Coir, Wood Fiber, Rice Bran and Water.

Plant Height (cm) by mixing with Substrates					
Vegetable Type	Potting Soil	Coco Coir	Wood Fiber	Rice Bran	Water
Tomato	45.25	50.50	48.00	52.65	55.80
Lettuce	22.30	25.00	30.60	24.50	35.00
Spinach	23.50	20.45	25.00	24.00	28.50
Capsicum	50.30	45.60	48.92	50.45	55.50
No of Leaf (Pc) per Plant by mixing with Substrates					
Vegetable Type	Potting Soil	Coco Coir	Wood Fiber	Rice Bran	Water
Tomato	50	55	57	58	60
Lettuce	15	20	18	17	20
Spinach	16	21	18	20	25
Capsicum	60	62	65	67	70
Number of flowers (Pc) per plant by mixing with Substrates					
Vegetable Type	Potting Soil	Coco Coir	Wood Fiber	Rice Bran	**Water**
Tomato	15	18	20	17	25
Lettuce	-	-	-	-	-
Spinach	-	-	-	-	-
Capsicum	5	7	6	7	8
Number of fruits (Pc) per plant by mixing with Substrates					
Vegetable Type	Potting Soil	Coco Coir	Wood Fiber	Rice Bran	Water
Tomato	12	16	15	18	20
Lettuce	-	-	-	-	-
Spinach	-	-	-	-	-
Capsicum	3	4	4	4	5
Weights (gm) of per fruit by mixing with Substrates					
Vegetable Type	Potting Soil	Coco Coir	Wood Fiber	Rice Bran	Water
Tomato	70	80	85	75	90
Lettuce	-	-	-	-	-
Spinach	-	-	-	-	-
Capsicum	90	80	95	85	110
Yield per pot (gm) by mixing with Substrates					
Vegetable Type	Potting Soil	Coco Coir	Wood Fiber	Rice Bran	Water
Tomato (Fruit)	840	1280	1275	1350	1800
Lettuce (leaf)	120	160	144	136	180
Spinach (leaf)	144	189	162	180	250
Capsicum (Fruit)	270	320	380	340	550

System requirements

For successful cultivation of vegetable crops hydroponically, the following factors must be kept in mind:

1) PH of solution should be in between 5.8-6.4 i.e. slightly acidic to neutral.
2) Electrical conductivity (EC) of solution should be in the range of 1.2-3.5 Mho.
3) Temperature of the total system should not exceed 25-30°C.

Table 4: Optimum Range of EC and pH values for hydroponic crops.

Vegetable Crops Name	EC Mho	PH
Tomato	2.0 to 4.0	6.0 to 6.5
Lettuce	1.2 to 1.8	6.0 to 7.0
Spinach	1.8 to 2.3	6.0 to 7.0
Capsicum	2.5 to 3.5	5.5 to 6.5

SWOT analysis of hydroponics system in Bangladesh

The SWOT analysis provides a framework for assisting researchers or planners in identifying and prioritizing corporate goals as well as further identifying the strategies for achieving them (Ommani, 2011; Seerat Jan *et al.,* 2020). Bangladesh has a significant possibility to embrace hydroponics on a broad scale in the future because Bangladesh has a great diversity of climatic conditions that support the growth of a wide range of crops and the marketing of harvested goods. Apart from this, low labour and input costs in Bangladesh makes it an ideal destination for food outsourcing. After completing the experiment, data were inputted for SWOT analysis and following results were obtained:

Strengths

♣ Hydroponics makes any land with water source useful for vegetable production.

♣ High yields can be obtained from lesser spaces.

♣ Due to the premium quality, produce can fetch premium prices.

♣ Less number of labors is required which means it is a less costly venture.

♣ Integrated pest and disease management can be done in a very effective way.

Weaknesses

♣ Till date, there is no association/ tie up with any industries regarding selling of the products or formation of any bodies among hydroponics cultivators.

♣ High initial cost of investment and capital expenditure (capex).

♣ It needs more diligence and devotion than conventional farming.

♣ There are no dedicated standards and laws in Bangladesh till date.

Opportunities

♣ Branding, packaging and selling of the hydroponically grown produce can be done in a clean, healthy and unique way.

♣ More cash crops such as gingers, saffron, turmeric etc. should be tried to grow hydroponically.

♣ These crops are gaining good traction in Bangladesh.

♣ Hydroponically grown crops can be sold to niche/ urban markets which fetches high return.

Threats

♣ There must not be any competition regarding price but on quality in between conventionally and hydroponically grown products.

♣ There is a wrong perception among some people that hydroponics is unnatural.

♣ Certain soil grown produce are being marketed vigorously and may be a threat to hydroponic produce as for eg. Calyx-On tomato.

♣ Inconsistent supply arrangement may also ruin the market intake.

Vegetables such as Tomato, Lettuce, Spinach and Capsicum are important protective foods, which are highly beneficial for the maintenance of good health and prevention of diseases. They contain valuable food nutrients, which can be successfully utilized to build up and repair the body. They are rich in sources of carotene, ascorbic acid, riboflavin, folic acid and minerals like calcium, iron and phosphorous. Vegetables are a large class of plants being used for a large range of purposes including nutrition, medicine, flavorings, beverages & industries. They give a variety of flavors and colors to feed and food which include leaves, stems, flowers and fruits. Low yields and seasonal availability of vegetables are prevalent in Bangladeshi vegetable agriculture, which results in low per capita availability and severe nutritional insufficiency. On the consumption side, veggies do not make up a significant portion of the diet. Improved production technologies, such hydroponics, can be employed to get around productivity limitations. This study assesses the financial sustainability of the investment made in vegetable research and development and quantifies the project's effects on farmers' revenue and nutritional availability.

CONCLUSION:

According to Polycarpou *et al.* (2005), the hydroponics technique is extremely helpful in areas where environmental stress (cold, heat, dry land, etc.) is a significant issue. Since a crop grown in a hydroponic system is not affected by climatic change, it can be farmed all year round and is not regarded to be in season (Manzocco *et al.,* 2011). Further, commercial hydroponic systems are automatically operated and expected to reduce labour and several traditional agricultural practices can be eliminated, such as weeding, spraying, watering & tilling (Jovicich *et al.,* 2003). Hydroponics saves

large amount of water as irrigation and other kind of sprays is not needed and water logging never occurs. The problem of pest and disease can be controlled easily while weed is practically non-existent. Higher yields can be obtained since the number of plants per unit is higher compared to conventional agriculture. Hydroponics is viewed as a viable method for cultivating various crops in the past few decades. Hydroponics can make a significant contribution in locations with limited soil and water as well as for the impoverished and landless people, just as it is possible to grow short-duration crops like vegetables year-round in extremely small spaces with cheap labor. In Bangladesh, the hydroponic industry is expected to grow exponentially in near future. To encourage commercial hydroponic farm, it is important to develop low cost hydroponic technologies that reduce dependence on human labor and lower overall startup and operational costs. The most intensive type of crop production now employed in the agriculture sector, hydroponic culture is mostly used in industrialized and developing nations to produce food in small spaces. It is extremely productive, conserves water, safeguards the environment, and can be carried out on a small amount of land. By providing constant and readily available nutrition, hydroponics allows to grow up to 50% faster than soil. It also provides higher yield than conventional method. In a short amount of time, hydroponics has grown substantially, which has spurred experimentation and research in the field of indoor and outdoor hydroponic agriculture.

ACKNOWLEDGEMENT:

It's me the author expresses by the praises to Almighty Allah who enables to pursue to complete my higher education (Master of Science (M.S.) in Agroforestry & Environmental Science) from SAU, Dhaka, Bangladesh. The author states her cordial and deep gratefulness to co-author Hasan Habibur Rahman for his valuable suggestion, cordial association and active help in carrying out the research work and preparation of this thesis.

CONFLICTS OF INTEREST:

The authors declare no potential conflict of interest.

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Citation: Heera IJ., and Rahman HH. (2023). Vegetables production (tomato, lettuce, spinach and capsicum) through utilization of hydroponic technology, Iraq. *Int. J. Agric. Vet. Sci.*, **5**(4), 109-115. https://doi.org/10.34104/ijavs.023.01090115