Int.J.Curr.Microbiol.App.Sci (2020) Special Issue-10: 252-259

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 Special Issue-10 pp. 252-259
Journal homepage: http://www.ijcmas.com

Review Article

Role of Hydroponics towards Quality Vegetable Production: An Overview

Satya Prakash[1*], Rajat Singh[2], A. R. Kumari[3] and Adarsh Kumar Srivastava[4]

[1]Department of Horticulture, S.V. P. Uni. & T Meerut, (U.P), India
[2]Department of Horticulture, .V. P. Uni. & T Meerut, (U.P), India
[3]KVK Siwan DRRPCAU Pusa Samastipur, (Bihar), India
[4]Agril. Extension, KVK, Dhanbad Jharkhand

**Corresponding author*

A B S T R A C T

Vegetable growers are using indiscriminate use of chemicals and pesticides for management of the insects, pests during the vegetable production. Harvest the vegetables without gap of spraying of the pesticides. So that the big part of insecticides leads to different types of diseases like dermatology and cancer through residue of pesticides. So in present scenario, availability of quality vegetables is the major issue, besides this use of indiscriminate uses of chemicals and pesticides, the production cost of vegetable are also increasing resulting in decrease in net return. To get rid of this issue, there are many techniques adapted by farmers for improved quality of vegetable production. Hydroponics is one of those useful techniques, in this, several benefits are, less time for growing crops than conventional growing, minimum disease and pest incidents, weeding, spraying and watering, *etc.* can be eliminated. Under hydroponics, by nutrient film techniques (NFT), 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.

Keywords

Pesticides, Insecticides, Vegetable, Technique, Nutrient Film Techniques (NFT)

Introduction

Hydroponics is the science of growing plants without soil. Learn how just about any plant, especially vegetable, can be grown using this method. The term Hydroponics was derived from the Greek words meaning "hydro" (water) and "pono" (labor) the first modern use of hydroponics was by W.F. Gericke from the University of California during the 1930's. Gericke used hydroponics to grow tomatoes, beets, carrots, potatoes, fruits, flowers and more plant are grown in rows or on trellises, just like in a traditional garden, but they have their roots in water rather than in dirt. Hydroponic crop production has significantly increased in recent years worldwide, as it allows a more efficient use of water and fertilizers, as well as a better control of climate and pest factors. Furthermore, hydroponic production increases crop quality and productivity, which results in higher competitiveness and economic incomes. In fact, soil provides structure, not the actual food itself, for plant roots. The food comes from other materials mixed in the soil, such as compost, broken-down plant waste or fertilizers. Plant grown hydroponically can actually grow faster and healthier than plants in soil because they do not have to fight soil borne diseases in addition, all the food and water they need are given directly to their roots around the clock. Actually Europe is considered the biggest market for hydroponics in which France, the Netherlands, and Spain are the three top producers, followed by the United States of America and Asia- Pacific region.

In Hydroponics, the nutrients are dissolved in water and the solution goes into the plant roots, which uptake the water with minerals toward different parts of plant. The majority of previous hydroponic research has focused on leafy greens, peppers and tomato fruit (Arias *et al.,* 2000; Buchanan and Omaye, 2013; Gruda, 2009; Koyama *et al.,* 2013). Hydroponics can be grown in arid or urban conditions regardless of soil quality, making hydroponics advantageous for growing food closer to the consumer (Bellows *et al.,* 2003). In addition, growers often claimed that quality of hydroponic produces is superior because it uses a highly controlled environment and enables a more homogeneous production without any loss of water and nutrients. Moreover, hydroponics is not dependent on seasonality, and therefore, their productivities are higher and homogenous throughout the year.

An example of this waste reduction can be seen in lettuce, the most hydroponically cultivated crop in the world, in which about 99% of their hydroponic leaves are valid and they can be sold to a value approximately of 40% more expensive than a lettuce grown traditionally. Moreover, with hydroponics, there is a better opportunity to place the fresh produces in the market since their average nutritional quality and consumer's acceptance are higher. Worldwide consumers are increasingly interested in having more environment-friendly fresh vegetables due to the strong and well-established inverse relationship between vegetable consumption and the risk of many types of chronic and degenerative diseases like cancer, cardiovascular, and neurological disorders. Because of this growing consumer interest, the content of health-promoting compounds is becoming a vital consideration for fruit and vegetable growers. In fact, fresh vegetables and fruits are rich sources of bioactive compounds with significant health benefits, and these beneficial compounds can be influenced by several key factors including genotype selection and environmental conditions (light, temperature, humidity, atmospheric CO_2). Water/moisture, nutrients, and oxygen – all these different types of hydroponics must deliver those three important fundamental things to achieve success in plant production. there are categorize hydroponic systems into six different types Nutrient film technique (NFT), wick system, ebb and flow (flood and drain), water culture, drip system, and aeroponic system.

Types of hydroponic techniques

There are many different hydroponic techniques used throughout the world. Four of the main types

(1) Nutrient film technique.

(2) Dynamic root floating technique.

(3) Water culture technique.

(4) Ebb and flow method.

This word was first used in 1929 by Dr. Gericke, a California professor who began to develop what previously had been a laboratory technique into a commercial means of growing plants.

Nutrient film technique (NFT)

It is one of the most popular systems. Channels are built out of plastic or wood and are lined with polyethylene plastic. A pump is used to circulate water throughout the channel. 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 (Court, 1998).

Dynamic root floating technique (DRFT)

It is a hybrid of several hydroponic systems. In Taiwan, The Taichung District Agricultural Improvement Station developed the DRFT in 1986. Nutrient solution is pumped through one end and allowed to circulate through all the channels before being collected back into the tank reservoir. Instead of a continuously circulating nutrient solution system like in the NFT, the water pump is constantly turned on and off to alter the depth of the water. Alternatively, the pump can remain on at all times and a drainage system can be installed to vary the depth. One feature of the DRFT is the concave panels underneath the floating boards. This extra space allows roots called aeroroots to grow above the nutrient solution and therefore receive more oxygen. Also, various techniques are used to control the temperature of the nutrient solution. When temperatures reach above 30^0C, semi-transparent polyethylene sheets are hung over the roof to block out some sunlight. Additionally, the DRFT channels are lined with insulating material to impede heat transfer from the immediate surroundings. The main advantage of the DRFT is that it can maintain the temperature of the nutrient solution. Since oxygen is less soluble in warm water, the DRFT is well-suited for hydroponic farming in tropical and subtropical climates such as those found in Thailand (Kao, 1991).

Water culture technique

In the technique, plants are supported on top of the nutrient solution as This differs from the NFT and the DRFT systems because the roots hang freely into the nutrient solution. Root aeration can be a major problem when water is left to stand, so an air bubbler can be used to oxygenate the water. Alternately, pumps can be used to circulate the water and baffles located at the end of each bed will oxygenate the water as it returns to the reservoir. Roots should remain in complete darkness to ward off the growth of nutrient-consuming algae. The plant stems are supported on trays that float on top of the solution (Resh, 1997). This method is effective for plants such as lettuce, but not for larger plants or those that take a long time to grow such as tomatoes or cucumbers (Court, 1998).

Ebb and flow method

In this method water is pumped into the tank and then allowed to gradually drain. This differs from the water culture method because as the water drains, the roots are exposed and receive more oxygen. Also, cycling the water ensures that the water is less stagnate and will contain more oxygen. Careful attention must be given to the pumps because if the pumps fail, the plant roots can dry out quickly, especially in hot climates (Court, 1998). Ebb and flow systems work best with small plants such as basil or parsley (Turner, 2008).

Hydroponics vs. conventional farming

Hydroponic farming offers many advantages when compared to conventional farming. One of the main advantages is that crops can be grown in places with barren or contaminated land. Hydroponically grown plants are also more resistant to water with a high salt content. Another advantage includes not having insects, animals, and diseases such as fungi already present in the growing medium. Labor intensive work such as tilling, cultivating, fumigation, and watering is not required for hydroponic farming (Jones, 1997). If the system is automated using pumps or even computers, labor costs will decrease dramatically hydroponic systems are very efficient. In general, hydroponic plants only use one-tenth of the amount of water used by plants grown in soil because in traditional farming a majority of the water passes through the root layer quickly. The nutrient solution, required for hydroponic farming, only contains 25% of the amount of essential elements found in solid fertilizers. Since plants do not have to compete for surrounding soil space for nutrient reserves, more plants can be grown using less space in a hydroponic system. Spacing is only limited by the amount of available light. Plants also grow much faster and bigger in hydroponic systems. Therefore, hydroponic systems have higher yields per unit area when compared to traditional farming (Turner, 2008)

The vegetable production under soil-less culture in India is given in Table 1. Later on during 1960s and 70s, commercial hydroponics farms were developed in Abu Dhabi, Arizona, Belgium, California, Denmark, German, Holland, Iran, Italy, Japan, Russian Federation and other countries. During 1980s, many automated and computerized hydroponics farms were established around the world.

Advantage of hydroponic vegetable production

Hydroponically produced vegetable can be of high quality and need little washing. Soil preparation and weeding is reduced or eliminated. it is possible to produce very high yield of vegetable on a small area because an environment optimal for plant growth is created. All the nutrients and water that the plant need are available at all times. This technique is very useful for the area where environmental stress (cold, heat, dessert, *etc.*) is a major problem (Polycarpou *et al.,* 2005). Crops in hydroponic system are not influenced by climate change therefore, can be cultivated year-round and considered as off 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 and 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.

Nutrient Solution Management

While optimum nutrition is easy to achieve in soilless culture, incorrect management of the nutrient solution can damage the plants and lead to complete failure. The success or failure of a soilless culture garden therefore, depends primarily on the strict nutrient management programme. Carefully manipulating the nutrient solution pH level, temperature and electrical conductivity and replacing the solution whenever necessary, will lead to a successful soilless culture garden.

pH Level

The pH is a measure of acidity or alkalinity on a scale of 1 to 14. In a nutrient solution, pH determines the availability of essential plant elements. The optimum pH range for soilless culture nutrient solution is between 5.8 and 6.5. The further the pH of a nutrient solution from recommended pH range, the greater the odds against the success. Nutrient deficiencies will become apparent or toxicity symptoms will develop if the pH is higher or lower than the recommended range for individual crops. The pH values for different soilless crops are given in Table.

Cooper's 1988 and Imai's 1987 nutrient solutions were also used for growing leafy vegetables, tomatoes and cucumber. Proper pH and EC of the nutrient solution is very essential and should be maintained properly for optimum plant performance. Optimum range of EC and pH values for different hydroponic crops is shown in Table 1. Ideal EC range for hydroponics for most of the crops is between 1.5 and 2.5 dS m-1.

Higher EC will prevent nutrient absorption due to osmotic pressure and lower levels severely affect plant health and yield. So, appropriate management of EC in hydroponics technique can give effective tool for improving vegetable yield and quality (Gruda, 2009). As an example, yield of tomato under hydroponic system increased as EC of nutrient solution increased from 0 to 3 dSm-1 and decreased as the EC increased from 3 to 5 dS m^{-1} due to increase of water stress (Zhang *et al.,* 2016). Level of EC @1.5, 2 and 3 dS m^{-1} at vegetative, middle vegetative and generative phase, respectively had increased crop height, fruit number and pepper fresh weight.

Hydroponic research on Lettuce, Cucumber and leafy green vegetable

Leaf lettuce is an excellent choice for hydroponic growing. It thrives in the simplest of setups and does not need a lot of extra attention. You can harvest the outer leaves of your lettuce as it grows, meaning that you will end up with an extended harvest of crisp, fresh lettuce. As you cut the outer leaves away, the inner leaves quickly grow to take their place. Lettuce can be successfully grown in Nutrient film technique (NFT).Horizontal and vertical hydroponic system was also evaluated with different nutrient solution for yield optimization of lettuce (Touliatos *et al.,* 2016). Growing of lettuce in recirculating hydroponic system at spacing of 50 plants m-2 significantly increased yield and yield components (Maboko and Plooy, 2009). In other experiment, it was observed that both the hydroponic and organic system perform equal in terms of lettuce yield, quality and nitrate content. Just like lettuce, most other leafy green vegetables will grow well in a hydroponic system. Spinach not only thrives, but also you get the added advantage of no more sandy grit down in your spinach. Other good leafy green choices are kale, arugula, mustard greens, watercress and Swiss chard. Harvest these all at once or snip off a bit at a time, leaving the rest of the plant to keep growing. Do not let them get too big for your setup, since overly large greens may suffer from lack of air circulation. The results of Mwazi *et al.,* (2010) showed that salinity has negative impact on vegetable growth, but spinach has some tolerance to saline water when spinach grown in floating system, lack of aeration and hypoxia was not severe enough to influence yield and component as spinach is short duration crops but quality somehow was affected (Lenzi *et al.,* 2011).

Table.1 List of crops that can be grown in soil-less

	Cops name	**Botanical name**
Vegetables	Tomato	*Lycopersicon esculentum*
	Chilli	*Capsicum annum*
	Brinjal	*Solanum melongena*
	Green bean	*Phaseolus vulgaris*
	Beet	*Beta vulgaris*
	Winged bean	*Phaseolus vulgaris*
	Capsicum	*Capsicum annum*
	Cabbage	*Brassica oleracea var. capitata*
	Cauliflower	*Brassica oleracea var. botrytis*
	Cucumber	*Cucumis sativus*
	Melon	*Cucumis melo*
	Radish	*Raphanus sativus*
	Green Onion	*Allium cepa*
	Potato	*Solanum tuberosum*
Leafy vegetables	Lettuce	*Lactuca sativa*
	Spinach	*Spinacea oleracea*
	Celery	*Apium graveolens*
Condiments	Parsley	*Petroselinum crispum*
	Mint	*Mentha spicata*
	Coriander leaves	*Coriandrum sativum*

Source: Singh and Singh (2012)

Table.2 The pH values for different soilless crops

Vegetable	**P^H Range**
Beans	6.0-6.5
Broccoli	6.0-6.5
Cabbage	6.5-7.5
Carrots	5.8-6.4
Cucumbers	5.8-6.0
Garlic	6.0-6.5
Lettuce	6.0-6.5
Onions	6.5-7.0
Peas	6.0-6.8
Pumpkin	5.0-6.5
Radish	6.0-7.0
Tomatoes	5.5-6.5

Source: Hydroponic Food Production by Howard M. Resh Woodbridge Press, 1987

Cucumber will produce bountiful hydroponic crops, but they are likely to need some support to keep them from tipping over as they grow, Miniature cucumber plant, such as those developed for container growing, work best in a hydroponic raft system. Given enough space and support, any of them will grow. Check the cukes daily once they start to form, since the hydroponic environment may result in plants that grow much faster than you may expect.

Water conservation in hydroponic technique

Hydroponic saves between 70-90% more water than soil, as water is recirculated and reused. There are additional benefits crops may yield up to three times that of traditional gardening. For nutritional value, hydroponic vegetable may contain up to 50% more A, B, C and E Vitamins than conventional crops. This indoor method is not seasonally-dependent eliminating weather concerns of additional benefit, as there are no soils borne pests, hydroponics reduces the need for pesticides. It also uses 60% less fertilizer than traditional methods. Hydroponics is the cultivation of plant in water rather than in soil conditions for growing rely on a controlled environment for temperature and lighting. Hydroponics can grow many things, from fruits and vegetables to herbs and flowers, however, tomato and leaf green , such as lettuce, are the most popular. Water is not wasted in this process, as it gets recovered, filtered, replenished and recycled. Waste nutrient solution can be used as an alternative water resource for crop cultivation under hydroponic system (Choi *et al.,* 2012).

In conclusions, hydroponic is extending worldwide and such system offer many new alternative and opportunities for growers and consumers to have productions with high quality including vegetables. Hydroponic food production seems to have a positive overtone because of the numerous environmental benefits, it is important to consider the obstacles that small scale and commercial farmer may encounter. It seems that hydroponic can be an essential instrument to have vegetables with high nutritional quality .However, both hydroponic and soil based production systems require proper control, and they must be implemented correctly with full respect with plant needs, soil, water, environmental , growers, and consumer safety.

References

Choi, B., Lee, S.S. and Sik Ok, Y. 2012. Effects of waste nutrient solution on growth of Chinese cabbage (*Brassica campestris L.)* in Korea. *Korean Journal of Environmental Agriculture* 30 (2): 125-131.

Gruda, N. 2009. Does soil-less culture systems have an influence on product quality of vegetables. *Journal of Applied Botany and Food Quality* 82(2): 141-147. Jones, J (1997). Practical Guide for the Soilless Grower. Boca Raton, FL: St. Lucie Press.

Jovicich, E., Cantliffe, D.J. and Stoffella, P.J. 2003. Spanish pepper trellis system and high plant density can increase fruit yield, fruit quality and reduce labour in a hydroponic, passive-ventilated greenhouse. *Acta Horticulturae* 614: 255-262. Kao, T (1991). The Dynamic Root Floating Hydroponic Technique. Retrieved December 2, 2008, from http://www.agnet.org/library/eb/330/

Lenzi, A., Baldi, A. and Tesi, R. 2011. Growing spinach in a floating system with different volumes of aerated or non aerated nutrient solution. *Advance Horticulture Science* 25(1): 21-25.

Manzocco, L., Foschia, M., Tomasi, N., Maifreni, M., Costa, L.D., Marino, M., Cortella, G. and Cesco, S. 2011. Influence of hydroponic and soil cultivation on quality and shelf life of ready-to-eat lamb's lettuce (*Valerianella locusta L. Laterr*). *Journal of the Science Food and Agriculture* 91(8): 1373-1380.

Maboko, M.M., Plooy, C.P. and Bertling, I. 2011. Comparative performance of tomato cultivars cultivated in two hydroponic production systems. *South African Journal of Plant and Soil*. 28(2): 97-102.

Mwazi, F.N., Amoonga, S. and Mubiana, F.S. 2010. Evaluation of the effect of salinity on spinach (*Beta vulgaris var cicla*) grown in hydroponic system along the coast of Namibia. Agricola 14-17.

Polycarpou, P., Neokleous, D., Chimonidou, D. and Papadopoulos, I. 2005. A closed system for soil less culture adapted to the Cyprus conditions. In: Hamdy Resh, H (1997). Hydroponic Food Production. Santa Barbara, California: Woodbridge Press Publishing Company.

Singh S, Singh BS. 2012. Hydroponics - A technique for cultivation of vegetables and medicinal plants. In. Proceedings of 4th Global Conference on- *Horticulture for Food, Nutrition and Livelihood Options Bhubaneswar, Odisha India* p220.

Turner, B. (2008). How Hydroponics Work. Retrieved November 18, 2008, from http://home.howstuffworks.com/hydroponics.htm

Touliatos, D., Dodd, I.C. and McAinsh, M. 2016. Vertical farming increases lettuce yield per unit area compared to conventional horizontal hydroponics. *Food and Energy Security* 5(3): 184-191.

Zhang, P., Senge, P. and Dai, Y. 2016. Effects of salinity stress on growth, yield, fruit quality and water use efficiency of tomato under hydroponics system. *Reviews in Agricultural Science* 4: 46-55.