Journal of Advanced Zoology

ISSN: 0253-7214
*Volume **44** Issue **04 Year 2023** Page **352:356***

Design of Low-Cost Hydroponic Technology for Cultivation of Leafy Vegetables for Human Food Security in a Cold Desert Area of the Trans-Himalayan Range

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Article History

Received: 06 June 2023
Revised: 05 Sept 2023
Accepted: 16 Nov 2023

Abstract

For many decades, food security has been a worldwide concern. The present research aimed to examine an efficient technique for planting system i.e. hydroponic (a soil less system of farming) and statistical experimental design approach was used to compare the growth of different Leafy Vegetables (Spinach and Lettuce Varieties) in the Cold Desert Region of Trans Himalaya under the designed hydroponic system. The results showed that the leafy vegetable variety that were grown in the NFT system, exhibited significant differences in above attributes. The BC ratio of nutrient solution was found to be four times higher.

Keywords: *Trans-Himalayan, Hydroponic, Spinach and Lettuce*

1. Introduction

In mountain regions, reducing food insecurity is crucial to sustainable development. Cold deserts are present at higher latitudes in temperate regions (Dame 2018). They have colder temperatures than hot deserts. These results in dry environments that are caused by either remoteness from the coast, due to low atmospheric humidity from a lack of onshore winds, or the presence of high mountains that separates the desert from the coast. The Cold desert present in the Himalayas is known as the Ladakh Range. It extends to the southeast from the mouth of the Shyok River in the Ladakh region to the Tibetan border and is considered to be a segment of the Karakoram Mountain range (Patel 2023). These ranges run parallel to the northeast bank of the Indus River. Hydroponics can be defined as the practice of growing plants using only water, nutrients, and a growing medium. The word hydroponics can be deciphered as the root's "hydro", meaning water, and "ponos", meaning labor. In simple words, this method of gardening does not use soil. Hydroponics is not a whole new concept and use of this technique dates back to thousands of years ago in the Hanging Gardens of Babylon and the Floating Gardens of China. The only difference is that modern technology has enabled us to grow plants faster, stronger, and healthier (Dame at al. 2011, [2]Kumar et al. 2023) despite the general theory behind hydroponics remaining the same. William Frederick Gericke, known to refer to hydroponics the earliest (last 100 years). His work at the University of California, Berkeley, began to popularize the idea that plants could be grown in a solution of nutrients and water instead of soil. For leading a good healthy life, a balanced diet having all the important nutrients are necessary, of which Green leafy vegetables are the primary resource. The most common cause of anaemia among pregnant and lactating women and children is iron deficiency. Green leafy vegetables are rich in essential mineral nutrients and iron, which can help eliminate this deficiency. To encourage human food security in a cold desert area of the Trans-Himalayan range, Hydroponic Cultivation of green leafy vegetables is vital so that, the vegetables are available all through the year (Dame at al. 2011, Nazir et al. 2023 and Stobdan et al. 2018).

The Nutrient Film Technique (NFT), is a well-liked commercial hydroponic setup. It contains a fertilizer solution that is continuously pumped into the channels that runs along the bottom which is used to cultivate plants. Once the solution reaches the end of the channel, it is then returned to the

system's starting point by falling back into a main reservoir. As a result, it becomes a recirculating system, similar to deep water cultivation. In contrast to deep water culture, your plant roots in an NFT system are not fully immersed, that is where its name comes from "film." One plant at a time can be harvested or replaced in these channels utilizing net pots and growth material. Some of the Nutrient Film Technique's advantages are that very less growth media is required and there is less wastage because of recirculating system.

Fig.1. Cold Desert Region of Trans Himalaya (Chouhan & Sharma 2009)

Farming of the Future

Hydroponics, in my opinion, is a key approach to address the pressing concerns of fresh water and food supply in a sustainable and environmentally responsible manner. The future's farming has already started! One of the newest farming ideas making the rounds is the hydroponic system. It aids in plant growth by using water rather than nutrient-rich soil. Other materials are occasionally used in place of soil, such as vermiculite, rockwool, perlite, peat moss, etc. As a result, the hydroponic system needs to be built appropriately to enable the plants to take in oxygen and nutrients while submerged in water. Numerous hydroponic systems are available based on the space needed and the nutrient requirements of the plants. The rate at which the world's population is growing is driving up the demand for food production, and the conventional farming system will not be able to meet this growing demand. Therefore, creating new farming and planting systems is crucial in managing the coming food crisis.

2. Materials And Methods

Experimental details: Leafy greens such as Lettuce curly endive type var. grand rapid, Lettuce butter head type white var. White boston, Spinach var. Delta, Spinach var. all green are among the most popular locally grown vegetables at Vegetable Research Unit, Defence Institute of High-Altitude Research (DIHAR), DRDO, Leh-Ladakh (latitude: 34°08'23"N; longitude: 77°34'21"E and altitude: 3330 meter). During April to May 2021 the experimental trial the minimum and maximum temperature was 18^0C and 34^0C respectively with relative humidity of 46-66% inside the greenhouse. The used prepared stock solutions modified Hoagland solution 1 ml per litre (Kumar et al. 2023). They can be produced locally year-round in controlled environment greenhouses in hydroponics. This article will cover some of the basics of hydroponic systems and production methods for these crops.

Design: A hydroponic design requires three basic elements which include. The most common hydroponic growing systems for leafy greens are nutrient film technique (NFT). In NFT, seedlings are transplanted onto shallow channels where a thin film of nutrient solution is continuously circulated.

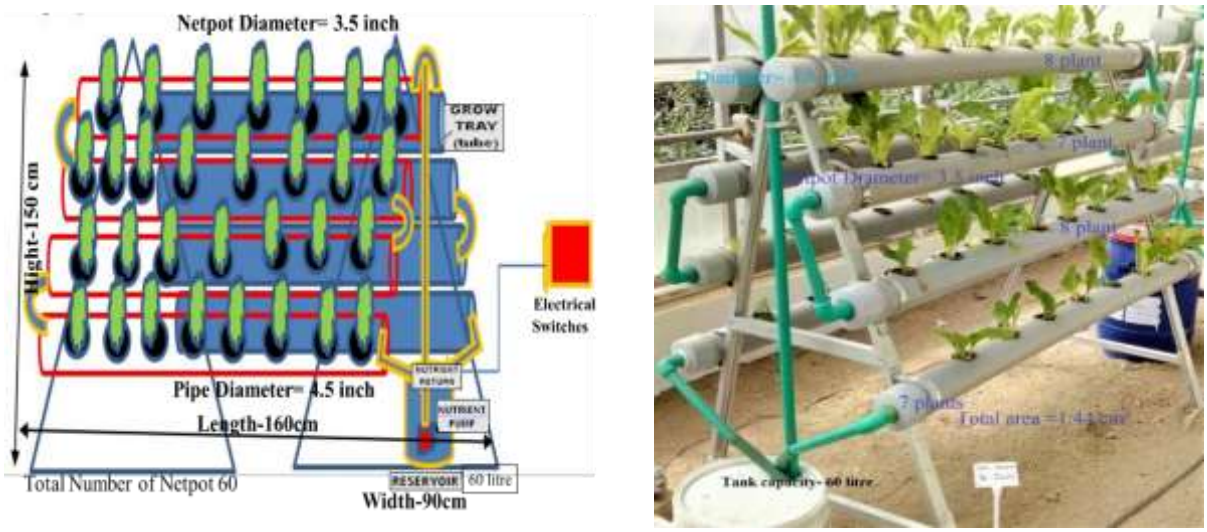

Fig.2. Design of a functional plan of a hydroponic system.

A growing PVC pipe- The plants have to be placed inside the growing container which can be kind of watertight vessel. The container should hold properly while the nutrient solution floods the inside, flows in the stream. The channels are sloped at 1 to 4 percent away from a centre aisle and drained at the ends back to the water reservoir. Pyramid 4 Tier Hydroponics System for Leafy vegetable production, number of Plant 60, Total area =1.44 cm2, LxWxH= 160x90x150 cm, Pipe Diameter= 4.5-inch, Net pot diameter= 3.5 inch

Sump tank- This tank is used for holding the solution as well as mixing it with the water. Some hydroponic agriculture system houses both the mixing and sump tank.

The pump: There are various kinds of pumps available in the market. We choose according to the size of the hydroponic system that you are building and how much water you need to pump into the system per hour. Pump motor Flow rate= 10 litre per minutes, Reserve Tank capacity- 60 litre.

Crop management and working of system

The basic prior need for growing plants in hydroponic. Lettuce and Spinach seed to be grown; therefore, a mixture of Cocopeat, Vermiculite and Perlite (5:2:1) media for nursery in green house. These seedlings were ready to transplant in 4 leaf stage and uniform seedlings were transplanted (Two plant in a net pots) in hydroponic system. The seedlings were placed into net pots in growing channels in hydroponic systems. The net pots were filled with clay balls for supporting seedlings. Nutrient solution and water are circulated from water drums to the PVC channels with the help of flexible pipe. The head of the submersible pump was divided using a T-joint to prevent water over flow. Water is returned to the vessels via the 4th and 8th pipes. Water and nutrient solution were thus re-circulated in this manner.

Plants measurement and sampling

Nine randomly selected plants were taken from each experimental site. all experimental data using SPSS 22 (SPSS Corporation, Chicago, Illinois, USA) and MS Excel 2019. The height of plant will be recorded using measuring tape from the crown level to apex of the primary leaf. It will be measured in centimetres (cm). The weight of entire fresh leaves (35 days after transplanting) harvested per plant will be recorded for each cultivar and the result will be expressed as yield per plant. The conventional methods of measuring dry matter, a sample of fresh produce is taken. The sample is weighed to determine the "wet weight" or moisture content. The produce is then dried in an oven until the moisture has fully evaporated. Next, the sample is weighed again to measure the dry weight. The following equation is then used to calculate the dry matter content:

Percentage of dry matter = (Dry weight / wet weight) x 100

Benefit-Cost Ratio (BRC)

The benefit-cost ratio (BCR) is a ratio used in a cost-benefit analysis to summarize the overall relationship between the relative costs and benefits of a proposed project. Benefit-cost ratio in agriculture considered as gross income divided by cost of cultivation.

B:C = Gross income/ cost of cultivation.

3. Results and Discussion

Plant growth attributes and biomass of leafy vegetable Cultivar

The study of plant growth, biomass and yield attributing characters leafy Cultivar grown in designed hydroponic system is presented in table 1 and 2. The compared characters (plant height, root length, leaf fresh weight, root fresh weight, dry matter & yield kg / unit) of spinach and lettuce vegetable varieties grown in hydroponic NFT systems

Table 1. *Plant growth and yield attributes of leafy vegetable Cultivar.*

Leafy vegetable cultivar	Plant height (cm)	Root length (cm)	Yield kg / Unit
Lettuce *var. Grand rapid*	24.0±1.8	20.0±2.0	8.4±0.6
Lettuce *var. Boston*	**27.3±2.**8*	18.3±1.3	7.5±0.5
Spinach *var. Delta*	24.8±2.6	**30.5±3.7***	9.7±1.2**
Spinach *var. All green*	23.3±1.3	31.5±4.4**	9.1±1.7*

Data were shown in mean ± standard deviation (n = 12). The values with the different letter within same column are statistically, ** & * indicate, significant at p<0.01, significant at p<0.05. by Duncan's test.

The leafy vegetable variety exhibited significant differences in above attributes grown in NFT system. It was observed that the plant height of Lettuce *var. Boston* (27.3 cm) in NFT was found maximum while minimum plant height was found in Lettuce *var. Grand rapid* in NFT system (24.0±1.8 cm). The highest Root length was recorded in Spinach *var. Delta* (30.5±3.7) and the was recorded in Lettuce *var. Boston* (18.3±1.3) gown circulated NFT system. Spinach var. Delta (9.7±1.2 g) grown in NFT circulated system exhibited maximum values for yield kg / unit followed by Spinach var. *All green* grown in NFT circulated system (9.1±1.7g) and lowest value of Lettuce *var. Boston* (7.5±0.5) at P<0.05. Crop grow different types of leafy vegetables at a time because the nutrient solution is same for all leafy vegetables and increasing growth and yield production thought hydroponic technology. The hydroponics method might possibly benefit the Trans-Himalayan range in the future. (Sharma et al. 2018, Acharya et al. 2021 and Kumar et al. 2022).

Table 2. *Plant biomass of leafy vegetable* Cultivar.

	Leaf fresh weight (gm)	Root fresh weight (gm)	Dry matter (%)
Lettuce *var. Grand rapid*	67±5.1	21.3±3.7	**6.4±0.3**
Lettuce *var. Boston*	62.4±2.7	20.4±1.6	6.7±1
Spinach *var. Delta*	**81.2±2.**8**	**25.1±6.8****	8.1±0.5
Spinach *var. All green*	75.8±4.3*	23.7±4*	8.6±1.1*

Data were shown in mean ± standard deviation (n = 12). The values with the different letter within same column are statistically, ** & * indicate, significant at p<0.01, significant at p<0.05. by Duncan's test.

Plant biomass (Leaf fresh weight, root fresh weight and dry matter) of leafy vegetable Cultivar grown in NFT system showed significant (P<0.05) difference. The Leaf fresh weight was significantly (P<0.05) higher in Spinach *var. Delta* (81.2±2.8 gm) cultivated in circulated NFT system and minimum was recorded in Lettuce var. Boston (62.4±2.7gm). The Root fresh weight was significantly (P<0.05) higher in Spinach *var. Delta* (25.1±6.8 gm) and minimum was recorded in Lettuce *var. Boston* (20.4±1.6 gm) cultivated in circulated NFT system. It was also observed that dry matter (%) of hydroponic leafy vegetable varieties is significantly higher in Spinach *var. All green* compared to all other varieties. For farmers with limited acreage, hydroponics technology offers a significant way to boost food productivity and quality. It also functions well in the absence of localized energy or water shortages (Sharma et al. 2018).

Benefit-Cost Ratio (BRC) of leafy vegetables

The hydroponic technology to develop from locally available materials. BCR can be expressed in monetary or qualitative terms. If a project has a BCR greater than 1.0, the project is expected to deliver a positive net present value to a firm and its investors. Crop sales per harvest (35 days after transplanting) is 75/- and total revenue obtained to be 558.7/- in a month. BC ratio calculated as a result of gross return and cost of cultivation only nutrient required based in table 3. Calculation of Benefit-cost ratio significant higher Begum at al. 2022.

Table 3. *Benefit-Cost Ratio (BRC) of leafy vegetables in Hydroponic technology type.*

Hydroponic System type	No. of Pot (Plant)	Nutrient required (ml)	Nutrient required Cost ⟨₹⟩ (price 0.40/ml)	Average yield kg / Unit	Average market price ⟨₹⟩	Benefit-Cost Ratio
4 levels	60*2	300	120	7.5	558.7	1.00:4.65

4. Conclusion

The crops grown Spinach and lettuce exhibited significant improvement in leaf area, plant height, root length and number of leaves per plant, fresh weight and yield in NFT system with greenhouse. Hydroponics can be used to grow fruits and vegetables with less resources and contribute to a global food system that is self-sufficient.

Acknowledgements

The present study was funded and supported by Defence Research & Development Organization (DRDO), Ministry of Defence, Government of India.

Conflict of interest

The authors declared that there is no conflict of interest.

References:

Acharya, S., Kumar, K., Sharma, N., Tiwari, V. K., & Chaurasia, O. P. (2021). Yield and quality attributes of lettuce and spinach grown in different hydroponic systems. *Journal of Soil and Water Conservation*, *20*(3), 342-349.

Begum, A. A., Rao, B. M., Gowd, M. H. P., & Ismail, T. (2022). Design and evaluation of low cost rectangular framed hydroponic system in leafy vegetables. *The Pharma Innovation Journal*, 11(12): 2391-2393.

Chouhan, T. S., & Sharma, U. K. (2009). Desert ecosystems in India. *Trop Biol Conserv Manag*, *9*, 51-111.

Dame, J. (2018). Food security and translocal livelihoods in high mountains: Evidence from Ladakh, India. *Mountain Research and Development*, *38*(4), 310-322.

Dame, J., & Nüsser, M. (2011). Food security in high mountain regions: Agricultural production and the impact of food subsidies in Ladakh, Northern India. *Food Security*, *3*, 1.

Kumar, K., Acharya, S., Verma, V. C., Tsewang, T., Tiwari, V. K., Avantika, A., ... & Chaurasia, O. P. (2023). Comparative evaluation of physico-chemical response of tomato varieties under hydroponic technique vs soil cultivation in natural ventilated greenhouse at trans-Himalayan India. *Vegetos*, *36*(3), 825-832.

Kumar, K., Kumari, K., Acharya, S., Tsewang, T., Mishra, A., Verma, A., & Chaurasia, O. (2023). P. Evaluation of Spinach and Lettuce Production (Growth, Morphological Characteristics, Biomass Yield, and Nutritional Quality) in NFT Hydroponic System in Greenhouse, Room, and Open Environment at Leh, *India. Eur. Chem. Bull.*,12(5), 5421-5435.

Kumar, K., Kumari, K., Tsewang, T., Tiwari, V. K., Sahay, D., Mishra, A., ... & Acharya, S. (2022). Hydroponic Technique: A New approach for Crop Production at Trans Himalayan High-altitude Cold Desert Regions of India. *International Journal of Plant & Soil Science*, 43-52.

Mishra, G. P., Singh, N., Kumar, H., & Singh, S. B. (2010). Protected Cultivation for Food and Nutritional Security at Ladakh. *Defence Science Journal*, *60*(2).

Nazir, S., Mustafa, S., Pandit, A., Norbu, T., & Chaurasia, O. (2023). Solar Energy powered active Greenhouse for the cultivation of Fresh Food during winter in Trans Himalayan Cold Arid Region, India. *Defence Life Science Journal*, *8*(1), 10-20.

Patel, V. K., Singh, L. P and Kureel, R. S. (2023). Challenges and possibilities in hydroponically production of medicinally importance culinary herbs, exotic and high value vegetables for food and nutritional security in cold desert Leh, ladakh region, India. Int. J. Adv. Res. 11(05), 943-952

Sharma, N., Acharya, S., Kumar, K., Singh, N., & Chaurasia, O. P. (2018). Hydroponics as an advanced technique for vegetable production: An overview. *Journal of Soil and Water Conservation*, *17*(4), 364-371.

Stobdan, T., Angmo, S., Angchok, D., Paljor, E., Dawa, T., Tsetan, T., & Chaurasia, O. P. (2018). Vegetable production scenario in trans-Himalayan Leh Ladakh region, India. *Def. Life Sci. J*, *3*, 85-92.