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RESEARCH ARTICLE

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

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Abstract

Leh a Cold Desert, which is capital of union territory Ladakh and strategic location for India. There is round the year dearth of culinary herbs & exotic and high value vegetables like- basil, rosemary, parsley, oregano, mint, lettuce and minor culinary herbs and turnip, tomato, capsicum, cucumber, bitter gourd, gourds, broccoli, cauliflower, cabbage etc. Meeting the demand of the region by conventional production is difficult due to the harsh climate i.e. extremely dry with scanty rainfall and very little snowfall. Being a cold desert, climate is extreme in Leh; ambient minimum temperatures are below or near freezing point, however, in winter, days are sunny and bright. The soil is underdeveloped and vegetation is very sparse. Major source of water for drinking and irrigation is glacier melt water. Moreover, supply of such culinary herbs and vegetables to Ladakh region necessitates the transportation with trucks which passes at a height of 5300 m, for more than 400 kms. Food items/vegetables in winters has to be air freighted as the roads are snowed. Storage of highly perishable items such as vegetable and culinary herbs is difficult. Local people and security personnel of armed forces posted in Ladakh region do not get access to green vegetables in winter, therefore, they suffer from nutritional issues. For hospitality industry also availability of these items for tourists become difficult and costly affair. With the using of hydroponic crop production technology which offers an alternate crop production system where soil is not used as a growing medium for the crops; fresh vegetables and culinary herbs can be indigenously produced in Leh-Ladakh. This technology will ensure quality food and nutritional security in this region. This production system is already being used successfully for crop production in cold regions of world similar to the climate in Leh. In this technique water culture scientists discovered that as compared to soil based growth,hydrophonic plant system needs only small number of inorganic elements in addition to water, oxygen, carbon dioxide and sun light to grow the plant Hydroponics farming can be a major advantage for Leh, Ladakh Indian Horticulture; it has the potential to produce crops in every season without soil. Such practices can help

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Leh, Ladakh farmers to increase their crop productivity even in small fragmented lands.This review paper focus on the challenges and possibilities to bring soil less farming in cold desert region Leh, Ladakh, India to ensure its stability so that it may prove more beneficial for growers to grow crops which areuninterrupted year-round production (plant factory), high quality produce, pesticide residue free produce, sustainable crop production technology, consistency in quality and supply of fresh produce.

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Introduction:-

Vegetables contributed major part in the human diet for balanced nutrition. Vegetables are rich sources of minerals, protein, vitamins, and dietary fibres which cannot be supplied by other food sources. Accordingly diets with high quantity of vegetables are widely recommended for their health-promoting properties. Most countries have dietary recommendations of vegetables.

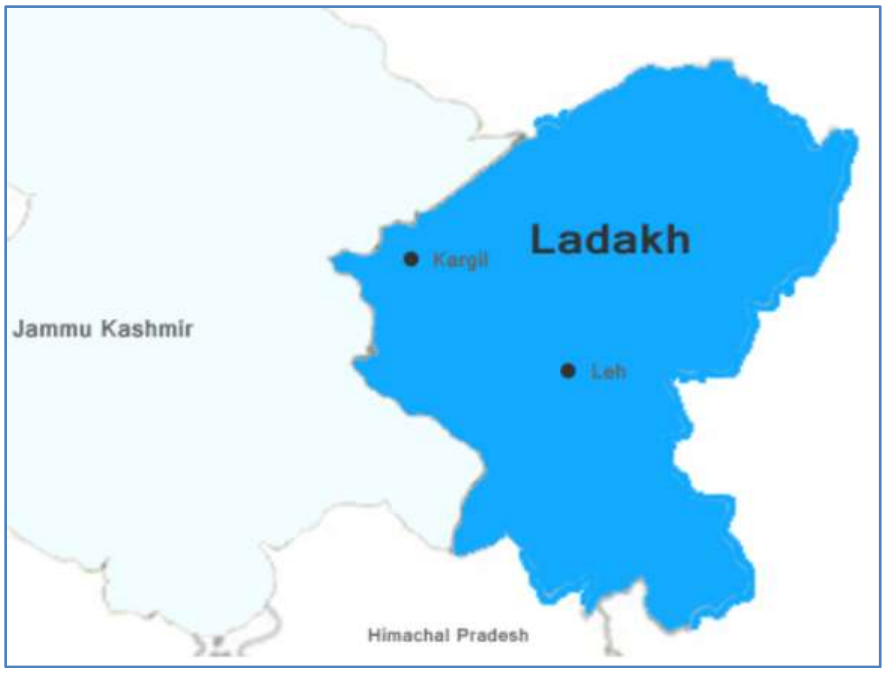
Wide variation in daily and seasonal climate makes it difficult to standardise package of practices for cultivation of vegetable crops in Leh, Ladakh region. Among the climatic factors, temperature is most important which has great impact on cropping pattern and production techniques. Since temperaturedecreases with increasing altitude, therefore, cropping season and duration depend upon the altitude. Although, Army is deployed up to 6,600 m altitude in the region but human settlement and agriculture is confined between 2,400 m to 4,200 m altitudes. For enhance production of vegetables to ensure the nutritional security in high altitude cold desert, a comprehensive alternate production technology like soilless cultivation is needfor year-round production. Hydroponic cultivation strategies in protected vegetables and aromatic & medicinal herbs have proved to increase certainty for dietary antioxidants production through adverse weather conditions while providing viable alternative livelihood opportunities to farming communities and professional entrepreneurs. Looking at this emerging demand hydroponics may be seen as a better technique of vegetables and culinary herbs production.

Leh, Ladakh is a high altitude cold arid region of India. Human settlement here is found from 2400-4200 meter above mean sea level in the region. The climatic and geographic differentiation segregates the region from rest of the world. The region is characterised by extreme temperature variations, low precipitation mostly in the form of snow, high wind velocity, sparse plant density, thin atmosphere with high UV-radiation and fragile ecosystem. The temperature drops down to -30 ºC in winter4. Long harsh winters reduce the cropping season to just four to five months in a year. Single-cropping is dominant, as double-cropping is possible only in a limited area falling below an altitude of approximately 3000 m. Agriculture production is entirely based on irrigation. The region remains cut-off for over six months in a year due to heavy snowfall. Availability of locally grown fresh vegetables is restricted to summer months and therefore, there are seasonal differences in dietary intake of food. The availability of fresh vegetable decreases significantly during the winter months, which has resulted in unbalanced diet. Micronutrient deficiencies including the lack of vitamin A, B6, B12 and folic acid are prevalent in the region. Seasonal shortfall and low dietary diversity among the local populace lead to micronutrient deficiencies, a phenomenon that has been described as ‘hidden hunger’3. Self-sufficiency in food is an important issue for the region. Filling the gap between the required quantity and the quantity locally produce is a difficult task in this region. Importing goods to Ladakh necessitates the shipping of goods by truck across the Himalayas, with passes as high as 5300 m, covering the distance of Manali to Leh (480 km) or Srinagar to Leh (420 km)5. There is a growing demand for local vegetable produce due to population increase, urbanisation and growth in income. Therefore, meeting the increasing requirements of fresh vegetable for the local populace and the army in this remote mountain area is a formidable challenge6. Therefore, the agro-techniques for the vegetable production being employed elsewhere are not suitable for this region. Specific agro techniques are required for this harsh region.

Geographical Area – Leh, Ladakh:

Ladakh is a barren yet beautiful region located in the north India, Sharing its east border with Tibet, Lahaul and Spiti to its south and the Kashmir valley to the west.Ladakh region has two districts leh&Kargil with total geographical area is 59,146 km². Its natural features consist mainly of high plains and deep valleys. The high plain predominates in the east, diminishing gradually toward the west. In southeastern Ladakh lies Rupshu, an area of large, brackish lakes with a uniform elevation of about 13,500 feet (4,100 metres). **Leh** is the joint capital and largest town of the

union territory of Ladakh located at the elevation of 11500 ft in the **Leh** district. Cold desert region of Ladakh having an annual average temperature of 5.2 °C and average humidity of 51.3% makes outdoor production of herbs extremely limited.



Cultivation Challenges in Cold Desert Region:

Agriculture in Ladakh Region is a way of life for the agrarian population and nearly 70% population is directly or indirectly dependent on this sector. Despite the vast geographical area, 62% of the households has less than 1 ha cultivable land. Single-cropping is dominant, as double-cropping is possible only in a limited area falling below an altitude of approximately 3000 m. Agriculture production is entirely based on irrigation. Glaciers are the main source of water for irrigation and the rivers that flow in the region remain underutilized for agricultural purpose.

Ladakh has recently been declared a Union Territory hence the region is bracing itself for development, incoming investment, industry, even more tourism and greater pressure on the fragile ecosystem. Given its physical distance and seasonal isolation from major markets, Ladakh must be self-sufficient. At the same time, it must use its strengths to tap into external markets and economies of scale. Oxygen level is low and under stress condition in this area. So, foods which are enriched with nutrition are required. The medicinal herb and high value vegetables should be grown in this area which is a cold desert and has harsh climate. If vegetables can be grown in harsh climate of winter in Leh, they could consume nutritious food and also supply vegetables to the defence personnel stationed in the region and tourists. With the farming season lasting only for six months from November to April in Leh, new technologies should be adopted to grow vegetables in winter that improves diets and boosts incomes.

In winter, Leh imports vegetables worth lakhs of rupees from other parts of the country. Despite the potential to grow some crops, there are challenges: -

1. Water scarcity, ground table is getting depleted, Frozen water lines from Nov- April with lowest temperature of minus 15 ^{o}C.
2. People do not get access to green vegetables in winter, therefore, they suffer from nutritional issues. Diet devoid of fruits and vegetables for majority of the year and low in variety.
3. Due to a lack of access to vegetables women suffer from folic acid deficiency and anaemia.
4. Seasonal shortfalls and low dietary diversity lead to micronutrient deficiencies, a phenomenon that has been described as “hidden hunger”.
5. Expensive food/vegetables in winters as it has to be air freighted because the roads are snowed.

The Cold Desert Vegetables in Leh, Ladakh

Ladakh, the land between the earth and the sky is considered virtually unfit for vegetation. But long ago, some plant species were able to establish themselves in this difficult terrain after natural introduction. Majority of such plants are perennial herbs and some of them were suitable to use as vegetables (Chaurasia et al., 2000.). Before introduction of some cultivated vegetable crops such as turnip, radish, carrot, onion, potato and certain leafy vegetables in late 1950s by the government officials (foreigner and Indian) and missionaries, the people of this region were dependent on these wild plants species as vegetables and this practice can still be seen in far-flung villages.After introduction of cucurbitaceous, solanaceous, and exotic crops in the last decade, total number of introduced vegetables has been increased and agro-techniques have been evolved for more than 65 types of vegetables (Singh& Singh, 2003).

Seasonal Availability of Vegetables

Climatic condition of the region restricts growing season of crops from May to September in open field condition. Vegetables are generally harvested from June to September while crops such as potato, onion, cabbage, carrot etc are harvested in late August to September. The region sees a glut of vegetable during the period which in contrast to an acute scarcity of fresh vegetable in winters. During winter passive solar greenhouse cultivation is the only source of locally produced fresh leafy vegetables. Crops such as potato, radish, carrot, cabbage, onion and turnip are stored in underground pits and root cellars for their consumption in winter months11. With the integrated use of hydroponic production system along with greenhouse technology, it will be possible to make fresh vegetables available throughout the year (Stobdan et al., 2018).

Commercially grown vegetables in trans-Himalayan LehLadakh regions:

Beans, beet root, bottle gourd,brinjal, broccoli, brussel's Sprout, Cabbage, Capsicum, Carrot, Cauliflower,Celery, Chillies, Chinese Cabbage, Coriander, Cucumber,Garlic, Knol-khol, Methi, Mint green, Onion, Peas, Potato, Pumpkin, Radish, Red Cabbage, Indian spinach, Summer squash,Tomato,Turnip etc.

Growing Demand for Local Vegetable ProduceIn Cold Desert:

To fulfill the requirements, it is difficult to import thevegetables from other parts of the country to Ladakh mainlydue to their highly perishable nature and involvement oflong distance transportation. The region remains landlockedevery year from November-May due to heavy depositionof snow on the road-passes. Air-lifting of the fresh vegetablesresults in heavy expenditure, which will not be affordableby the people. Army also requires huge quantity of freshvegetables to feed their troops deployed in this region andspends a substantial amount to import the vegetables fromother parts of the country. Including army and floatingpopulation, vegetables are required for a population ofabout 3.0 lakh in the region. If it is calculated based onthe ration scale provided to the Army, then total of 37,200metric ton/year vegetables are required. Out ofthis quantity approximately 17,705 metric ton/year vegetablesare produced locally and remaining quantity is either importedfrom other places of the country or the people replace itby other food ingredient in absence of availability of vegetables (Singh et, al. 2008).

There is a large number of military troops stationed in Ladakh due to strategic nature of the region. Providing essential nutritional support to the army operating in high altitude are best taken from resources available locally as timely supply of fresh vegetables from low land is not always possible due to logistics constrains (Angmo et al., 2017). There exist mechanisms to supply fresh vegetables to the army directly from the farmer's field through the farmers' cooperative marketing societies (Mishra et Al., 2010). Therefore, supply of vegetable to army has emerged as major market to the local farmers in this remote mountainous region.

Alternative Production System - Hydroponic Production Technology

The most available growing media for plants is soil, which provides nutrients, water, air and importantly it provides anchorage for successful growth of plants. However, unfavourable soil composition, soil erosion causing degradation, poor drainage, unsuitable soil reaction, presenceof disease-causing organisms and nematodes are some of the serious limitations for plant growth (Dholwani, 2018) .To eliminate these limitations, the hydroponics system of cultivation was introduced to agriculture. "Any method in which plants are grown without using soil as a rooting media and essential nutrients can be supplied through irrigation water" is said to be soilless culture. The fertilizers (containing nutrients) are supplied by dissolving in the irrigation water in appropriate amount (Savvas, 2003). Soilless farming can be classified according to the techniques employed. It is generally classified into two types, substrate culture and water culture (Olubanjo and Alade, 2018). Most hydroponic systems operate automatically to control the amount of water, nutrients and photoperiod based on the requirements of different plants (Resh, 2013).

Hydroponic Cultivation is a futuristic technology and popular all over the world because of efficient resources management and quality food production at places like Leh where soil based agriculture faces various challenges such as harsh climate, ground water scarcity, natural disaster, climate change, indiscriminate use of chemicals and pesticides which is depleting the land fertility.

The medicinal plants found in Ladakh cannot be mostly found in rest of the world. It is unique in nature and its habitats. Plant can grow in places where the land is limited, doesn't exist, or is contaminated. In early time period, Hydroponics is successful technique used to supply fresh vegetables and culinary herbs for cold area where the temperature is low. It has been considered as the future farming to grow foods for astronauts in the space by NASA. Roots of plants usually expand and spread out in search of foods, and oxygen in the soil but in case of Hydroponics, roots are sunk in a tank full of oxygenated nutrient solution and are directly in contact with vital minerals. This means that grow plants closer, and consequently huge space savings.

With hydroponic technology we can have total control on climate, temperature, humidity, light, the composition of the air. Which means we can grow foods all year, regardless of the season and produce foods at the right time to maximize profits. Plants grown by the process of hydroponically use only 10% of water, as compared to one grown on the field because water is recirculated, in this method. Plants will take up water they need, while run-off water will be captured and return to the system. Water loss in this system will only occur in two forms - evaporation and leaks from the system. With this technology we have a 100% control of the nutrients (foods) that plants need in this method. As plants are placed in favorable conditions, nutrients are provided at the sufficient amounts and come into direct contacts with the root systems. Therefore, plants do not waste valuable energy in search for diluted nutrients in the soil and put their complete focus on growth.

The hydroponic method of growing, automatically irrigates a balanced nutrient solution that can be controlled to give higher or lower fertiliser doses depending on crop requirements. pH levels, particularly in culinary herbs, can also be finely controlled allowing planting of specific crops in areas where soil pH is prohibitive to growth. Hydroponic system gives a large improvement in water efficiency due to controlled irrigation, increased production and reduced transpiration.

It is envisaged that hydroponics technology combined with traditional wisdom can sustainably grow yearlong produce in Leh's cold desert during the long harsh winters with sub minus 15 oC temperatures. Emphasis would be to grow a wide range of vegetables and culinary herbs cheaply year round. These can be grown with the help of futuristic technologies such as Hydroponics Technology which can address to the local problems. There is a need to work on the vegetation in the freezing temperatures, using hydroponics technology for year round sustainable growing in Ladakh's cold desert for health & prosperity. Moreover, the time is appropriate for implementing this vision.

The Leh vegetables and aromatic & medicinal culinary herbs market has great potential. People in Leh region are looking for highly nutritional and top quality dietary antioxidants. Hydroponic cultivation system which is suitable for Peri-urban and urban production ofthe major vegetables like turnip, tomato, capsicum, cucumber, bitter gourd, Ridge gourd, Bottle gourd, broccoli, cauliflower, cabbage etc. culinary herbs such as basil, rosemary, parsley, oregano, mint, coriander, spinach, fenugreek and other minor herbs under protected conditions (Fig. 1).

Benefits of the Hydroponic Production Technology:

1. Greater plant density- plants can be moved as they grow. Use of a growth room for germination and seedling production and the spacing of certain crops in the greenhouse decreases the average area needed per plant over conventional soil production.
2. Leafy green vegetables, salads, herbs and other high value vegetables can be grown by this system of hydroponics;
3. Many vegetables and herbs rich in vitamins, minerals, and antioxidants. can be grown in this medium;
4. Less growing time of crops than conventional growing;
5. Round the year production;
6. Less water consumption- In methods where the root system is contained in a closed trough or tube, less evaporation occurs and water consumption is reduced.
7. Improved quality and consistency of herbs;
8. Increased control over crop nutrition;

9. Minimal disease and pest incidence and weeding, spraying, watering etc can be eliminated;
10. Pesticide residue free produce;
11. Improved resistance to adverse weather conditions;

Limitations:-

Along with several benefits, hydroponics also has some limitations.

1. High Start-up Cost
2. In-depth Technical Knowledge Required
3. Reliable Supply of Water and Continuous Power
4. Crop Loss - Poor Design, Construction or Operation
5. Water based diseases can easily be introduced due to poor handling.
6. Suitable Back-ups in Case of Breakdowns
7. Require daily attention
8. Seasonal Variability

Sustainable Hydroponic Production System in Cold Desert Region Leh, Ladakh

In Ladakh, there is a wide scope of medicinal plants. The country with the same biodiversity like Tibet, Nepal, Bhutan etc. earns in million through medicinal plants; Ladakh has the same wide scope. Cosmetic industry, perfume industry, pharmaceutical, wellness center can be opened using medicinal plants.

Theculinary herbs contain high concentrations of antioxidants and vegetables provide the nutrition. In a normal diet, intake of herbs may therefore contribute significantly to the total intake of plant antioxidants, and be an even better source of dietary antioxidants than many other food groups. Aromatic & medicinal & medicinal herbs are used frequently if not all the time in restaurants and other facilities with food services. Having fresh plants with high standards is the demand of service industry. These facts determined more and more companies that develop in food domain, to invest in small hydroponic units. This way, they will have constant aromatic & medicinal herbs, and not only they are eliminating the wastage but also the incapacity to forecast the quantity it is needed for a period of time.

Producers of medicinal plants are also attracted to hydroponic systems for cultivation because recent studies proved that growing in soilless cultures in protected environments results in higher concentrations of active principles found in plants comparing with traditional soil cultivation. Not only do hydroponic herbs grow faster, they have significantly more flavor and aroma than herbs grown in soil. According to research performed at the University of Minnesota, it is a known fact that herbs grown hydroponically have 20-30% more aromatic & medicinal oils than field grown. Therefore, a small hydroponic herb garden can provide a continuous harvest of gourmet-quality produce in a relatively small space (Smith, 2013).

Hydroponic cultivation of vegetables and herbs can result higher concentrations of bioactive substances because of the total control the grower can have. The controlled environment gives the possibility for manipulation of phenotypical variation and important compounds from the plant. The objectives are for growing the potential of bioactive substances, reducing toxins and resulting in a uniform and superior product. The compounds targeted are often the ones resulted in secondary metabolism which is influenced by electric conductivity, pH, humidity, that need to be carefully monitored (Canter et al., 2005).

Vegetables and culinary basil can be grown outdoors or in controlled environments. Although the demand for fresh produce such as basil has increased (Wolf et al., 2005), year round production in colder climates is only possible in controlled environments. There are several hydroponic systems frequently employed in greenhouse production of various food crops including Dutch buckets, slab and bag culture, NFT, and DFT (Fenneman et al., 2013). The two most prevalent types of hydroponic systems used for leafy crops such as basil are NFT and DFT systems (Fenneman et al., 2013; Hochmuth and Cantliffe, 2014; Jensen, 2002; Morgan, 2005).

Soilless production has crops grown in pot plants or small bags filled with a growing media; they are fed nutrient rich irrigation water through the use of a dripper directly around the root zone. Growing substrates include Rockwool, cockpit, saw dust, peat moss, vermiculate, sand and perlite (Harris, 1994). European growers, in particular the Dutch, were ‘steering’ their crops between the two stages of growth, prolonging the harvest season and maximizing yields. The introduction of Rockwool production methods in Holland in the 1970’s gave growers another tool in increasing yields together with carbon dioxide enrichment, humidity control, electrical conductivity

(EC) and plant maintenance Jensen(2008). Hydroponics takes the crop out of the soil and grows them in a media that is clean. Growing media can be discarded and replaced minimizing the risk of soil borne diseases. pH levels, particularly in flowers, can also be finely controlled allowing planting of specific crops in areas where soil pH is prohibitive to growth. pH also plays an important role in the availability of elements. The chart below describes the preferred pH ranges of common hydroponic elements.

Growing systems

Hydroponics, in its most basic definition is a production method where the plants are grown in a nutrient solution rather than in soil. Many innovative systems have been developed that replace the traditional gravel filled bed. When evaluating the type of system to install, consideration should be given to such factors as the type of crop grown, space requirements, growing time, support system and economics (John and Bartok, 2009).

Crops

Although almost any crop can be grown hydroponically, the most common are leaf lettuce, tomatoes, peppers, cucumbers, strawberries, watercress, celery and some herbs.

Following hydroponic system can be used for production of culinary herbs, exotic and high value of vegetables in cold desert region.

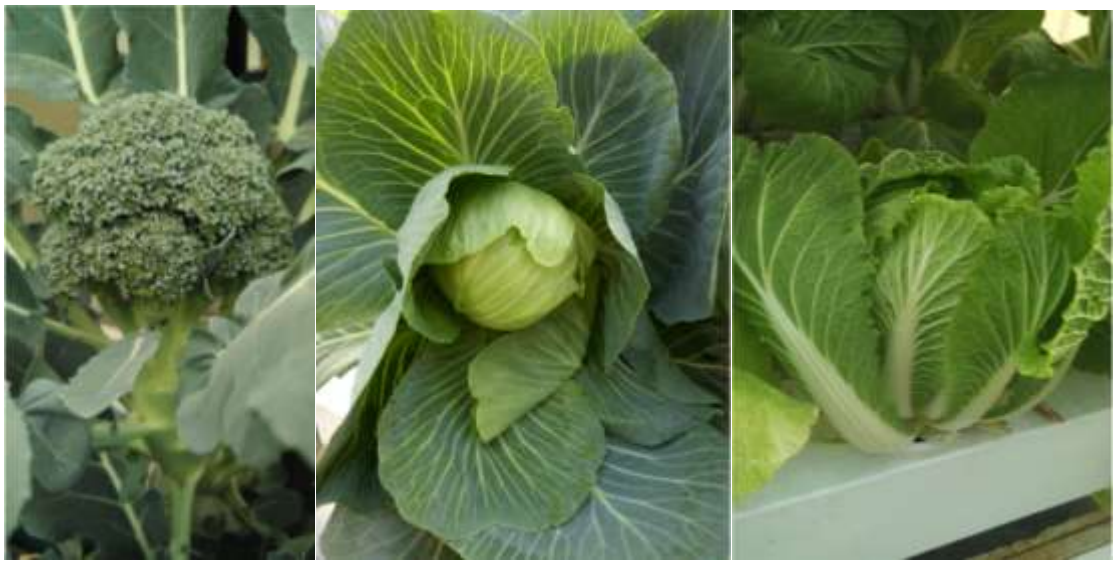
1. Nutrient Film Technique (NFT)
2. Deep Flow technique (DFT)
3. Grow Bag System

Nutrient Film Technique (NFT)

This system was developed by Dr. Alen Cooper in the mid-1960s in England. Inthis system nutrient circulated throughout the system and then enter into the growth tray via water pump (Sharma et al., 2018). It uses reservoir system and an automated pump to supply nutrients and water. Plants are grown in 'V' shaped inverted channel, which gives you the benefit of growing more produce in small area (George and George, 2016). Nutrients are mixed accordingly to make the nutrient solution which is placed in primary reservoir from which it flows through the system continuously feeding the plants (Mohammed and Sookoo, 2016). N.F.T. system helps to maximize water-use efficiency by recyclingexcessnutrientsandwaternotusedbyplants(PutraandYuliando, 2014). N.F.T system is most commonly used for growing smaller and quick growing plants leafy herbs and vegetables. (Dholwani, 2018). N.F.T. systemwas used to determine the idea of water flow rate in order to optimize the nutrient uptake with growth of lettuce. Different flow rates were assigned as 10, 20, and 30 L/hour. As a result, it is concluded that the flow rate of 20 L/hour enhances the growth of lettuce rather than 10 L/ hour and 30L/ hour (Tawaha, et al., 2018).

a. Mint **b. Coriander** **c. Lettuce**

d. Seedless Cucumber **e. Tomato** **f. Copoled Capsicum**



g. Broccoli **h. Cabbage** **i. Chines Cabbage**

Fig:- Hydroponic Cultivation in NFT and DFT System (a-i)

Deep Flow technique (DFT):

Deep Flow technique (DFT) is a hydroponics system in which 2-3 cm deep nutrient solution flows through PVCpipes. The plants are inside plastic pots fitted with the PVC pipe at regular or desired interval. The main and submain pipes are fixed over the raised platform made inside the protected structure. Pump, tanks, valves, timers and other accessories including nutrient monitoring system are placed over the floor of the protected structure. PVC pipes are arranged in single horizontal plain or in multiple zig-zag vertical plain.

Grow Bag System:

In this technique grow bags made with UV stabilized polyethylene sheets of 1 meter length, 15-20 cm width and 8-10 cm height are used for growing plants. Single or paired rows can be used with the plant spacing kept at 30-60 cm depending on the type of crops. Fertigation is done with special stake drippers fitted with poly tubes and lateral pipes. It is very common, cheap and easy technique. Solid media with high porosity, better aeration, high water and air holding capacity and efficient drainage are used in sterilized form for growing plants. The most common examples are coco-peat, perlite, vermiculite, vermi-compost, gravel, tur, rockwool, saw dust, coconut fibre and peat moss.

Essential Nutrients:

The appropriate management of plant nutrition must be based on basic aspects that are influenced by uptake and use of macro, and micro-nutrients (Sonneveld and Voogt, 2009). Macro-nutrients are needed in relatively large amounts, whilst micro-nutrients or trace elements are needed in small amounts. Furthermore, nutrient availability to the plant in the case of the soilless systems presents more or less consistent phenomena of synergy and antagonism

Future perspective:

As population increases and arable land declines due to poor land management, people will turn to new technologies like hydroponics to create additional channels of crop production. There is no chance of soil-borne insect pest, disease attack or weed infestation too. Overall soil-less culture provides efficient nutrient regulation, higher density planting and leading to increased yield per acre along with better quality of the produce. Hydroponics is extending worldwide and such systems offer many new alternatives and opportunities for growers and consumers to have productions with high quality, including culinary herbs, exotic and high value vegetables enhanced with bioactive compounds. The hydroponic technology is still in its elementaryphase in the country and concerted efforts are requiredto bring it at par with the commercial level.Economically viable and technologically feasible hydroponic technology suitable for the cold desert Leh, Ladakhagro-climatic and geographical conditions is needed at theearliest. With the integrated use of hydroponic technology with protected structure storage, it will possible to make fresh vegetables available throughout the year.With this scenario hydroponic crop production technology offers great scope for the production of vegetables like tomato, capsicum, cucumber, bitter gourd, Ridge gourd, Bottle gourd, broccoli, cauliflower, cabbage etc. culinary herbs such as basil, rosemary, parsley, oregano, mint, corianders and other minor herbs in Leh, Ladakh.

Conclusion:-

In the cold desert region of Leh, Ladakh, India where the growing season is limited from April to August only and all vegetables and culinary herbs are available late in summer. This Union Territory being land locked and remote, air lifting of medicinal herbs and high value vegetables in bulk is unviable and uneconomical. The inflow of tourists and demand from security personnel requires of an alternate production system for fresh supply of vegetables and aromatic & medicinal culinary herbs. Consequently, based on contemporary technology, hydroponic production system will not only produce the medicinal herbs and high value vegetables all the year round but will shorten the production cycle of each crops. Moreover, the quality of the produce will be far superior to that of culinary herbs fetched from wild or other states.Hydroponics is the fastest growing sector of vegetables and herbs, and it could very well dominate dietary antioxidants production in the future. Besides conventional herbs, antioxidants herbs shall also be grown in the smart hydroponic production system for meeting the demand of local and foreign tourists. The hydroponic system can be energized through solar panels to save energy cost and reduce carbon foot prints.

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