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VERTICAL FARMING AND ITS SCOPE IN VEGETABLE PRODUCTION IN INDIAN CONDITIONS

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Introduction

Vertical farming is the practice of growing crops or vegetables in vertically stacked layers or hanging the plant parts *e.g.* vines on vertical structures which supports upright growth. It often incorporates controlled environment which aims to optimize plant growth, and soilless farming techniques suchas *hydroponics, aquaponics and aeroponics.* If we go for fully controlled farming in these type of hydroponics system,there needs to appropriate control of humidity, temperature, light and up to some extent diseases and insect pests. Controlling these conditions favors both quality and quantity production per unit area and time of the crop. But in India, most of the farmers are engaged in poly-house cultivation or vertical vegetable farming with locally available material like *bamboo structures* and*iron pipes*(covering them with plastic sheets) and different colored light emitting tapes for insect pest prevention.

Most vertical farms use enclosed structures similar to greenhouses that stack vertically, either directly above each other or staggered for better natural light exposure. If saving space is of utmost importance, hydroponic methods as a growing medium instead of soil, allow for reduced weight and lower water requirements by up to 70%. The use of aeroponics further reduces weight and water requirements. Most vertical farms are either hydroponic or aeroponic and do not have run off, which would make the potted plants heavier. The main advantage of utilizing vertical farming technologies is the increased crop yield that comes with a smaller unit area of land requirement. The increased ability to cultivate a larger variety of crops at once because crops do not share the same plots of land while growing is another sought-after advantage. Additionally, crops are resistant to weather disruptions because of their placement indoors, meaningless crops lost to extreme or unexpected weather occurrences. Lastly, because of its limited land usage, vertical farming is less disruptive to the native plants and animals, leading to further conservation of the local flora and fauna.

It is a known fact that the world's population is increasing at an alarming rate. At the same time, traditional cultivation methods are becoming unpopular. In this regard, vertical farming plays an important role. As the name suggest, it means producing food in vertically stacked growing layers, and it may serve as a solution in addressing problems of small spaces in urban areas. Vertical farms apply *Controlled Environment Agriculture (CEA)* techniques to some extent. CEA allows farmers to control many variables that influence crop growth and development, such as lighting, air, temperature control, and nutrient supply. Vertical farms are closed production facilities that share a lot with manufacturing industries, which are constantly optimizing their processes. The main advantages of vertical farms are year round crop production, irrespective of external weather, predictable and stable yields, considerably

shorter crop cycles, a reduced water consumption, minimal usage of the plant protection chemicals a decreased growing area and the repurposing of urban buildings and unproductive spaces.

Hydroponic, aeroponic or even aquaponic systems favor a clean and quick crop development while maintaining the resource usage to a minimum. Under the vertical farming cost of production should be as much as low; therefore, the produce must be sold at the same price levels as products grown in an open field where the light, air, soil and water are almost free. Controlling each and every variable comes at a cost. The high capital and operational costs (electricity and labor) force companies to scale up in order to achieve profitability or focus on cultivation of higher value crops. The possibility of being close to the point of consumption is another huge point in favor of vertical farms. The lesser distance travelled not only guarantees freshness but is also a *"green"* selling point, saving CO_2 emissions from shipping. As technologies keep evolving (like LED lighting did in recent years), costs will go down and efficiency will increase even further. This will allow *Vertical Farms* to be more profitable as they lower their production costs, and also diversify the crops produced. It is hard to predict whether vertical farms will help feed the world someday; however, the necessity for fresh, safe, dependable food will always exist. The vertical farming industry has a bright future.

Types of vertical farming

i) Outdoor vertical farming

Outdoor vertical farming is the cultivation of vegetables by creating the vertical supporting structures with locally available material for *e.g.* bamboo structures with G.I. wires which supports the climbing of vegetables.

ii) Indoor vertical farming

Indoor vertical farming consists of various fixed or permanent structures supporting the plant growth. Mainly all the cultivation is done under poly-house, net houses, shade nets, bamboo made structures covered with plastic sheets. This consists of *hydroponic's, aeroponic's, aquaponic's*.

Types of vertical farming structures

1. Stacked horizontal systems

In this system,existing commercial growing practices are done under protected structures. In this system multiple of vegetables plants are tied with a wire or supports to grow vertically for plant growth and these wires are adjustable according to the harvesting heights as the plant grows. Many horticultural hybrids, such as, muskmelon, red and yellow capsicum, tomato, cucumber and sweet pepper are grown under large-scale protected structures using hydroponic systems. This system includes the supporting structures for plant stand and root growth made of rock wool and the plant roots are fed by drip system with controlled concentrations of nutrients.

2. Multi-floor towers

This structure is different from the horizontal stacked system. There are multiple floor towers on which plants are grown. Different or same type of plants is grown on different floors of a tower. In this system there is an appropriate control of growing conditions

including pH, humidity, temperature, shade, light *etc.* according to the suitability of crop or plants grown.

3. Balconies

This is an alternate idea than indoor multiple floor cultivation. This method is best suitable for the individual house or family members rather than commercial scale. This can be adopted as a hobby or as per need to save money and in return fresh produce from own house.

Fig. 1 (A) Hydroponic structure for small polyhouses; (B) Hydroponic structures for balconies at ICAR-CIPHET, Abohar, Punjab

Crops suitable for vertical farming

Most commonly plants grown in vertical structuresare those which have upright growth, are non-bushy type and bears fruit alongside its stem. This includes vegetables, flowers, herbs and some medicinal plantsthat consumes less vertical space *e.g.* lettuce, tomatoes, cucumber, sweetpepper, mint, coriander, spinach, strawberry *etc.*

Benefits of vertical farming

1. Higher net returns per unit area
2. Faster growth resulting higher yields
3. Saving of water and fertilizers
4. Employment generation
5. Increase in farmers income
6. Year around production
7. Cleaner production than traditional methods
8. Lesser probabilities of crop failure
9. Lesser use of chemicals on insect pest control
10. Forward step toward nutritional security
11. No adverse effect of environmental calamities

Challenges in vertical farming

1. Huge investments in infrastructure setups
2. Different crops have different climatic or nutritional requirements so mixed farming is not possible
3. Not all the crops grown on horizontal farming are possible to grown under vertical structures
4. Labor cost, maintenance cost, energy cost *etc*. variable costs are too high in modernvertical farming structure as compared to horizontal/open field cultivation
5. Natural processes like cross pollination have to be done manually, and it needs higher manpower at a specific time, which is high cost oriented
6. Planning for the meeting of market or consumer demands at a fixed time period is too difficult to handle because some time produce is ready early or sometime late, so the bulk produce from vertical structures get wasted or have to be sold at a lower price
7. Organic production of vegetables is difficult in such structures due to dependency on chemical fertilizers and readymade nutrient solution, and high yielding hybrids

Precautions to be taken while growing crops vertically in hydroponics structures

- **pH**

  pH of growing media and water suitable for different crops check accordingly
- **EC**

  It should be maintained between safe limits for better plant growth
- **Temperature**

  Temperature required in vertical and field growing may vary according to season and crops growing inside and outside
- **Crop to be grown**

  While starting cultivation under hydroponics you have to choose crop wisely, hence we should go for high value crops
- **Variety or hybrids**

  Choose the crop variety or hybrid wisely according to season/consumer preference/ distance transportation suitable /processing purpose accordingly
- **Site Selection**

  Site for vertical farming should be chosen accordingly to the ease of availability of sunlight, water, electricity, labor, store houses transport facility etc.
- **Planning**

  Prior to starting vertical farming one should make plan of sowing/ transplanting dates with respect to harvesting dates and produce required, fertigation, timelyarrangement of skilled/trained labor and technical or expert for proper functioning etc.

Forthcoming prospects of vertical farming in India

As per health concern and day by day growing population, concept of nutritional security is becoming matter of concern and vegetables plays important role in this subject, so there are chances for higher demand and quality vegetables in future. As per studies, there is decrement in cultivable land area due to environment hazards, shifting of profession, urbanization, lack of labor etc.

Keeping in view the future demands due to increasing population and thereby nutritional securitythrough vegetable cultivation at limited space, we need to discover, modify and popularize such type of cultivation methods. Hence, one of the best adopted methods is *vertical cultivation* with some modifications *e.g. aeroponic's, hydroponic, aquaponic's* under protected structures with automatic controlled environmental conditions.

At present 6.5–8.0 m height poly-houses are constructed. However, most of the vertical space remains unutilized. Under such circumstances, maximum vertical space can be utilized by growing different crops in different tiers at a time. If one crop fails or fetches lower market price, another crop may compensate it. In India demand for high-value vegetables like broccoli, lettuce, coriander, green pea and green chillies, etc. are increasing speedily due to increase in purchasing power. Moreover these crops are high return and low investment crops, so farmer's income will increase so they can raise their living standards and vegetable availability increased at lower and sustainable prices. Along with the market expansion, climate change, load of population on agriculture, chemical free produce, minimizing use of resources, researchers are focusing on the development of new efficient systems.

Conclusions

1. Vertical farming is a new technology reaching towards higher production per unit area of land rather than traditional method of cultivation to meet the demand of increasing population on the same or decreasing land.
2. By using the greenhouses and poly houses in combination with multiple level of growth surfaces can be used with some combinations of vertical farming for lowering the cost of cultivation.
3. To boost the production and minimizing the cost of operation more and continuous research work is required on vertical cultivation as compared to soil cultivation.
4. There is a necessity for combined work on quality crop production, minimal cost of cultivation, exotic crop cultivation technology intervention
5. At present we have to focus more on extension work to promote the existing technology of vertical farming among farmers and train them in vertical cultivation of different crops.Further attention with additional research into maximizing productivity and reducing system costs is the need of the hour

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