Sustainable Alternatives to Conventional Farming

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ABSTRACT

The exponentially growing global population puts excessive pressure on crop production. Traditional agriculture is unequipped to meet mankind's food needs by 2050. We will need to add arable land the size of Brazil to feed a populace predicted to touch 9 billion in 40 years. Not only are present agriculture practices highly inefficient, but they are also unsustainable in the long run.

Vertical farming can substitute conventional agriculture faultlessly. It provides higher perpetual crop production, lesser use of pesticides and uses very low energy and natural resources in comparison to established methods used currently in farming. It uses state of the art technologies like hydroponics, aeroponics, aqua hydroponics and Grow lights and can work out all the problems linked with farming.

Keywords: Vertical farm, Hydroponics, Aquaponics, Aero hydroponics, Grow lights, Crops

1. INTRODUCTION

Human beings need air, water and food to survive. UN reported that nearly 1 billion people go hungry around the globe and 42 percent of them live in Indian subcontinent. There are the challenges of creating more arable land. By 2050, 100 percent more food will be required than produced today. We will be able to add only 100 million hectares of more land. Adding to this, we are losing land at a disturbing rate due to climate change and civilization. Thus the field of agriculture needs a radical change.

2. WHAT IS VERTICAL FARMING?

The vertical farms are multi-storey buildings with controlled environmental conditions to have year round crop production. Here, various life forms like plants, animals, fungi are cultivated for food, fibres or other products or services.

The plants are artificially stacked vertically one above another. It is powered by solar and wind energy balancing the high energy consumption the internal environmental requires. The food is grown organically and herbicides and pesticides are not used. The black and gray water is collected and recycled. [1]

2.1 Techniques

2.1.1 Aeroponics

The principle is based on cultivating crops whose roots are not placed in soil, but in tubs filled with flowing nutrient solution. In such containers roots are provided the best conditions regarding oxygenation and moisture leading to swifter plant growth. The containers are easily transportable and can be mounted on top of other. Nutrients can drip down through the growth columns where they can reach the crops efficiently.

Since young crops require maximum sunlight, they are kept at the topmost level of growth column. Later they can be gradually lowered by making use of a rotational mechanical system. For example: for producing a kilogram of tomatoes using conventional requires 0.2 to 0.4 cubic meters of water, while aeroponics requires only 0.02 cubic meters. As aeroponics is continual cycle, it lets the workforce gain exhaustive skills within a short period whereas traditional farming workers gain it by many years of experience. [2],[3]

2.1.2 Hydroponics

Hydroponics is a method of cultivating crops using mineral nutrient solutions, without soil. Terrestrial vegetation may be cultivated with their roots either in the nutrient solution only or in an inert medium. Examples of such medium are perlite, gravel, mineral wool, expanded clay pebbles or coconut husk. A variety of crops can be grown hydroponically. The list includes strawberries, lettuces, tomatoes, onions, peas and beans which have been explained in detail. Solution culture and medium culture constitute the main types of hydroponic systems. In solution culture, a solid medium is not used for the roots.

Solution culture types are static solution culture, continuous-flow solution culture and aeroponics.The medium culture procedure is always named after the type of medium, e.g. gravel, sand or rock wool. In static solution culture, plants are cultivated in tubs of nutrient solution. In this method of culture, the mineral solution continually flows past the roots. It can be more easily automated than static culture as alterations to the temperature and mineral concentrations can be made in a large tank that has capacity to serve thousands of plants [4]

2.1.3 Aero hydroponics

Aero-hydroponics is another new format of hydroponics in which oxygen gas is infused into the nutrient solution. It uses net pot, rock wool and vine clips to support the plants while their roots under a continual mist of nutrient solution. In this the roots of absorb nutrients faster and there is rapid growth and superior crop yields. Once this system is put into place, it will run ad infinitum without any additional investments in components like growing media and non-recirculating minerals. [5]

2.1.4 Aquaponics

Aquaponics is a umbrella term merging aquaculture and hydroponics. It allows the double-use of water, minerals, energy, and space. The crops get nutrition from the aquaculture section. In this system, fishes are grown in a tank from where it drains into gravel bed where beneficial bacteria break down the poisonous ammonia found fish waste to Nitrite and ultimately to Nitrogen, Watercress is used as secondary water filtration on the gravel bed. This filtered water is then pumped to the growing beds. [6]

2.2 Grow lights

Grow lights are fluorescent lights that emit a spectrum similar to that of the sun, which is used to grow plants. Thus plants with the help of grow lights can grow and photosynthesise without natural sunlight. A range of bulb types can be used as grow lights apart from fluorescent lights, such as incandescents, high-intensity discharge lamps, and LEDs. Today, the most widely used lights for professional use are HIDs and fluorescents. Fluorescent lights offer excellent overall lighting options. [7]

Plants respond differently to different colours of light. Light on either end of the spectrum, blue light or red light, have the greatest impact on photosynthesis. Blue light, referred to as cool light, encourages compact bushy growth. Red light, on the opposite end of the spectrum, triggers a hormone response which creates blooms.

Grow lights producing the orange and reddish light typically produce substantial heat, however, some lights are able to produce full spectrum light without the heat. Grow lights come in all shapes, sizes and price ranges. [8]

2.2.1 Incandescent Lights.

These incandescent lights work well for specific plants where the light is placed a minimum of 24” from the plant. These lights get extremely hot so they must be used with care. Spot grow bulbs, colour corrected incandescent lights, install easily and are good for use with a specific plant or a small grouping of plants. Most spot incandescent bulbs last less than 1,000 hours.

2.2.2 Fluorescent Grow Lights

Fluorescent lights are reasonably energy efficient and relatively easy to install. A typical fluorescent bulb will last approximately 20,000 hours. Fluorescent light is typically on the blue end of the spectrum. Blue light encourages bushy compact growth which makes them perfect for seed starting. Blue light is also cool to the touch making it possible to place lights within just a few inches of the seedlings.

2.2.3 LED Lights

The newest type of grow lights use LED technology. One major advantage to the LED lights is the small size. LED lights are only a few inches in diameter and are easy to mount. LED lights weigh a fraction of other lights and are easy to configure where needed. According to LED manufacturers, LED grow lights maximize blue and red light to provide and excellent balance for plants. They do not have much green-yellow light. Since humans see green-yellow light best LED grow lights appear dim to our eyes. Grow lights in the form of LEDs are bright and long-lasting; they emit light wavelengths which correspond to the absorption peak of the plant's photochemical processes. [9]

2.3 Crops

2.3.1 Strawberries

Cultivated without soil in a nutrient solution, hydroponic strawberries are an experience of the future. Strawberry cultivators worldwide fumigate the soil with methyl bromide before planting to control pests, diseases and weeds. The fumigation is crucial to produce high quality fruit and good yields. Unfortunately, methyl bromide has proven harmful for the ozone layer and was banned worldwide in 2005. For the buyer this meant a raise in the astronomical prices for fresh strawberries grown out of season. Growing strawberries hydroponically eliminates the need for methyl bromide. One of the key benefits of cultivating strawberries hydroponically, besides the wonderful taste, is that they can be produced at an elevated height. This is a great benefit commercially as the picking rate is swifter and less tiring and cultivation is easier. Yields per plant are greater in hydroponics than in soil. Crops can be grown on poor land and weeds are completely eliminated. Gardens are vertically tiered for lesser space usage. NFT (Nutrient Film Technique) and multi-tiered deep water culture are the most preferred choices. [10]

2.3.2 Tomatoes

Tomatoes cultivated hydroponically, are superior in taste and nourishment than soil-grown tomatoes. A tomato's flavour is largely reliant on temperature and illumination. In vertical farming, the precise requirements can be met with grow lights, temperature control and supplementary nutrition. The drip irrigation is the most preferred choice. This is a completely automated, re-circulating system in which nutrient solution is pumped from storage and supplied through drip emitters to plants and it uses gravity as a convey to drain back to reservoir.

Irrigation needs to be modified as the plants grow; mature plants ideally require 4 litres a day whereas smaller seedlings will require less. The nutrient reservoir needs to be changed at least every week. Ebb and flow tables, also known as "flood and drain" tables are an additional technique used for growing tomatoes. Cherry tomatoes can also be cultivated in deep water culture. Full summer daylight can be replicated by artificial metal halide light. At ripeness; tomatoes need a

16-18 hour photo-period to guarantee utmost fruit production followed by a 8 hour respiration period in darkness. [11]

2.3.3 Lettuce

These are grown best, nitrogen rich soil with a pH of between 6 to 6.8. A temperature range should be maintained low enough so that it prevents from flowering quickly. It is also risked to numerous pests, fungal and bacterial diseases in outside farming conditions. Depending on the type of lettuce, it normally takes 65-130 days from planting to harvesting. Lettuce is used in raw as well as in cooked or grilled forms.

Using Hydroponics for growing lettuce, yields about 64 heads of lettuce per square foot annually while conventional growing yields only three heads annually. [12]

2.3.4 Onions

These are cultivated in fertile soils which are well drained. They are required in high amt of nutrients. Phosphorous is needed in high quantity which is less available in cold areas. Nitrogen and phosphorous can be added at intervals (nitrogen to be added at least four weeks before harvesting). The preferred Ph range is of 6 to 6.5. [13]

2.4. Advantages

Vertical farming almost yields almost 5 to 10 times more than conventional technique. Also, it will reduce risks from pest and other disease and so better quality crops and there yield are obtained. Conservation of water. Techniques like aeroponics, hydroponics and Aquaponics are used which requires limited amount of water. Usage of gray or black water can also be done. Threats of fungal and bacteria diseases and by pests and mosquitoes are kept away due to indoor farming technique.

Further, it is safe from harsh climatic conditions. For example, the crop of lettuce gets spoiled when the temperature rises above a specific value. With vertical farming, these conditions can be monitored. The amount of land required in vertical farming is very less as compared to conventional farming and can also be conducted on waste lands and hence it the need of carrying out deforestation for more agricultural land is eliminated. Thus it contributes in preserving the human ecosystem. By controlling the operating and functional conditions, year round crop production can be obtained. [14]

2.5. Sustainability

Vertical farming is sustainable in every sense. Vertical Farms would also incorporate valuable strategies to transform waste into resources. For instance, vertical farms would be designed to purify sewage into fresh water and to generate electricity using decomposed by-products.

Maximizing resources in this fashion would allow the farms to be self-sufficient and reduce their total carbon output. [15]

3. CONCLUSION

Vertical farming can satisfy the demands of the increasing population, utilizing less land, water, chemicals and grow healthy crops. The food prices are 5-10% high as compared to conventional farming but can be decreased with the further advancement in technologies.

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