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In this article we review the vertical farming and the future advancements in this area. We also discuss the implementation and other requirements from various perspectives, such as nutrition and artificial lights.
By Hossein Nazarian, Cademix Institute of Technology

Feature

Almost one in every seven individuals on the planet is chronically hungry, lacking sufficient nourishment to be healthy and active. According to the United Nations, 795 million people throughout the world do not have enough to eat, and the world's population is expected to reach 10 billion by 2050, with two-thirds of the population living in cities. As the world's population grows, so does the demand for food, which necessitates increased usage of arable land and water. Soil deterioration is also a big issue, as it reduces the soil's potential to support production and environmental activities. In order to feed the globe in the future, new farming technologies are necessary. In order to feed more people while using less land, creative solutions are required.

What are Innovative solutions?

Agriculture in a controlled environment (ACE) is a food-production method based on technology. ACE's goal is to protect the crop from the outdoor threats and provide optimal growing conditions during the crop's development. Through this method production takes occur in a controlled environment, such as a greenhouse. Growers frequently cultivate the plants on a soilless media to guarantee that the root zone receives adequate amounts of water and nutrients, as well as supplemental lighting to ensure that obtains sufficient daily light. ACE optimizes all resources such as water, energy, space, capital, and labor. Agriculture in a controlled environment has the potential to produce crops all year, with the ability to boost yield by altering input quantities.

Vertical farming

Think that how we are able to produce high quality fresh vegetables near to consumers in urban locations. It is feasible regardless any climate or on any sort of soil. Cities can become self-sufficient in other sectors of manufacturing, which is advantageous because supply shortages in times of crisis can be terrible. Vertical farming can help to solve this problem. Every day of the year, production and quality can be planned.

Even before the COVID19 pandemic, it triggered a renewed interest in alternative Gardens, such as indoor gardening which was already experiencing a comeback. In a [2018 US National Gardening Survey](#) we observe a serious upswing of people interested in growing herbs and other edible plants inside the buildings.

The primary concept of a multilayer plant production site is to produce a large number of plants in a small space. This method maximizing the equipment and space investment by growing plants in layers on shelves. Because each layer shades the lower layer, we have to place the lamps on each shelf, making the growing system workable only with the addition of artificial light.

Vertical farming in cities vs. greenhouses

Vertical farms have already introduced to regions like huge cities where natural light is sparse or there is no suitable cultivation area. They are currently as a feasible option for greenhouse production in metropolitan environments. lettuce, aromatic plants, and culinary condiments, the so-called microgreens, sprouts, and the so-called baby vegetables, count as the most commonly farmed crops in vertical farms.

Through this procedure, you can control all of plant growth parameters. The approach also has a number of long-term advantages. When compared to other methods of production, it uses less water and fertilizers and takes up less land. You can grow without pesticides in theory. Electricity usage and required investments, on the other hand, are significant.



Plantlet produce project in shelves under artificial light

Definitions and prerequisites

Traditional field farming, at the ground level, relies on soil as the primary growing medium. Growers must encounter a number of constraints when it comes to soil. Limitations which take high amount of resources to make little probable changes. Because vertical farms do not employ soil, they are not limited to a single place.

Another advantage of indoor vertical farms over traditional farming is that they do not require sunlight. Indoor vertical farms use have to provide their own light source for year-round photosynthesis, whereas typical farms' growing cycles regulate by seasonal variations in temperature and sunlight. Indeed, as the cost of lighting source has decreased, the number of vertical farming systems has increased around the world. In fact, nothing could develop without the lights.

Visible light for plants

Electromagnetic waves transfer energy via the air. Electromagnetic waves include microwaves, radio or television waves, X-rays, ultraviolet rays, and visible light, all of which have varied frequencies and wavelengths. The electromagnetic spectrum depicts many frequencies and wavelengths that refer to by various names (microwave, radio waves, visible light, etc.). The human eye captures visible light with wavelengths between 400 to 700 nanometers (nm), which roughly correlates to the photosynthesis region of the spectrum. PAR, or photosynthetic active radiation, also define as light with a wavelength of 400 to 700 nm. Within and beyond the visible wavelengths, sunlight has a continuous spectrum. In the human brain, different wavelengths convert into colors by the human eye. Short wavelengths about 400 nm regard as blue, while longer wavelengths around 600 nm have perceived as red. The yellow-green wavelength area is the most sensitive to the human eye.

Light in plants

Plants absorb light in a spectrum that is approximately identical to the human eye, but unlike humans, they absorb red and blue light the best. Through photosynthesis, chlorophyll as one of the key chemicals that allows plants to absorb light and use its energy to convert water and carbon dioxide into oxygen and complex organic compounds. There is a green plant pigment found in the chloroplasts. It is responsible for the green coloration of leaves and stems. Chlorophyll a and b, differ in their light absorption curves, are the two main forms of chlorophyll found in higher plants. Because of the minor difference, they can collect different wavelengths, allowing them to capture more of the solar spectrum. Plants seem green because chlorophyll absorbs mostly red and blue light and reflects green wavelengths.



Lettuce Production Under Artificial Light

Artificial light in Vertical Farming

Due to artificial light is the only source of light in vertical farms, light intensity and spectrum are more important than in a greenhouse. It is also very important topic in the [other fields such as modern architecture](#). Certain crops demand a high level of light intensity, which generates a significant amount of heat. We should later cool down the environment using various methods. The lower the cooling costs and the better the environmental management are, the less heat generated by the light source. Despite their compact size, fluorescents are not the best choice for vertical farming. The main reason is that they require expensive cooling facilities such as heat sink.

Unlike fluorescent lighting, LED lighting allows for less heat dissipation since the LEDs' effectiveness value is higher than fluorescent lighting, indicating that a greater amount of the energy input transfer into light rather than heat. However, because LEDs emit heat, it is best to use an LED lighting type with a light spectrum that we adjust so we can employ lower light intensities. When there is less light to install overall, it saves money on

hardware, installation, electricity, and cooling.

Light dispersion

In vertical farms, between addition to the optimum light intensity and spectrum, it is critical that the light dispersion, or uniformity, in the shelves is as good as possible to provide a consistent production rate across and among shelves.

Only red and blue LED chips used in the earliest LEDs for the horticultural sector; these spectra are still available and can use at a modest cost. Because they lack all other wavelengths in the spectrum, red and blue light boost photosynthesis but do not encourage biomass formation. High amount of yield is critical in a vertical farm as possible, so the best spectrum for the planted plant species should carefully select.

Nutrition in shelves

In the vertical farming, plants are planted through the shelves and fed up by hydroponic system. The term “hydroponics” is derived from the Greek words “water” and “work,”. Specifically, they refer to methods of cultivating plants without the use of soil. Although hydroponics may appear paradoxical to some, it offers a unique and sustainable approach to cultivate delicious and healthful foods.

Hydroponically grown plants have their roots dipped directly into nutrient-rich liquids. Plants produced in a hydroponic system have smaller root systems since they directly reach to the necessary nutrients. This matter leads to conserve energy and allows it to be redirected to leaf and enhance the growth more quickly. Plants grow more quicker in nutrient-rich solutions than they would in traditional ways. In addition, the hydroponics often delivers higher agricultural yields than traditional methods. Furthermore, because hydroponic systems do not rely on soil, they reduce pests and soilborne diseases. Hence, they results in healthy crops that you can feel good about cultivating and eating.



Tomato plantlet with developing rooting system produced through Vertical Farming

Are Indoor Vertical Farming Capable of Feeding the World?

While indoor vertical farming offers distinct advantages to the challenges of feeding an expanding world, the output of these farms alone would not be sufficient to feed the entire population. To build a more resilient and sustainable food system, traditional and indoor growers must continue to collaborate.

We're only getting started; there's still a lot of opportunity for development. Growers will discover how to obtain a lot more from their farming system. Breeders are developing unique kinds for this type of farming. Vertical farming can only be taken to the next level if crop experts, technicians, marketers, and investors work together. That is both required and feasible.

I hope you find this article (Vertical Farming with Artificial Light: Review and Future advancement) useful.

Here it is some of my articles you can find them:

1. [Growing in Sawdust: Alternative Planting Medium in Vertical farming.](#)
2. [Healthy Food Production Challenges in Developing Countries.](#)
3. [In vitro Regeneration of Alstroemeria cv. 'Balance' by Indirect Organogenesis.](#)

4. [In vitro Regeneration of Alstroemeria cv. 'Balance' Based on Direct Organogenesis.](#)
5. [Innovative Optimal Approach to Implement Fast Propagation Tissue Culture.](#)

Feel free to contact me for questions, consulting or any projects.

Email: hossein_nazarian@yahoo.com

Email: hossein.nazarian@cademix.org

LinkedIn: <https://www.linkedin.com/in/hossein-nazarian/>

Xing: https://www.xing.com/profile/Hossein_Nazarian

About the Author

Hossein Nazarian is a graduate of MSc. in Agricultural Biotechnology Engineering from Iran and an associate member at the Cademix Institute of Technology and the [Cademix Career Autopilot Program](#).

He has also obtained his bachelor diploma in Plant Production Engineering which has provided him with an understanding of different aspects of agriculture. For instance he was working on cultivation, irrigation, fertilization, plant protection and commercial services. He has been working in several areas in agricultural sector since 2009. He has valuable experiences as an instructor and technical expert in plant pests, diseases, nutrition, and plant protection programs. Also He he has some experiences in the greenhouse cultures and plantlets produce through artificial light in the shelves. He has been working in agribusinesses for 12 years and try to solve farmers' problems. Further he helps to produce healthy products to improve the health level of society.

Specialties: Plant nutrition, Plant protection, Field management. Greenhouse consultant (rose, cucumber, strawberry, transplant,...), Tissue culture, Marketing, Agile management.

Keywords related to Vertical Farming

Hydroponic, Artificial light, Urban farming, Greenhouse culture, Vertical garden. Vertical green, Vertical gardening, Artificial light for plants are some of the keywords. Further keywords, Hydroponic system, Hydroponic garden, Hydroponic design, Hydroponic greenhouse, Arable land. Soil deterioration, globe in the future, Creative solutions, Indoor, Indoor plants, Indoor garden, Indoor greenhouse. In addition, Shelf greenhouse, Controlled environment. Controlled environment agriculture, Controlled environment technologies, Multilayer plant production, Lettuce, Aromatic plants. Culinary condiments, Microgreens. Further, Sprouts, Baby vegetables, Energy-efficient LED lights, Photosynthesis, Photosynthetic Active Radiation, Electromagnetic waves, optic, grow lights, Visible light. Finally other keywords are Plant pigments, Photoreceptors, Photosynthesis, Spectrum, Chlorophyll, Phytochromes, Fluorescents.



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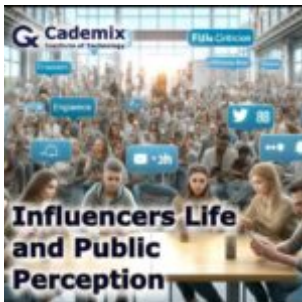
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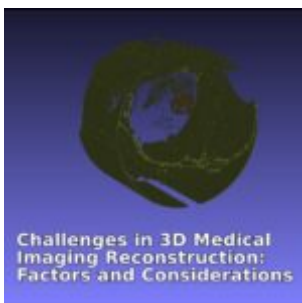
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