

2- Controlled Environmental Agriculture (CEA)

3- Vegetable Crop Production without soil (Vertical farming a. Hydroponic System and b. Aeroponic System)

Controlled Environmental Agriculture (CEA) is a technology-based approach to crop production that leverages exterior growing structures and indoor systems. These CEA systems are designed to optimize growing conditions for the health of the crop and reduce the risk of diseases and pest damage, while evading susceptibility to outdoor weather conditions.

CEA systems range from simple structures, such as shade and hoop houses, to greenhouses and vertical farms. Greenhouses and vertical farms are the primary structures used in CEA. These structures use extensive interior growing technologies like hydroponic, aeroponic, aquaponic, and aquaculture to optimize plant health. To date, CEA farms generally have a limited product catalogue, with leafy greens and herbs currently the primary crop focus.

Advantages:

1. High yield: Controlled environment agriculture helps to obtain higher product yields per unit area by increasing product efficiency. CEA provides an ideal environment to control the growth and production of plants and to optimize the desired values needed by plants. Therefore, plants are grown by this method yield higher.
2. Year-round production: CEA is seasonally independent and allows plant production throughout the year.

3. Protection from diseases and pests: CEA is an ideal method to protect plants from diseases and pests. The environment in which plants grow can be completely sterile, thus preventing the spread of diseases.

4. Water and fertilizer savings: Controlled environment agriculture provides the ability to precisely control the water and fertilizer needs of plants so that water and fertilizer can be saved. CEA allows plants to give the right amount of water they need. This helps conserve water and reduces water consumption. When compared to conventional farming methods, it has been observed that water saving has increased to 95% and above in some crops and cultivation methods. In direct proportion to the amount of water used, the amount of fertilizer used is reduced and unnecessary fertilizer use is avoided.

5. Food safety, and reduced use of pesticides and herbicides: CEA allows you to control the environment in which plants are grown. Therefore, plants are grown to avoid contamination with chemicals or toxins, ensuring food safety. The need for pesticides and herbicides for the control of plant diseases can be reduced or completely abandoned.

6. Less land requirement: CEA can achieve higher yields by using less land.

Disadvantages:

1. High cost: Since Controlled environment agriculture requires high technology, it is more costly than traditional (conventional) farming methods.

2. Energy consumption: CEA is higher in terms of energy consumption. In this field, the use of renewable energy sources and the development of devices that consume less energy come to the fore.
3. Manpower: CEA requires more manpower. It requires workers with special skills to control the growth and production of plants.
4. Limited plant species: Some plant species, especially high canopy plants, can be difficult to grow indoors.
5. Risk factors: CEA may also come with certain risk factors. These factors may include disease, ventilation problems, ambient humidity control, and others. At this point, system conditions, functions, and optimization gain importance.
6. Lack of natural conditions: CEA tries to imitate the conditions in which plants naturally grow. However, since some natural factors, such as wind and insects, are not in artificial environments, the quality of plants grown by this method may decrease. Institutions and scientists working on CEA technology continue to work to mimic these deficiencies in CEA conditions.

Some Examples about CEA:

1. Greenhouses

As a pivotal type of CEA, greenhouses are enclosed structures with transparent walls and roofs, allowing sunlight in while retaining warmth. Greenhouse controlled environments let farmers adjust temperature, humidity and light, creating the perfect plant growth conditions. Greenhouses offer protection from adverse weather and pests and extend the growing season, making them a cornerstone of CEA.

1-Cucumbers: Day, 75 to 80° F; night, 65° F. Lower temperatures delay plant growth and fruit development.

2-Tomatoes: Day, 75 to 80° F; night, not below 60° F. High daytime temperatures (85 to 90° F and above) can cause fruit set failure and prevent red color development in maturing fruit.

3-Lettuce: Day, 65 to 70° F; night, 50 to 55° F. Higher temperatures induce seed stalks in some varieties.

2. Vertical Farming

A structural innovation in CEA, vertical farms leverage vertical space by stacking crop layers in a controlled setting. Unlike traditional horizontal farming methods, vertical farms typically stack layers of hydroponic or aeroponic systems that deliver nutrients by water or air. Vertical farms maximize space use, making them ideal for urban areas with limited land. The precision control in vertical farms over factors like light, temperature and humidity ensures optimal crop growth conditions.

a• **Hydroponic systems:** Growing plants without soil using a water-based nutrient solution. Hydroponics is a technique of growing plants in nutrient solutions (water containing fertilizers) with or without the use of an inert medium (sand, gravel, vermiculite, rock wool, perlite, peat moss, coir or sawdust) to provide mechanical support.

Some Vegetable crops that can be grown on commercial level under hydroponics like, Tomato, Pepper, Cabbage, Cauliflower, Cucumber, Radish, Onion and some Leafy vegetables like, lettuce and Kang Kong.

b• Aeroponic systems: Growing of plants by suspending their roots in the air and regularly misting the roots with a water and nutrient solution.

c• Aquaponic systems: Combines plant growing with fish or aquaculture production using wastewater from the aquatic species to fertilize a connected plant system. Vegetable crops like potato, tomato, lettuce and some of the leafy vegetables are being commercially cultivated in aeroponic system.

3. Indoor Grow Rooms

Integral to CEA, indoor grow rooms are enclosed areas outfitted with artificial lighting, temperature control systems and precise irrigation setups. Indoor grow rooms tailor environmental conditions to meet the specific needs of plants, enabling year-round cultivation independent of climate limitations. Especially beneficial for high-value crops, indoor grow rooms ensure consistent, quality yields.