



Hydroponics in Strawberry Cultivation: A Modern Approach for High-Quality Fruit

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INTRODUCTION

Strawberry (*Fragaria* × *ananassa*) is a high-value fruit crop appreciated for its attractive appearance, pleasant aroma, refreshing taste and nutritional properties. It is rich in vitamin C, antioxidants, anthocyanins and other bioactive compounds. Traditionally, strawberries are cultivated in soil under open-field or protected conditions. However, increasing problems such as soil-borne diseases, poor soil fertility, limited cultivable land and irregular water availability have encouraged growers to adopt soilless production technologies.

Hydroponics is one such modern cultivation technique in which plants are grown without soil and supplied with water and essential mineral nutrients through a carefully prepared nutrient solution. Strawberry is particularly suitable for hydroponic cultivation because it is a relatively shallow-rooted crop and can perform well in controlled environments.



What is Hydroponic Strawberry Cultivation?

In hydroponic cultivation, strawberry plants are grown in a soilless growing medium or directly in a hydroponic system. The roots receive water, oxygen and essential nutrients in appropriate quantities. Common growing media include **cocopeat, perlite, vermiculite, rockwool and mixtures of cocopeat and perlite.**

Different hydroponic systems can be used for strawberries, including **drip irrigation systems, nutrient film technique (NFT), deep water culture and vertical hydroponic**

systems. Among these, drip systems and substrate-based systems are commonly preferred because they provide good control over water and nutrient supply.



Why Hydroponics for Strawberry?

Hydroponic strawberry production offers several advantages over conventional soil cultivation. The most important benefit is the ability to manage the root-zone environment precisely. Water, nutrients, pH and electrical conductivity can be monitored and adjusted according to crop requirements.

The major advantages include:

- Efficient use of water and fertilizers
- Reduced dependence on soil quality
- Better control over plant nutrition
- Reduced exposure to soil-borne diseases
- Cleaner and more attractive fruits
- Possibility of vertical cultivation and better land utilization
- Suitable for protected cultivation
- Improved control over growing conditions

- Potential for higher productivity per unit area
- Easier harvesting because plants can be maintained at a convenient height

Selection of Planting Material

The success of hydroponic strawberry production largely depends on the quality of planting material. Healthy, disease-free and vigorous plants should be selected. **Runner plants or certified nursery plants** with a well-developed root system can be used.

Suitable cultivars should be selected according to the local climate, protected structure and market requirements. Cultivars with good fruit quality, attractive colour, desirable size and continuous or extended fruiting characteristics are generally preferred for protected production.



Growing Media

Although hydroponics does not use soil, many strawberry systems use an inert or relatively low-nutrient growing substrate to provide physical support to the plants.

Cocopeat is widely used because of its good water-holding capacity and aeration. **Perlite** improves drainage and air-filled porosity. A mixture of cocopeat and perlite can provide a suitable balance between moisture retention and root aeration.

The growing medium should be clean, well-drained and free from harmful pathogens and excessive salts.

Nutrient Management

Nutrient management is the heart of successful hydroponic strawberry cultivation. Plants require essential elements such as nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, manganese, zinc, copper, boron and molybdenum.

Instead of applying fertilizers to soil, these nutrients are supplied through the irrigation water in a balanced nutrient solution. The concentration of nutrients should be adjusted according to the growth stage of the plant.

During vegetative growth, adequate nitrogen is required for healthy leaf and canopy development. During flowering and fruit development, balanced nutrition with adequate potassium, calcium and other essential nutrients is particularly important for fruit size, firmness and quality.

Excessive fertilization should be avoided because high salt concentration in the root zone can damage roots and reduce plant growth.

Importance of pH and EC

Two important parameters in hydroponic nutrient management are **pH and electrical conductivity (EC)**.

The pH determines the availability of nutrients to the plant. For strawberry, the nutrient solution is generally maintained in a mildly acidic range, commonly around **pH 5.5–6.5**, depending on the production system and nutrient formulation.

EC provides an indication of the concentration of dissolved salts in the nutrient solution. The appropriate EC varies with cultivar, growth stage, environmental conditions and production system. Therefore, growers should follow a crop-specific nutrient schedule rather than using one EC value throughout the crop cycle.

Regular monitoring of pH and EC helps prevent nutrient deficiencies, toxicities and salt accumulation.

Water Management

One of the major advantages of hydroponics is precise water management. Water is delivered directly to the root zone, minimizing unnecessary losses.

However, strawberry roots require both adequate moisture and oxygen. Continuous waterlogging should therefore be avoided. In substrate-based systems, irrigation frequency should be adjusted according to temperature, humidity, plant size, substrate moisture and crop stage.

Good drainage is essential to prevent root-zone problems.

Protected Environment

Hydroponic strawberries are often produced under **polyhouses, greenhouses or other protected structures**. Protected cultivation allows growers to manage temperature, humidity, irrigation and light more effectively.

Strawberry plants generally perform well under moderate temperatures. Excessive heat can negatively affect flowering, pollen viability and fruit quality. Therefore, ventilation, shading, cooling and humidity management may be required depending on the local climate.

In regions with high temperatures, protected structures should be designed to provide sufficient ventilation and temperature management.

Pollination Management

Pollination is an important factor in strawberry production because poor pollination can result in misshapen fruits and reduced marketable yield.

In protected structures, natural pollinating insects may be limited. Therefore, growers should ensure adequate pollination through appropriate methods, which may include **natural pollinators, managed pollinators or mechanical/assisted pollination**, depending on the production system.

Good pollination contributes to uniform fruit development and better fruit shape.

Plant Training and Runner Management

Strawberry plants produce runners that can consume plant resources if allowed to develop excessively. In fruit production systems, unnecessary runners are generally removed so that the plant can direct more assimilates toward flowering and fruit development.

Dead, damaged or diseased leaves should also be removed carefully to maintain proper canopy ventilation and reduce disease pressure.

Flowering and Fruit Development

After flowering, strawberry fruits require appropriate environmental conditions and balanced nutrition for proper development. Potassium, calcium and other nutrients play important roles in fruit development and quality.

Adequate light is also essential because photosynthesis supplies the carbohydrates required for fruit growth. Therefore, excessive shading should be avoided.

Temperature, nutrition, irrigation and pollination should be managed together rather than independently because all these factors influence fruit yield and quality.

Disease and Pest Management

Although hydroponics reduces many soil-related problems, it does **not eliminate pests and diseases**. Common problems may include mites, aphids, thrips, whiteflies and fungal diseases under favourable environmental conditions.

Preventive management is therefore essential. Growers should use clean planting material, maintain sanitation, remove infected plant parts and monitor plants regularly. Proper ventilation and irrigation management can help reduce excessive humidity and disease development.

Integrated pest management (IPM) should be preferred over indiscriminate pesticide use, particularly because strawberries are generally consumed fresh.

Harvesting and Post-Harvest Handling

Strawberries are delicate and highly perishable. Fruits should be harvested carefully when they have developed the desired colour and maturity according to the target market.

Harvesting during cooler parts of the day can help maintain quality. Fruits should be handled gently to avoid bruising. Proper grading, packaging, pre-cooling and cold-chain management can significantly extend shelf life and reduce post-harvest losses.



Economic Potential

Hydroponic strawberry cultivation can provide opportunities for **high-value production from a relatively small area**, especially near urban and semi-urban markets where consumers may pay a premium for fresh, attractive and locally produced strawberries.

However, hydroponic farming requires higher initial investment than conventional cultivation. Costs may include protected structures, hydroponic systems, growing media, fertigation equipment, water-quality management, planting material, climate management and skilled labour.

Therefore, growers should prepare a detailed economic analysis before establishing a commercial unit. Market access and reliable technical management are as important as production technology.

Challenges in Hydroponic Strawberry Production

Despite its advantages, hydroponic strawberry production has several challenges:

1. **High initial investment** for protected structures and hydroponic equipment.
2. **Technical knowledge** is required for nutrient and irrigation management.
3. Incorrect pH or EC can quickly affect plant growth.
4. Poor water quality can lead to nutrient imbalance and salt accumulation.
5. Temperature and humidity must be managed carefully.
6. Hydroponic systems require regular monitoring and maintenance.
7. Power or irrigation-system failure can rapidly affect plants.
8. Market prices for strawberries can fluctuate considerably.

Thus, hydroponics should not be considered simply as a method of growing plants without soil; it is a **precision production system** requiring regular monitoring and management.

Future Prospects

The integration of hydroponics with **protected cultivation, automation, sensors, fertigation, vertical farming and digital agriculture** can further improve strawberry production. Sensors can be used to monitor parameters such as temperature, humidity, substrate moisture, pH and EC. Automated fertigation systems can then deliver water and nutrients according to crop requirements.

In the future, data-driven crop management and controlled-environment agriculture may make it possible to produce high-quality strawberries more consistently throughout the year in suitable locations.

CONCLUSION

Hydroponic strawberry cultivation represents an important opportunity for modern horticulture, particularly where land and water resources are limited or where high-value protected cultivation is economically feasible. By providing precise control over water, nutrients and the root-zone environment, hydroponics can support efficient and quality-oriented strawberry production.

However, successful production depends on **healthy planting material, suitable cultivars, proper growing media, balanced nutrition, pH and EC management, efficient irrigation, pollination, environmental control and**

effective pest and disease management. With appropriate technical knowledge and market planning, hydroponic strawberry cultivation can become a promising component of modern high-value horticulture.