Food and Agriculture Organization of the United Nations

Introduction and advantages of protected cultivation systems

Introduction

In recent years, agricultural productivity has been affected by a range of issues including frequent and adverse climatic events, the increased spread of pests and diseases, and the lack of natural resources such as land and water. This has resulted in significant economic losses, leading farmers to seek alternative production systems that can protect crops, make efficient use of limited natural resources, and increase yields at the same time.

Protected cultivation systems offer one such alternative, and have been adapted over time to efficiently control or address the key factors of production that affect yield – from water, nutrients and soil, to climate, pests and diseases.

Advantages and limitations

Protected cultivation systems offer the following advantages:

- Possibility to provide optimal climatic conditions for growth, minimizing the negative effects of extreme climatic events such as excessive rain, heavy wind, cold snaps and heat waves
- Efficiency in the use of land, water, nutrients and sunlight
- Efficient pest and disease control that minimizes the use of pesticides and increases crop quality
- More and better-quality sunlight for crops
- Increased yield as compared to open-field production systems
- Reduced risk of losses in investments made for inputs and labor (due to increased control and mitigation for external factors)
- Possibility to grow crops year-round and to schedule harvesting for when market windows occur
- Suitability for areas with limited availability or access to land and water

Figure 1. Difference in crop performance between protected (left) and open-field (right) agriculture

Figure 2. High-quality tomatoes produced in a protected cultivation system

Moreover, protected cultivation systems allow for the use of innovative practices and technologies such as soilless culture (e.g. hydroponics, aquaponics and substrates), grafting for high-quality seedlings, biological control agents, recirculating nutrient solutions, vertical farming, drip irrigation and renewable energy sources.

The use of protected cultivation systems may also involve limitations however, and the following aspects and issues should therefore be considered and addressed:

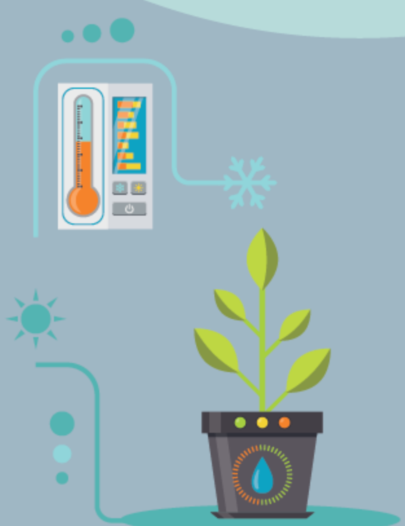
- Climate control systems: In tropical lowland areas, high temperatures and humidity present major challenges for year-round production, whereas temperate areas typically require winter heating. In either case, small-scale farmers who cannot afford the high cost of cooling or heating may stop planting or risk lower yields.
- High initial investments: These may depend somewhat on economies of scale; the larger the area to be set up and installed, the lower the cost per unit area.
- High level of expertise: Specific knowledge and skills with regard to crops, infrastructure, climate, water, soil and nutrients, as well as pest and disease management, are required.

Figure 3. Vegetables grown using soilless culture

Requirements

Technical requirements

- As noted in the previous section, the use of climate control systems for heating, cooling or aeration is typically expensive. Instead, a good location – coupled with careful design and management of covering materials – can contribute significantly to managing climate, while requiring much lower investment.
- Crops that can be harvested continuously tend to have high rates of success in protected cultivation systems, and should therefore be prioritized for the most efficient use of space and the highest return on investment. These include indeterminate tomatoes, peppers and cucurbits, as well as short-cycle crops such as lettuce, aromatic plants and herbs.
- The person in charge of managing the crops should have a minimum level of knowledge and skills in integrated crop management, including cultural practices, record-keeping, irrigation, plant nutrition, and pest and disease management. They should also be open to learning, observant and detail-oriented.



Site requirements

- **Slope of land:** An incline between 0.5 and 2 percent is ideal.
- **Sunlight:** There should be enough solar radiation to promote plant growth.
- **Aeration:** Ideally, the site should be in an area with enough breeze to ensure natural ventilation, but sites that are prone to heavy wind should be avoided, as these can damage covering materials – or even the structures themselves.
- **Altitude:** The higher the site is above sea level, the lower the temperature. This is an important consideration, especially in tropical areas.
- **Water:** The quality and quantity of the supply should be adequate for crop requirements. Water availability will define the area to be cultivated.

Figure 4. One-roof structure designed for hillside areas

Designs

Selecting the best design

Design selection will depend on the following factors:

- **Management:** Investment and design should be decided according to the level of knowledge and management.
- **Cost:** There are many options, ranging from low-cost systems to more expensive, high-tech, automated systems. Adaptation is important in order to develop systems that are not only affordable, but also efficient.
- **Climate:** Design selection should take into account whether heating or cooling systems need to be installed. In areas prone to hurricanes or typhoons, construction materials must be sufficiently sturdy and appropriate.
- **Topography:** Ideally, the land should be flat. However, it is also possible to adapt the design for sites located on hillsides and slopes.
- **Availability of materials:** Systems have been successfully adapted using locally available materials such as rough wood, timber and bamboo for structures. While this may reduce the lifespan of a structure, it also reduces the cost of investment.

Figure 5. Low-cost greenhouse using a combination of plastic, netting, rough wood and bamboo

Figure 6. Lettuce cultivated in a tunnel-type structure covered with plastic

Types of design

Across a wide range of protected cultivation systems and designs, the most common types include:

- Structures covered with plastic film: High or low tunnels are partially or totally covered with plastic in order to protect the crops from rain, or from cold winters in temperate areas.

- Structures covered with netting: Shades and anti-insect houses are partially or totally covered with different types of netting to provide both shade and protection from insects. They are used mainly in areas with high temperature and/or low precipitation.
- Structures covered with both plastic film and netting: Combining plastic film and netting together provides better protection for both climate and pests and diseases, and can therefore facilitate longer or even year-round growing seasons.

Figure 7. Peppers cultivated in an anti-insect net house

Structure orientation

The greenhouse must be situated such that it receives maximum sunlight while being protected from heavy winds. The orientation should also promote natural (non-forced) ventilation, so as to exploit the Venturi effect (as shown in Figure 8), and reduce the cost of cooling during periods of high temperature.

Figure 8. Ideal orientation to promote natural ventilation, showing the flow of cooler fresh air (blue) and of hotter air (red)

Conclusions

Protected cultivation systems are a sustainable alternative for increasing productivity, while reducing the negative effects of climate change and minimizing the incidence of pests and diseases at the same time. However, the mere use of structures, covering materials and climate control systems do not necessarily guarantee high yields.

Instead, it is important to understand that the advantages and benefits of protected cultivation systems can only be achieved when all factors that affect production are managed in an integrated manner, resulting in a steady supply of high-quality produce for market supply, and thus generating consistent incomes and improving livelihoods.

Figure 9. Low-cost greenhouse showing high yield

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