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Innovation and Research in Greenhouse Cultivation

Dr. Chong Chou

Associate Professor, Wuhan University, China

ABSTRACT

Greenhouses come in a wide variety of sizes, ranging from little sheds to gigantic glasshouses and even industrial-sized buildings. The simplest kind, known as a "cold frame," is a miniature greenhouse that is often set up in a domestic setting. On the other hand, huge commercial greenhouses are high-tech production facilities for growing fruits, vegetables, and flowers. The glass greenhouses are outfitted with a variety of apparatus, including as screening installations, heating and cooling systems, and lighting, which may be managed by a computer in order to provide the ideal environment for the development of plants. The growing parameters, such as air temperature, relative humidity, and vapour-pressure deficit, are then managed using a variety of methods in order to provide the ideal setting for the production of a particular crop.

Keywords: Greenhouse Cultivation, safety, and advancements in technology.

INTRODUCTION

There are many new technologies that have been created all over the world to improve the yield and productivity of crops that are grown inside of covered structures. These technologies are used in protected agriculture. Today, it is possible to fully automate the controlled environment condition in a greenhouse using technology such as wireless networks, sensors, GPS, and GIS, amongst other things. The majority of applications for sensors include tracking the weather, monitoring soil moisture, mapping yields, etc. Automation in agriculture refers to the process of carrying out tasks such as planting, transplanting, weeding, and harvesting with the assistance of machines and other forms of robotic technology. New technologies have been adopted to manage disease in protected agriculture, and some of these new technologies limit the emission of greenhouse gases caused by nitrogenous fertilisers. Other new technologies provide an effective light source for crop production by making use of light-emitting diodes (LEDs), and other new technologies give an efficient light source.

Internet of Things in the Greenhouse Cultivation

The usage of cloud computing has proven to be beneficial in intelligent greenhouses. The storing of sensor data in the cloud and the integration of smart technologies have resulted in significant cost savings and increased agricultural yields. These benefits were achieved by remotely monitoring crop water levels, fertiliser levels, soil pH, humidity, and temperature. Farmers are provided with knowledge on the current weather condition through the use of forecast data, which assists the farmers in mitigating the effects of the difficulties caused by climate change and global warming. However, there are substantial drawbacks associated with the utilisation of cloud computing in certain regions that have subpar network connections and slow internet speeds.

Robotics for fertilisation in the greenhouse

Monitoring the make-up of nutrient solutions generated by fertilisation systems was the initial motivation behind the idea to employ electronic tongues in this capacity. A collection of non-specific sensors and multivariate calibration tools make up this innovative approach to the analysis of chemical substances. The model projected concentrations of ammonium, potassium, and nitrate in nutrients, drainage, and tap water that were different from the sensor array and temperature data. Additionally, the model anticipated quantities of sodium and chloride that were undesirable. It would appear that this method is a promising method for online estimate of the levels of nutrients and chemicals that should be avoided in fertilisation solutions.

Robotics in Greenhouse Agriculture

Seedling production systems are an optimised form of production, the goal of which is to achieve production in a limited amount of space while simultaneously raising yields and improving quality. Protected cultivation is an intense form of crop production that shields plants from the effects of unfavourable environmental conditions. It also creates an atmosphere that is conducive to the growth and production of plants, thereby enhancing both their quality and quantity. A significant number of people are required to be employed in a greenhouse at all times. In point of fact, the cost that is allotted to manual labour is the most significant cost factor: more than thirty percent of the entire cost of production is spent on the wages of growers and their workers. In addition, the availability of trained workers for repetitive operations carried out in uncomfortable greenhouse conditions rapidly decreases, which leads to a decrease in the available workforce. In addition, the issue of labour shortages has grown even more relevant during the current COVID-19 pandemic caused by the SARS-CoV-2 virus, which is restricting international travel by migrant workers. This is because the pandemic is making it more difficult for migrant workers to travel internationally. As a result of this, conservation agriculture is an excellent candidate for being automated. In recent years, agricultural technology has gained a lot of attention in scientific study, and many efforts have been made to further this goal. In particular, the emphasis has been placed on the utilisation of robotics and automation for the enhancement of crop production. In particular, the employment of robotics in protected agriculture has the potential to improve overall performance and productivity while also enhancing both the quality of work and the safety of the workplace. In this regard, many authors acknowledge that automation is a valuable tool that can remove worker shortages, raise the efficiency of human work, and even reduce the quantity of employment that requires the participation of humans. Robots are able to effortlessly do repeated activities, which allows them to replace human labour while working in hazardous situations. As a result, the hazards that humans are exposed to are considerably reduced. One example of this would be using robots to spray chemicals and pesticides in protected areas. As a result, the development of greenhouse automation can result in better working conditions, the protection of personnel from both physical and chemical threats, as well as improvements in their health, comfort, and safety.

Utilisation of Robots in Vertical Farming

The prevention and treatment of illness in cultivated areas that are enclosed

This critical reevaluation of research and development strategies in phytopathology is required as a result of the revolutionary technological advancements in greenhouse production systems. At the same time, this revolution gives growers with an exciting challenge and chance to battle plant diseases relatively cheaply and without the constant use of pesticides. Specifically, this potential allows growers to avoid the usage of pesticides. The viewpoint that insecticides are a cure-all has given way to the notion that insecticides are still beneficial, but only as part of fully integrated environmental and biological control programmes and as escape mechanisms for germs and illnesses that have developed resistance to them. Some vegetable growers in the 120-hectare greenhouse industry around Learnington in southwesterly Ontario have not used any pesticides or fungicides other than methyl bromide, which is a soil disinfectant used to manage nematodes, for years. Methyl bromide is also used to kill worms. They rely mostly on disease-resistant cultivars, biological methods of insect control, and conditions that are disease-free.

Planting cucumbers on ridges will offer faster warming of the root zone and improved drainage in greenhouses with a history of disease. This will allow for the prevention of black root rot, which is caused by Phomopsis sclerotlordes. It is possible that disinfecting the soil on a yearly basis is not required because the disease builds up over time.

THEORY OF OPERATION

Because the roof and walls of a greenhouse are transparent, incident solar radiation can travel through them and be absorbed by the floor, earth, and contents of the greenhouse, which causes them to get warmer. This results in the greenhouse having a higher temperature. In turn, these warm up the air all around them within the greenhouse. The existence of a roof and walls prevent the warmed air from escaping the structure by convection, which results in an increase in temperature within the greenhouse because the structure is not exposed to the outside air.

This is in contrast to the earth-centric notion referred to as the "greenhouse effect," which describes a reduction in the amount of heat that a planet loses due to radiation.

In a heated greenhouse, quantitative studies imply that the effect of infrared radiative cooling is not insignificantly tiny, and that it may have economic repercussions. The findings of an investigation into problems caused by near-infrared radiation in a greenhouse fitted with screens having a high coefficient of reflection led researchers to the conclusion that the installation of such screens might lower the amount of heat required by approximately 8%. Researchers also proposed applying dyes to surfaces that were transparent. Composite glass, which is less reflective, or basic glass with an anti-reflective coating, which is less effective but cheaper, both yielded savings as well.

Ventilation

One of the most essential elements necessary for the operation of a profitable greenhouse is adequate ventilation. Greenhouses and the plants they contain can be vulnerable to a variety of issues in the event that adequate ventilation is not provided. The primary goals of ventilation are to bring the temperature and humidity levels up to the ideal level, as well as to ensure that air is constantly moving and, as a result, to avoid the accumulation of plant infections like

Botrytis cinerea, which thrive in environments with still air conditions. In addition to ensuring that there is a supply of fresh air for photosynthesis and plant respiration, ventilation also makes it possible for vital pollinators to have access to the greenhouse crop.

Ventilation can be accomplished by the utilisation of vents, which are often managed automatically by a computer, in conjunction with recirculation fans.

Heating

When it comes to operating a greenhouse anywhere in the world, one of the most significant costs is the cost of heating or energy. This is especially true in locations with colder climates. The quantity of heat that is lost through the greenhouse covering is the primary challenge associated with the process of heating a greenhouse as contrasted to a building that has walls that are solid and opaque. Because the coverings are required to let some light into the structure, the coverings themselves are not particularly good at insulating the building. Due to the fact that standard plastic greenhouse covers have an R-value of approximately 2, a significant amount of money is spent in order to continually restore the heat that is lost. When additional heat is required, most greenhouses use furnaces that are powered by either natural gas or electricity.

There are ways of heating known as passive heating that generate heat with a little amount of input energy. When solar energy is in relatively high supply, like during the daytime and summer months, it can be stored and then used to raise the temperature when it is in lower supply, as during the nighttime and winter months. The heat that would otherwise be lost from livestock can be recovered and utilised to heat greenhouses. For instance, putting a chicken coop inside of a greenhouse allows for the recovery of the heat that would otherwise be lost from the chickens. Additionally, geothermal heating is utilised in some greenhouses.

Cooling

When the temperature inside the greenhouse rises to an unsafe level for the plants that are housed there, the windows are normally opened to provide ventilation and cooling. This can be accomplished by hand or with the use of an automated system. The difference in temperature between the inside and outside can cause window actuators to open, or electronic controls can manually open the windows. Electronic controllers are frequently utilised in order to monitor the temperature and make conditions-responsive adjustments to the operation of the furnace. This can be as straightforward as using a straightforward thermostat, but in larger greenhouse operations, it can become extremely sophisticated.

In extremely warm environments, the usage of a shade house, which provides cooling through the use of shade, may be useful.

Lighting

The plants in the greenhouse make use of the light that comes in via the windows during the daylight hours. Grow lights, which are often electronic light emitting diodes (LEDs), are installed in some greenhouses. These lights are turned on at night to boost the amount of light that the plants receive, which in turn boosts the output of specific plants.

Carbon dioxide enrichment

For close to a century, people have been aware of the fact that increasing the concentration of carbon dioxide in greenhouse culture to approximately 1100 parts per million can promote faster plant development. The controlled serial enrichment of carbon dioxide was a technique that was first implemented on a large scale in the Netherlands after the invention of the necessary equipment for the process. Secondary metabolites, such as the cardiac glycosides found in Digitalis lanata, are created in greater quantities when the plant is grown in a greenhouse at higher temperatures and in an environment with a higher concentration of carbon dioxide. As a result of minimising the overall airflow required to supply appropriate carbon for plant growth and, as a direct result of this, reducing the quantity of water lost to evaporation, carbon dioxide enrichment can also reduce the amount of water that is used in greenhouses by a significant fraction. These days, commercial greenhouses are typically situated in close proximity to suitable industrial facilities for the purpose of maximising their individual and collective benefits. For instance, Cornerways Nursery in the United Kingdom is positioned in such a way that it is in close proximity to a significant sugar refinery. This allows the nursery to make use of the waste heat and carbon dioxide produced by the refinery, which would otherwise be released into the atmosphere. The refinery is able to cut its carbon emissions, while the nursery not only sees an increase in tomato harvests but also eliminates the need to provide its own heating for the greenhouse.

According to Liebig's law, enrichment is only successful in situations in which carbon dioxide has assumed the role of limiting factor. In a climate-controlled greenhouse, the need for irrigation may be minimal, and the soils may already be rich in nutrients. Rising CO2 levels will only boost primary output in less-controlled gardens and open fields until the point where soil depletion occurs (this is assuming that there will be no droughts, flooding, or both, which is prima facie shown by the fact that CO2 levels are continuing to climb). Experiments conducted in the laboratory, test plots conducted using free air carbon enrichment (FACE), and data taken in the field all show replicability.

Private Greenhouse in Finland

In residential greenhouses, the 'horticultural glass' grade of glass used is normally 3 millimetres (or 1/8 inch) thick. This is an excellent quality glass that should not contain air bubbles (which might cause leaf burning by acting like lenses).

Polyethylene film and multiwall sheets of polycarbonate material or PMMA acrylic glass are the most common types of plastics that are utilised.

Glass greenhouses used for commercial production are frequently high-tech production facilities for growing flowers or vegetables. The glass greenhouses are outfitted with a variety of systems, including those for screening, heating, cooling, and lighting; some of these systems may be automatically controlled by a computer.

Light in Dutch

A pane of horticultural glass that was formerly used as a standard unit of construction in the United Kingdom and other nations in Northern Europe was referred to as "Dutch Light." This pane had dimensions of approximately 730 millimetres by 1422 millimetres and was known as "Dutch Light." When compared to employing smaller panes, such as the 600 mm width that is frequently used in modern household designs, this size provides a bigger glazed area. However, in order to maintain the same overall greenhouse size, using smaller panes would require a larger amount of supporting framework. A greenhouse with sloped sides (which results in a broader base than at eaves height) and making use of these panes uncut is frequently described to as having "Dutch Light design." A cold frame that uses a full- or half-pane is known as being of "Dutch" or "half-Dutch" size.

Solar panels with spectrum selectivity installed in greenhouses

This paragraph is taken from the article "Agrivoltaics: Greenhouses with Spectrally Selective Solar Modules," which can be found here.

There is a possibility that in the not-too-distant future, greenhouses will find some use for emerging photovoltaic technologies that filter out the light wavelengths that aren't required by the plants growing within, but yet let through the colours of light that are required. There have been successful trials of similar greenhouses in the past.

"Semi-transparent" PV panels, which are utilised in agrivoltaics, extend the distance between solar cells and make use of clear backsheets in order to improve food production below. As the sun moves from east to west, the stationary PV panels "spray sunlight" over the plants below, protecting them from "over-exposure" to the sun's rays and mimicking the effect of transparent greenhouses in this regard. At the same time, the PV panels generate power from the top of the structure.

USES

A greater degree of control over the conditions under which plants are grown is made possible by greenhouses. Temperature, levels of light and shade, levels of light and shade, irrigation, fertiliser application, and air humidity are some of the important parameters that may be managed within a greenhouse, depending on the technical specifications of the greenhouse. Greenhouses can be used to compensate for deficiencies in the growth qualities of a piece of land, such as a short growing season or low light levels. As a result, greenhouses can boost food production in environments that are considered to be on the edge of habitability. In places where the sun is intense and the air is dry, people build structures called shade homes.

Greenhouses are becoming increasingly essential in the food supply of countries that are located in high latitudes because they have the potential to allow some crops to be cultivated continuously throughout the year. Greenhouses at Almera, Andalusia, Spain, make up about 200 square kilometres (49,000 acres) of land, making it one of the largest agricultural complexes in the world.

Greenhouses are frequently utilised for the cultivation of transplants, as well as flowers, vegetables, and fruits. When it comes to the cultivation of specific plants for commercial purposes, such as tomatoes, special greenhouse cultivars are typically utilised.

It is possible to cultivate a wide variety of flowers and vegetables in greenhouses during the late winter and early spring months, and then move them outside once the weather warms up. Racks designed for seed trays can also be used within the greenhouse to stack seed trays in preparation for subsequent transplanting outside. When cultivating plants within a greenhouse until they reach their mature size, hydroponics, and in particular hydroponic A-frames, can be employed to make the most efficient use of the available interior space.

Pollination can be accomplished through the use of bumblebees, as well as through the use of other species of bees, as well as through the use of artificial pollination.

When compared to production done outside, the somewhat restricted environment of a greenhouse imposes a different set of management needs on those working in the space. Insects and diseases, as well as wide swings in temperature and humidity, need to be managed, and irrigation is essential for meeting the plant's water requirements. Most greenhouses employ sprinklers or drip lines. It is possible that significant amounts of heat and light will be required, in particular for the cultivation of warm-weather vegetables during the winter months.

In addition to their use in agriculture, greenhouses offer a variety of other potential applications. GlassPoint Solar, which has its headquarters in Fremont, California, is in the business of producing steam for solar-enhanced oil recovery by enclosing solar fields in greenhouses. For instance, GlassPoint stated in November 2017 that it is establishing a solar enhanced oil recovery facility near Bakersfield, California that will utilise greenhouses to enclose its parabolic troughs in order to maximise solar energy collection.

An "alpine house" is a type of greenhouse that has been modified specifically for the purpose of cultivating alpine flora. The objective of an alpine house is to recreate the conditions that are optimal for the growth of alpine plants and, in particular, to protect the plants from the damp conditions that are present during the winter. Because the plants that are planted in Alpine houses are hardy, or require no more than protection from severe frost in the winter, Alpine houses typically do not have heating. They are constructed to have a very high level of ventilation.

CONCLUSION

The most recent advancements in worldwide greenhouse production are discussed in this paper. These improvements demonstrate the high degree of innovation and research that has been conducted in industry and research centres over the past several years in order to achieve output that is more environmentally friendly and competitive. The effects of climate change will almost probably, in the not too distant future, give rise to additional questions and lead to adjustments in most existing production strategies, particularly those relating to rising temperatures and the lack of available water. As a result, innovative and effective solutions are required to meet this new circumstance without putting the competitiveness of the horticulture crop value chain in jeopardy.

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