Design of Greenhouse automated carbon cycling system for carbon savings

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***Abstract*— Given the realities of global warming and climate change, the agricultural sector must produce food in more efficient and sustainable ways. In this context, we studied ways to utilize carbon dioxide for crop growth by improving greenhouse heating systems that use fossil fuels. This study studies the design and feasibility of a system that collects carbon dioxide generated by burning fossil fuels in winter greenhouses and supplies it to the crop area. The study results suggest the following important conclusions: First, this system can promote crop growth and improve agricultural productivity, and optimize crop growth conditions. Second, it has the ability to minimize energy consumption and reduce greenhouse gas emissions by considering energy efficiency. As a result, this system is expected to help achieve carbon neutrality in agriculture by minimizing the environmental impact of fossil fuel use.**

***Keywords*— Smart Agriculture, Crop growth, Carbon neutrality, Carbon, Integrated control**

I. INTRODUCTION

Climate change and agricultural sustainability are emerging as critical challenges affecting current and future agricultural productivity and food security. Extreme weather events caused by rapid climate change are negatively affecting crop growth and harvest, and the agricultural sector is one of the main sources of greenhouse gas emissions that contribute to extreme weather events. In particular, carbon dioxide emissions from the use of fossil fuels to heat greenhouses in winter are a significant part of the environmental problem [1, 2].

To address these issues, this study aims to design a system that reduces carbon dioxide (CO2) emissions from the winter greenhouse heating process while promoting crop growth. In doing so, we propose a logical and practical way to minimize CO2 emissions from the use of fossil fuels, while at the same time utilizing CO2 as a resource to promote photosynthesis and growth of crops.

Chapter 2 of this thesis discusses the environmental impact of heating greenhouses and Chapter 3 discusses the impact of carbon dioxide on crop growth. Chapter 4 describes the construction of an automated carbon cycle system and how to utilize the collected carbon, and finally, the conclusion describes what is required to utilize this system and the expected benefits.

II. ENVIRONMENTAL IMPACT OF GREENHOUSE HEATING

Heating greenhouses with fossil fuels can cause a number of environmental problems. These problems include

When fossil fuels (coal, oil, and natural gas) are burned, large amounts of carbon dioxide are released into the atmosphere. This is one of the major greenhouse gases, contributing to global warming and climate change. Global warming can lead to extreme weather events, sea level rise, and ecosystem changes, and can negatively impact agriculture and ecosystems [3].

Therefore, greenhouse heating using fossil fuels is one of the major contributors to worsening environmental problems. To solve these problems, it is necessary to introduce green energy sources and energy-efficient heating systems, save energy, and reduce greenhouse gases.

III. HOW CARBON DIOXIDE(CO_2) AFFECTS CROP GROWTH

CO_2 has important effects on crop growth. In general, CO_2 has beneficial effects on crops, and these effects are as follows

CO_2 promotes photosynthesis in crops, a process that utilizes the sun's energy to produce sugars and oxygen from CO_2 and water. When more CO_2 is available, photosynthesis rates increase, which improves crop growth and productivity, leading to higher yields [4-5].

By utilizing CO_2 more effectively, crops are able to use moisture more efficiently. This helps crops survive and thrive in dry conditions.

CO_2 is one of the greenhouse gases, and it causes the greenhouse effect. Therefore, by managing CO_2 at the right level, we can control the greenhouse effect and regulate the temperature and humidity in the greenhouse.

IV. DESIGNING AN AUTOMATED CARBON CYCLING SYSTEM

When designing a schematic of a system to utilize carbon for heating greenhouses with fossil fuels, there are a number of important components to consider. The components of this system are shown and described in Figure 1 below.

A. System Configuration Diagram

1) Fossil fuel supply system

A system for storing and delivering fossil fuels (e.g., coal, oil, natural gas) is required. Includes fuel storage tanks and fuel delivery devices.

2) Fuel combustion system

A system that generates heat by burning fossil fuels. It requires a fuel burning device such as a boiler.

3) Heating system

A system that utilizes the heat generated to heat the interior of the greenhouse. It requires a heat exchanger, cooling, and piping system.

4) Carbon dioxide capture system

This is a system that captures carbon dioxide produced by burning fossil fuels. It requires a carbon dioxide capture device and a storage tank.

5) Carbon dioxide delivery system:

This is a system that supplies the captured carbon dioxide to crops. Carbon dioxide piping and distribution systems are required.

6) Environmental control system

This system controls the environment inside the greenhouse, regulating temperature, humidity, light, etc. It includes sensors, control devices, and crop monitoring systems.

7) Energy management and automation system

It is a system that automates the operation and monitoring of the system. It includes sensors, computer control systems, remote monitoring devices, etc. It is also a system that optimizes the energy efficiency of the system and monitors energy consumption. Includes energy storage devices, energy management software, etc.

8) Ventilation system

It is a system that manages air exchange and controls the air in the greenhouse. It requires ventilation fans, windows, and air purification systems.

9) Security and safety systems

This is the system that maintains the security and safety of the greenhouse and system. It includes CCTV, fire detectors, and emergency evacuation systems.

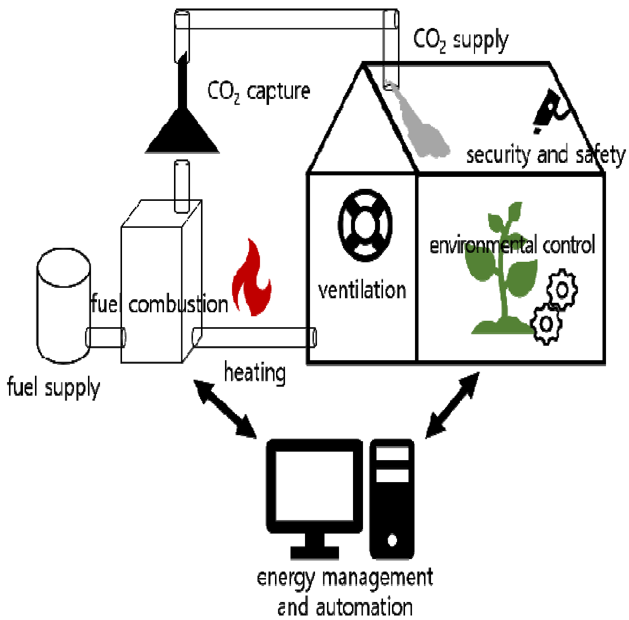

Figure 1 System configuration diagram

This system plays an important role in supplying carbon dioxide from fossil fuel combustion to the crop area to enhance crop growth and productivity. By monitoring and regulating the environment and crop conditions inside the greenhouse, it provides the best conditions for crop growth and minimizes the environmental impact of fossil fuel use.

B. Measures to improve energy and carbon utilization

In addition to reducing the energy used in the greenhouse, the idea was to install additional structures in the greenhouse as a way to improve the usability of the system. Installation of the structure can result in economic and environmental benefits by not only reducing heating and cooling costs but also facilitating the supply of carbon needed by crops. In situations where the structure is not needed or when the amount of light is insufficient due to the structure, it is automatically rolled up to the center rod to minimize the problem.

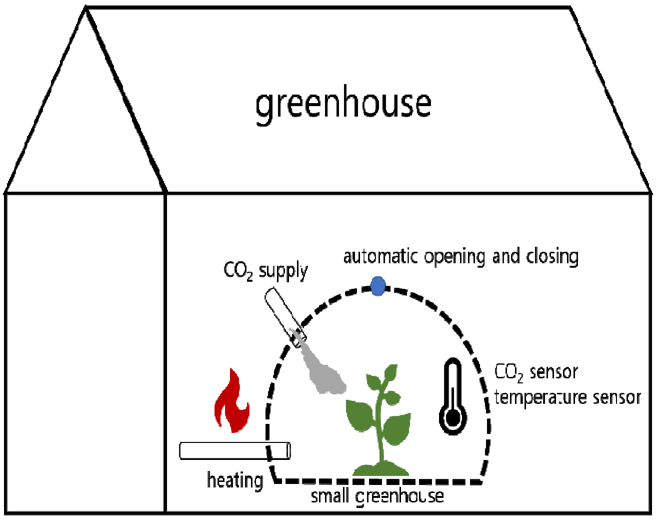

Figure 2 Measures to improve energy and carbon utilization

C. How Carbon is Collected and Utilized

In order for this system to be utilized automatically, it must include the following features

1. collect data from carbon dioxide sensors

2. input and analyze crop growth data

3. regulate carbon dioxide supply

4. automatic decomposition of more carbon dioxide than needed

5. continuously update and store data

This system basically measures the amount of carbon dioxide from the carbon dioxide capture device and the carbon dioxide sensor attached to the crops and supplies as much carbon dioxide as the crops need. Each day, the user enters the crop's growth data into the server, and based on that data, the system automatically calculates a more appropriate amount of carbon dioxide to supply to the crop. The excess carbon dioxide will be decomposed in a carbon dioxide capture machine to prevent environmental pollution.

```
class CarbonDioxideManagementSystem:
    def __init__(self, server_url):
        self.server_url = server_url
        self.captured_co2 = 0
        self.required_co2 = 0
        self.growth_data = {}
        self.co2_supply_rate = 1.0

    def capture_co2(self):
        """Capture CO2 from the collector."""
        self.captured_co2 = self.read_co2_sensor('collector')
        print(f"Captured CO2: {self.captured_co2} ppm")

    def read_co2_sensor(self, sensor_type):
        """Simulate reading CO2 levels from a sensor."""
        return random.randint(100, 600) if sensor_type == 'collector' else random.randint(300, 400)

    def input_growth_data(self, date, growth):
        """Input growth data for the crops."""
        self.growth_data[date] = growth
        print(f"Input growth data: {date} - {growth}")

    def analyze_growth_data(self):
        """Analyze growth data and adjust CO2 supply rate."""
        if len(self.growth_data) >= 2:
            sorted_dates = sorted(self.growth_data.keys())
            latest_date, previous_date = sorted_dates[-1], sorted_dates[-2]
            growth_change = self.growth_data[latest_date] - self.growth_data[previous_date]
            self.adjust_co2_supply_rate(growth_change)

    def adjust_co2_supply_rate(self, growth_change):
        """Adjust the CO2 supply rate based on growth change."""
        if growth_change < 0:
            self.co2_supply_rate *= 1.1
        else:
            self.co2_supply_rate *= 0.9
        print(f"Adjusted CO2 supply rate: {self.co2_supply_rate}")

    def supply_co2(self):
        """Supply the appropriate amount of CO2 to the crops."""
        self.required_co2 = self.read_co2_sensor('crops') * self.co2_supply_rate
        if self.captured_co2 >= self.required_co2:
            print(f"Supplied {self.required_co2} ppm CO2 to crops.")
            self.captured_co2 -= self.required_co2
            excess_co2 = self.captured_co2
```

Figure 3 Python code for the greenhouse automated carbon cycle system (partial)

V. CONCLUSION

In this paper, we have designed a system that utilizes carbon dioxide generated during the use of fossil fuels for crop growth through a greenhouse heating system. Such a system provides a sustainable solution in the agricultural sector as an important tool for crop growth and enhancement of agricultural productivity. Supplying additional carbon dioxide to crops through a carbon dioxide supply system improves agricultural productivity by increasing the rate of photosynthesis in crops and accelerating crop growth. It also reduces greenhouse gas emissions and reduces the contribution to global warming and climate change by capturing and reusing carbon dioxide generated during the use of fossil fuels.

In order to make this system practical, government support policies and regulations such as subsidies are needed to make it accessible to many farmers. In addition, it is necessary to improve awareness of environmental issues such as carbon neutrality, which is becoming more important socially and internationally than the economic benefits of using the system to produce crops or utilize wasted energy. As a result, the proper implementation and management of these systems will be an important factor in improving the sustainability and food productivity of the agricultural sector. Furthermore, it is expected to receive more attention as a solution for environmental conservation and greenhouse gas reduction.

In future research, we will modify the Python code used in this paper and develop related algorithms by conducting tests in real greenhouses. We will also study the improvement of the greenhouse structure for more efficient energy utilization.

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