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오이재배의 비닐하우스 시스템에서 스프링클러의 유량효과

Sprinkler Flow Rate Effect on the Greenhouse System for Soilless Cultivation of Cucumber

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〈Abstract〉

In this paper, soilless cucumber cultivation was investigated, fermented fertilizer to increase the cucumber yield was considered, and the greenhouse temperature control system for cucumber cultivation is developed. To do this, perlite was proposed to replace soil as growth medium. Fermented cows and pigs manure was proposed as plant fertilizer. Combination of fan, water sprinkler, and pipe heating system was proposed to control the greenhouse temperature. However, because this research was conducted during the summer, the greenhouse system observed in this study only focused on variations in the flow rate of the water sprinkles used. The experimental result shows that soilless culture in the greenhouse could be an alternative to traditional field production for high-value vegetable crops. Furthermore, application of fermented fertilizer of 10% could enhance the growth and increase the yield and quality of crops. The proposed sprinkler flow rate is best suited for cucumber crop with the best thrives was 0.846 kg/s.

Keywords : Cucumber, Greenhouse Temperature control, Fermented fertilizer, Soilless cultivation

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1. Introduction

Cucumber is one of the famous and a widely cultivated vegetable plant and belongs to the gourd family of “Cucurbitaceae”, genus of “Cucumis”. This is basically a creeping vine that bears cylindrical fruits that are used as vegetables. Oils extracted from cucumber seeds are used for medicinal purpose. Slicing, pickling & burpless are the three main varieties of cucumber cultivated across the globe and within these varieties, several different cultivars have been emerged in the market. Cucumbers are thought to have originated in Southeast Asia and have been in cultivation for around 3,000 years. Cucumbers then spread to China and have been used in Korea since the Goryeo dynasty, approximately 918 to 1392 CE. However, it is grown in all of the countries in the world.

Cucumber can be grown in greenhouse, polyhouse and in hydroponic system. Soilless culture is the modern cultivation system of plants that use either inert organic or inorganic substrate through nutrient solution nourishment. Possibly it is the most intensive culture system utilizing all the resources efficiently for maximizing yield of crops and the most intense form of agricultural enterprises for commercial production of greenhouse vegetables. Several studies suggested soilless culture in the greenhouse as an alternative to traditional field production for high-value vegetable crops. Soilless growing media are easier to handle and it may provide better growing environment in terms of one or more aspects of plant growth compared to soil culture. Organic substrates includes sawdust, coco peat, peat moss, woodchips, fleece, marc, bark etc. whereas, inorganic substrate of natural origin are perlite, vermiculite, zeolite, gravel, rockwool, sand, glass wool, pumice, sepiolite, expanded clay, volcanic tuff and synthetically produced substrates are hydrogel, foam mates (polyurethane), oasis (plastic foam) etc.. Various raw materials have been used to produce growing media for vegetable production throughout the world. However, the research focused on soilless cucumber cultivation are limited.

Application of Effective Microorganisms (EM) is known to increase the microbial diversity of soil and plants, improve soil quality, and enhance growth and increase yield and quality of crops [1]. EM is not specific type of microorganisms. It is a mixed liquid culture solution containing lactic acid bacteria, photosynthetic and nitrogen fixing bacteria, yeast, ray fungi and molds making about 5 families, 10 genera and 80 different species [2]. All of these are mutually compatible with one another and can coexist in liquid culture for extended periods [3]. Although there are several research related to fermented fertilizer for plant, not so many research focused on cucumber. Therefore, research on the optimal fertilizer composition for cucumber growth is required.

The cucumber crop is best suited for

warm season regions and thrives best between 20° C and 26° C. Cucumber crop is very sensitive to frost conditions. Commercial cucumber yield can be high in moderate warm temperature conditions. Therefore it is impossible to cultivate the cucumber during summer and winter season. To solve this problem, a greenhouse was developed to cultivate the cucumber crop during summer and winter season. During summer in Korea, the air temperature in a greenhouse can exceed 40° C, which has implications for the growth of crops and increases the cooling-energy consumption. Roof cooling has been widely used in building cooling energy saving, which can reduce roof surface and indoor temperature by reducing direct radiation and heat transfer. A metal roof coated with thermal reflective coating (TRC) was proved to be able to significantly reduce roof temperature. However, greenhouses need a certain degree of solar radiation for plants to grow, so a roof cooling method with a certain degree of transparency is needed. Roof sprinkling is one of the most effective ways to reduce the temperature of a building. It works by sprinkling water on the roof and utilizing the process of evaporation to cool it.

The main objective of this research was to investigate substrates for soilless cucumber cultivation, to find the optimum composition of fermented fertilizer to increase the cucumber yield and to design the greenhouse with temperature control system for four season cucumber cultivation.

2. Material and Method

2.1 Materials

The experiments were conducted during January-November 2019 in greenhouses located at Miryang city (113 ◦ 230 E and 22 ◦ 560 N). Studied hybrid was silver green variety cucumber (Cucumis sativus L.), hybrid with long fruit, and specific to greenhouse culture. Cucumber seedlings were seeds directly in pots filled with Perlite in warm greenhouse. Nutrient solutions had an EC of 0.7 and a pH of 5.8. Greenhouse temperature was set to 20-26° C Seedlings were watered daily with nutrient solution. All times it was kept the same EC and pH. The culture substrate, Perlite, has dry density of 83 kg/m3, wet density of 114 kg/m3, total porosity of 75%, air porosity of 36% and pH of 7.1. After a three-month growth, cucumber crops were harvested.

2.2 Methods

2.2.1 Medium Preparation for Soilless Cucumber Cultivation

In this research polypropylene plastic planting beds was used. These beds are resistant to rot, insect damage, UV and

moisture. It can manage the climate of the plants by allowing water and air to penetrate but not insects, encouraging plant production. It is made of recycled plastic, completely recyclable and do not just become landfill or breaking down into harmful elements. Because it is durable and designed for optimal plant growth, an individual bed can have a 7 to 10 year lifespan. The planting bed dimension is 1m x 0.3m x 0.3 m as shown in Figure 1. In this research perlite was used as the growing medium. Perlite as a grow medium is most recognizable as little white rocks. It's a type of volcanic glass that, when heated to a certain temperature, expands to several times its size. As perlite is relatively inexpensive and easy to use, it's a popular option for a grow medium among growers. It can be used on its own or in a mixture with another grow medium. The typical chemical composition of perlite varies slightly, as most volcanic glass does. However, perlite which is optimal for the expanding process typically consists of 70-75% silicon dioxide. Other chemicals include aluminum oxide (12-15%), sodium oxide (3-4%), potassium oxide (3-5%), iron oxide (0.5-2%), magnesium oxide (0.2-0.7%), and calcium oxide (0.5-1.5%). All of these are natural minerals, and are often part of other soil blends. Perlite was pored inside the planting bed then covered by white color mulch film for cooling effect. 5cm hole diameter was made every 10 cm along the planting bed for cucumber cultivation. After a three-month growth, cucumber crops were harvested and compared to soil cultivation.

2.2.2 Fermented Fertilizer Preparation

In this research fermented fertilizer or Biol is obtained with the use of inputs such as animal manure, mainly cows manure and pigs manure. Photosynthetic bacterium and Bacillus subtilis was added to accelerate the fermentation process. The procedure was carried out using the anaerobic digestion technique, according to the methodology described by [6]. The bucket was placed under the sun for a 60-day period. The bucket was shaken every week to achieve a uniform fermentation of all the materials. At the end of this period, the effluent was obtained. The solid and liquid parts of the fertilizer were separated by filtration. The

Fig. 1 Medium Preparation for Soilless Cucumber Cultivations

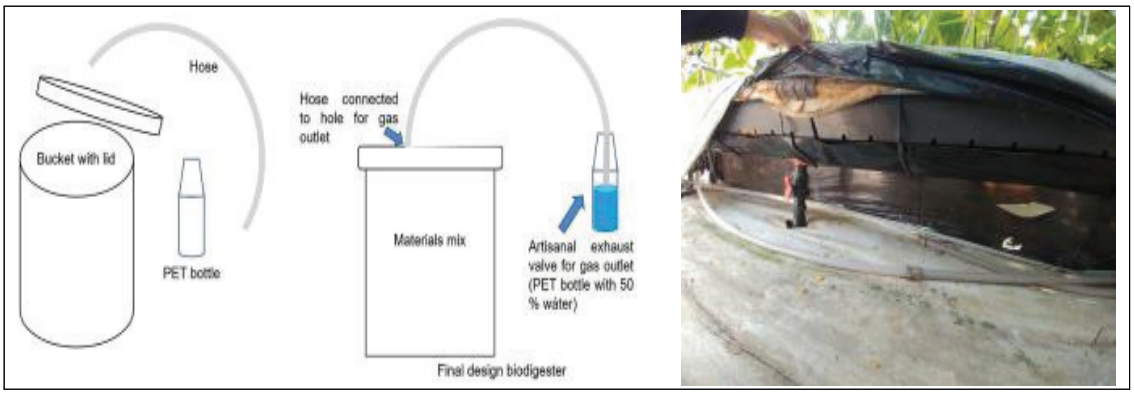


Fig. 2 Biodigester and irrigation system

liquid then mixed with the water as nutrient for cucumber. Constant volume of the nutrient solution was maintained by adding deionized distilled water every day. The nutrient level was maintained by adding fresh nutrient solution by every 3 days. The air pump was used for water oxygenation. The nutrient was pump trough all planting bed using water pump. The effect of nutrient percentage on water were investigated. Fig. 2 shows that the biodigester system and irrigation system.

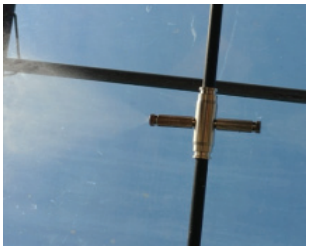
2.2.3 Greenhouse Design

It was a single greenhouse, oriented in an east-west direction; its dimensions (length × width × height) were 100 m × 20 m × 4 m, with a total area of 2000 m2. The greenhouse was covered with transparent plastic film (0.15 mm).

The dimensions of each row (length × width × height) were 90 m × 0.3 m × 0.5 m. The dropper outlets were spaced equally along the pipe and distributed water on both sides of the pipe. The water was pressurized by a booster pump to obtain a stable sprinkler flow rate. There was a fan and a wet curtain in the greenhouse; however, in order to investigate the effects of roof sprinkling alone, the effects of mechanical ventilation on the results were ignored. The air temperature in the greenhouse then were analyzed using Ansys Fluent.

Fig. 3 shows the fan, sprinkler, and pipe heating used in the greenhouse. The fan and sprinkler were used to control the temperature condition inside the greenhouse when the environment temperature was high (during summer), while the pipe heating was used when the environment temperature was low (during winter). In this study, the experiment was done in summer, therefore the greenhouse system used in this study was given three variations of sprinkle flow rate, there were 0.282 kg/s, 0.564 kg/s, and 0.846 kg/s. The measurement of the sprinkler flow rate in this study was done by measuring the time needed for discharging the water mass of 10 kg.

(a)



(b)

(c)

Fig. 3 Temperature control system used: fan (a), water sprinkle (b), and pipe heating (c)

3. Result and Discussion

3.1 Soilless Cucumber Cultivation

The experimental result shows that the planting system did have a significant effect on the number of fruit of treatments. Cucumber planed on soil normally can produce up to 30 fruits on a vine. However soilless cultivation can produce up tu 40 fruits on a vine. Moreover since the space between plant in soilless cultivation is narrower than soil cultivation the total production of the fruit could be 4~5 times than soil cultivation.

Fig. 4 Comparison of cucumber cultivation: with soil and without soil

3.2 Fermented Fertilizer

According to the experimental results in Fig. 5, the nutrient percentage on water did

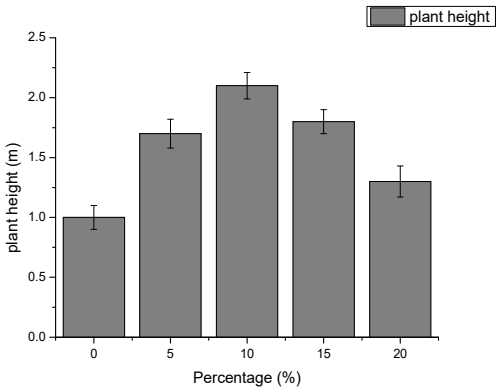


Fig. 5 The effect of nutrient percentage on plant height

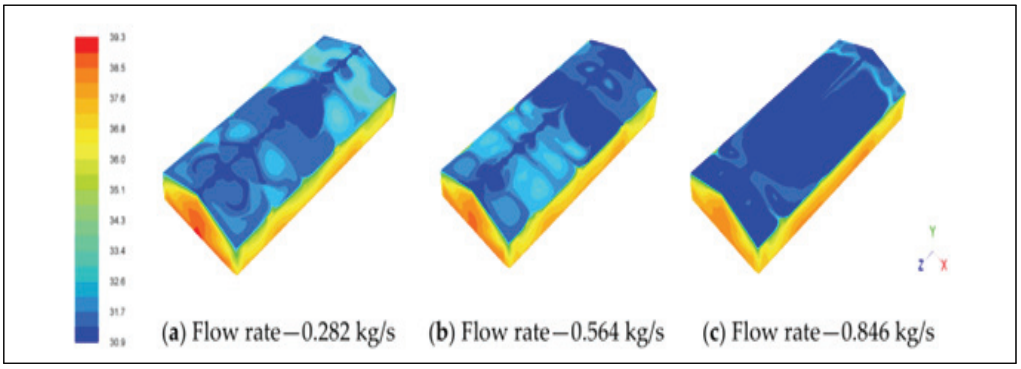


Fig. 6 Effects of sprinkler rate on roof temperature distribution (○C)

have a significant effect on the height of treatments. After the plants were germinated, the difference in the speed of growth was noticeable in the height of the treatments. For example the height of 10% nutrient has tallest height 2.1m compare to the other percentage.

3.3 Greenhouse Temperature Control

In order to study the effects of greenhouse roof sprinkling on air cooling, the roof film temperature and the air flow in the greenhouse were analyzed. The temperature distribution on the roof at different sprinkler flow rates is shown in Fig. 6. Based on the analysis, it was clear that the sprinkle flow rate had an effect on the rate of temperature decrease of the air in the greenhouse, but it had little effect on the average air temperature when the sprinkling process was over. While on Fig. 7 shows that the higher the flow rate, the lower the temperature produced each time.

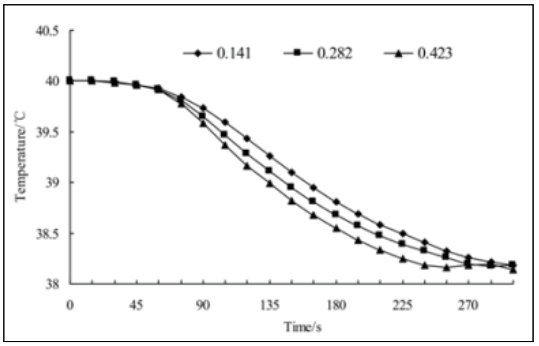


Fig. 7 Effects of sprinkler flow rate on the temperature in the greenhouse

4. Conclusion

The conclusion of this research can be obtained as follows:

(1) The experimental result shows that soilless culture in the greenhouse could be an alternative to traditional field production with the fermented fertilizer of 10%.

(2) The proposed sprinkler flow rate is best suited for cucumber crop with the best thrives was 0.846 kg/s.

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