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LIGHT ENVIRONMENT MONITORING FOR STRAWBERRY GREENHOUSE CULTIVATION DURING JEONJU WINTER

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ABSTRACT Growing strawberries in a controlled environment can be difficult during winter months when lighting hours are low. Cultivation is further compromised when low light conditions promote irregular growth, often resulting in reduced fruit quality. In this study, the internal light environment of strawberry cultivation in a greenhouse was monitored and characterized to better understand strawberry growth response. A total solar radiation (RAD) sensor and a photosynthetic photon flux (PPF) sensor were installed at the center of the test greenhouse and at five additional points (east, west, north, and south). Data were collected at 10-minute intervals over a period of four months during winter ('20.11~'21.2). A light distribution diagram was prepared based on the greenhouse dimensions to demonstrate uniformity and transmittance. Results from the two sensors showed high distribution at the south point and low distribution at the north point. The rate of decrease in RAD averaged at 54%, with the rate of decrease in PPF averaging 61%. This variance showed a significant decrease in the amount of light entering the greenhouse during winter months. The uneven light distribution in the test greenhouse resulted in the location being deemed unsatisfactory for strawberry growth. Therefore, supplemental lighting is needed to improve the environment for efficient strawberry cultivation.

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Keywords: single-greenhouse, light environment, total solar radiation, PPF

INTRODUCTION The main environmental factors that affect the quality and quantity of greenhouse crops include light, carbon dioxide, and temperature. During winter, natural lighting hours are reduced, which directly effects greenhouse crops. Such effects include an increased possibility pests and growth deformities, which reduce both the quantity and quality of crops (Choi et al., 2015; Lee et al., 2015; Choi et al., 2018; Choi and Jeong, 2019). In addition, in strawberry cultivation particularly, the lack of light, and resulting reduced photosynthesis rates in winter months causes insufficient carbohydrate residue buildup; ultimately lowering fruit quality (Lee et al., 2015; Lee et al., 2019). Transmittance of light in a greenhouse is influenced by the structure of the building, the type of cladding, as well as amount of solar penetration. It is well-reported that analysis of the light environment in a location where crops are to be cultivated is important for a successful and sustainable harvest (Lee et al., 2002). As light passes through cladding, the photometric quality of the light changes, which decreases the amount of light that is infiltrated. Therefore, it is important to measure and analyze total solar radiation (RAD) and photosynthetic photon flux (PPF) in order to effectively analyze the internal light environment. In this study, the internal light environment of strawberry cultivation greenhouses was monitored in winter. The light transmission rate was then analyzed according to its location to determine the uniformity of light distribution.

MATERIALS AND METHODS The size of the test location used for data collection in this study was a standard single vinyl greenhouse (7 m × 25 m × 1.7 m, W × L × H). The greenhouse was constructed on a [north]-facing slope, directed toward the [east], and covered with Polyethylene (PE) vinyl (0.1 mm thick). In order to measure changes in total solar radiation (RAD) and PPF both inside and outside the greenhouse, a total solar radiation sensor (S-Llb-M003, Oneset Computer Co., USA) and a photosynthetic photon flux sensor (S-Llx-M003, Oneset Computer Co., USA) were installed. The sensors were installed at a height of 1.35 m in the center of the greenhouse and at the eastern-, western-, northern-, and southern-most points (Fig. 1). As far as was possible, the sensors were positioned so as not to be affected by the structure, i.e., overhangs or beams causing shadows that would be detrimental to the study results. The study was conducted in winter, from 1 November 2020 until 28 February 2021. Measurements were taken at 10-minute intervals over this four-period.

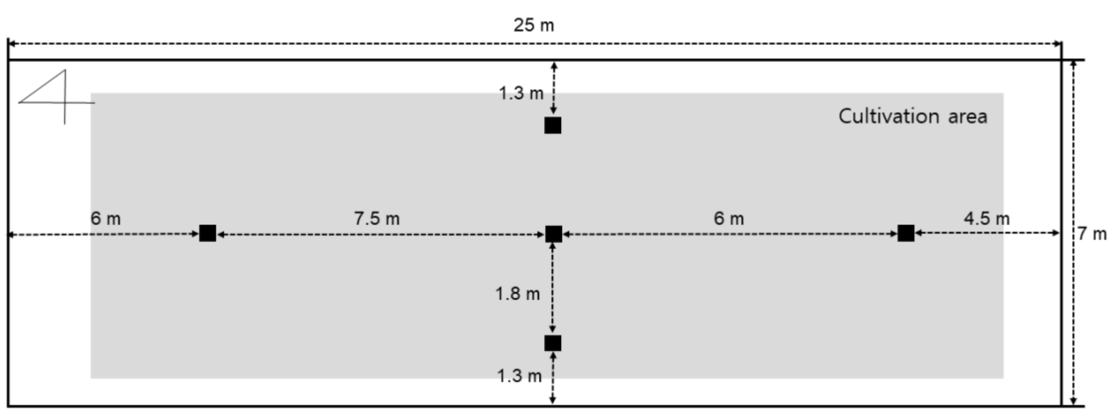

Figure 1. Total solar radiation (RAD) and photosynthetic photon flux (PPF) sensor installation location.

RESULTS AND CONCLUSION The results of analyzing the characteristics by measuring the total solar radiation and PPF of the strawberry greenhouse are as follows.

Total solar radiation (RAD) analysis As shown in Figure 2, average solar radiation during the study period was measured at 176.6 watts per square meter (W/m^2) for the central part of the greenhouse, 177.4 W/m^2 for the east, 173.7 W/m^2 for the west, 103.8 W/m^2 for the north, and 214.6 W/m^2 for the south. The RAD measured at the south point was the highest, with RAD measured at the northern point being the lowest(Fig.2). Light distribution was found to be uneven inside the test greenhouse. In addition, the rate of reduction in solar radiation was 40.1%–66.8% (averaging 52.7%) in the center, 36.5%–75.9% (averaging 52.4%) in the east, 40.0%–84.1% (averaging 53.0%) in the west, 44.9%–85.7% (averaging 68.1%) in the north, and 26.8%–66.2% (averaging 42.2%) in the south. In the case of RAD, there was a significant difference between the south and the north, which is believed to be due to the structure and materials of the central part of the greenhouse; the northern sensor was situated under shadow from the structure itself.

Photosynthetic photon flux (PPF) analysis A PPF value is measured as the amount of micromoles of photons striking a square meter per second ($\mu mol/m^2/s$). The average PPF of the test greenhouse was 307.1 $\mu mol/m^2/s$ in the center, 298.7 $\mu mol/m^2/s$ in the east, 266.7 $\mu mol/m^2/s$ in the west, 211.9 $\mu mol/m^2/s$ in the south, and 387.6 $\mu mol/m^2/s$ in the north. The PPF of the north was the highest, while the RAD was lowest in the south, showing the same tendency as the total solar radiation(Fig.3). During the month of November, PPF measurement was lower than the light compensation point for strawberries because of weather conditions. All levels that fell below the photo-saturated point of strawberries were measured during all four months, indicating that the amount of light required for crop photosynthesis was insufficient. The rate of reduction in PPF was 33.2%–71.6% (avg. 59.5%) in the center, 33.4%–79.5% (avg. 60.9%) in the east, 34.3%–90.5% (avg. 65.6%) in the west, 46.3%–84.8% (avg. 68.6%) in the north, and 11.1%–68.7% (avg. 48.6%) in the south(Fig.4).

The reduction rate of PPF was greater than that of RAD. This infers that the internal lighting environment of the test greenhouse does not meet the standards necessary for efficient growth of strawberries during winter. Therefore, supplemental lighting is needed to improve the production and quality of strawberry cultivation.

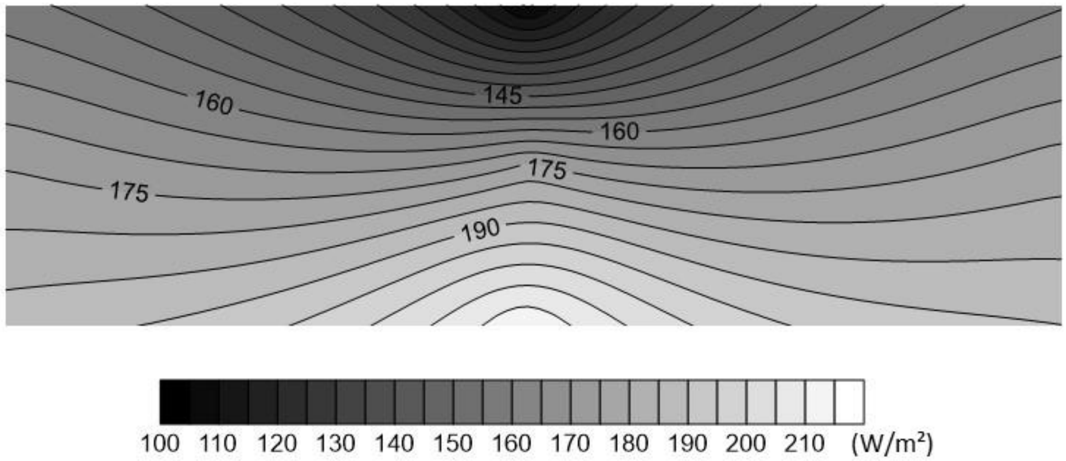

Figure 2. Total solar radiation distribution of the single test greenhouse.

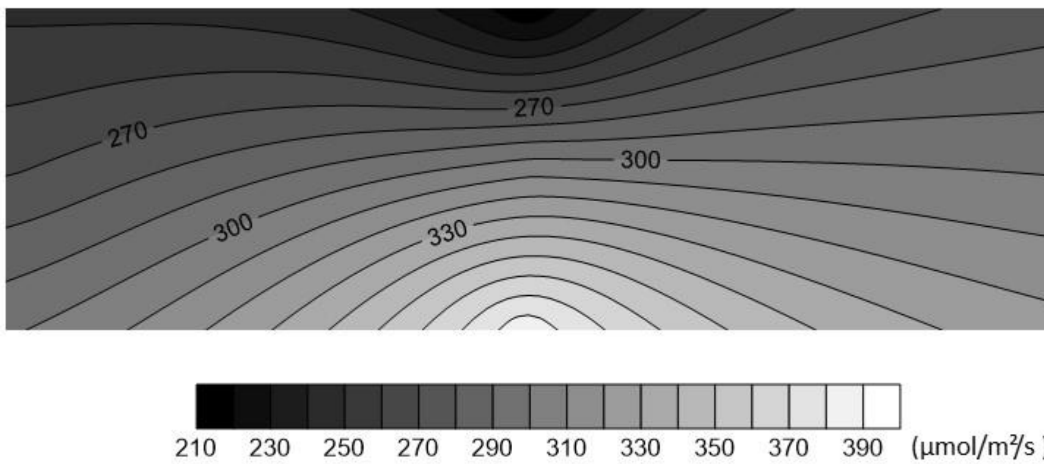

Figure 3. Photosynthetic photon flux distribution of the single test greenhouse.

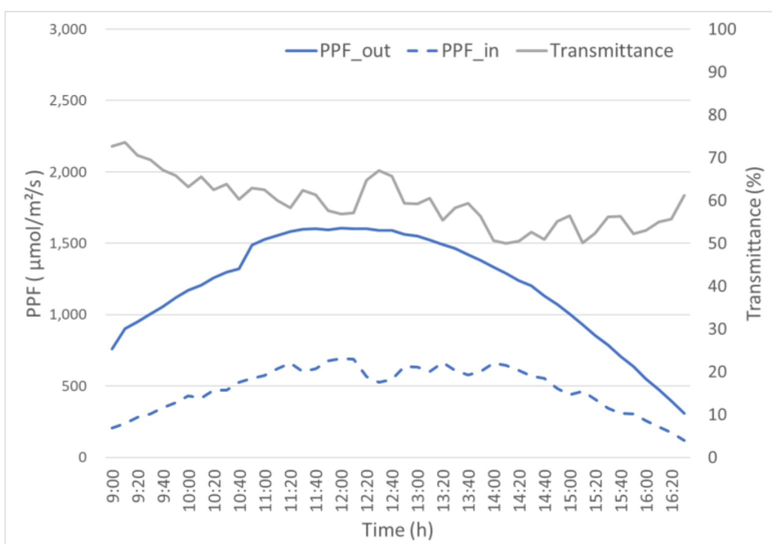

Figure 4. Transmittance of photosynthetic photon flux (PPF) in the test greenhouse.

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