(Form No. 13)

SUMMARY OF DOCTORAL THESIS

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Title: **Enhancement of lettuce growth by alternate current electro-degradation and green LED under recycled hydroponics**

（循環型養液栽培における交流式電気分解および緑色 LED によるレタスの生育促進）

In recycled hydroponics, allelochemicals accumulated in the culture solution inhibit plant growth due to autotoxicity. Alternating current electro-degradation (AC-ED) system successfully degraded benzoic acid (one of the principals allelochemicals in recycled hydroponics) after 24 hours at 551 and 940 Hz frequency with 50 and 80 % electrical duty. Lettuce seedlings fresh mass was negatively affected due to presence of benzoic acid in the solution where AC-ED was not applied. AC-ED was applied to non-renewed nutrient solutions (i.e., solutions remaining unchanged throughout the culture period) for detoxifying autotoxic allelochemicals. Lettuce plants were grown in solutions treated with AC-ED and nutrient management was performed based on the analysis of individual mineral nutrients remained in the culture solutions. Renewed solution (50% “Enshi” solution) was changed at 14-day intervals. There was no substantial difference in shoot fresh weight between renewed and AC-ED treated non-renewed solutions at different intervals and frequencies, but significantly, lower yield was recorded in non-renewed solution. In case of once-used non-renewed solution, thrice-weekly and continuous AC-ED application showed significantly higher yield compared to values for other solutions, and the lowest value was also found in non-renewed once-used culture solution. Therefore, it is recommended applying AC-ED to non-renewed solution either thrice weekly or continuously for efficient detoxification of accumulated allelochemicals to improve the growth, yield and quality of lettuce under two or more successive cultivations in recycled hydroponics.

Artificial grow light is one of the key requirements for successful crop cultivation in plant factory. Red and blue light-emitting diodes (LEDs) are widely used as light sources in plant factories. However, under only red and blue light plant leaves look purplish-gray which makes difficulty to check health status of plants by human naked eye. But the leaf color turns green when inspected under full spectrum of light environment. In this regard, the use of green light to red and blue create a white light environment which is congenial for the grower. Additionally, CO_2 assimilation of green light is usually lower compared to red and blue light because of its lower absorptance under low PPFD. But at higher PPFD (≥500 μmol $m^{-2}s^{-1}$), green light shows higher CO_2 assimilation rate compared to red and blue light through uniform distribution of full spectrum of light into the plant canopy and the lower leaves. In another study, optimal intensity of green light supplementation to the red and blue LEDs was evaluated for better growth, yield, and quality of lettuce. In experiment I and II, green light was added with red and blue light where total photosynthetic photon flux density (PPFD) was increased for the additional green light. In experiment III, 0, 10, 20, 30, 40, 50, 60, 70, 80 μmol m^{-2} s^{-1} green (G) light was supplemented to 235 μmol m^{-2} s^{-1} red (R) and 59 μmol m^{-2} s^{-1} blue (B) light maintaining 294 μmol m^{-2} s^{-1} total PPFD. Lettuce plants were cultivated hydroponically in three-step vertical grow beds using half-strength of Enshi nutrient solution. The temperature was maintained at 20±2 °C at day and night and the day length was 16 hours. In experiment I and II, the fresh mass of lettuce grown under the combination of R, B and G LEDs was found higher than those cultivated under R and B LEDs only. In experiment III, lettuce plants produced high fresh masses when 30 μmol m^{-2} s^{-1} of G light was supplemented with R and B lights maintaining the ratio 211:30:53 (R:G:B). By supplementing excessive G light (≥50 μmol m^{-2} s^{-1}) with R and B lights, lettuce shoot fresh mass declined. It is recommended to supplement 30 μmol m^{-2} s^{-1} of green light to red and blue light for a higher yield of lettuce. Therefore, the suitable LED (R:G:B) combination would be 72% of red, 10% of green and 18% of blue for lettuce cultivation in plant factories.