

(Form No. 14)

ABSTRACT 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)

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Lettuce growth and yield performances often reported to be declined under successive cultivation in recycled hydroponics. Allelochemicals accumulated in the culture solution inhibit plant growth due to autotoxicity. Contrarily, supplying optimum light is one of most key factors for production of crops in plant factory and release of growth inhibitors, a secondary metabolite linked to photosynthesis, might be influenced by light conditions. In this regard, mitigation of root exudates through electro-degradation and increasing photosynthetic efficiency through supplementation of green light with red and blue would improve lettuce yield. Firstly, efficacy of alternate current electro-degradation (AC-ED) was evaluated for recovering retarded growth and yield of lettuce under autotoxicity in recycled hydroponics. Then suitable red (R), green (G) and blue (B) LED (light emitting diodes) light was identified for successful lettuce production under recycled hydroponics. Lettuce plants were cultivated hydroponically in three-step vertical grow beds using half-strength of Enshi nutrient solution under controlled environmental conditions in plant factory. Results from the experiments revealed that, 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 and lettuce seedling fresh mass was negatively affected due to presence of benzoic acid in the solution. By continuous or thrice weekly application of AC-ED in non-renewed culture solution, lettuce growth and yield performance were recovered whereas the lowest was recorded in non-renewed. Results of the second study indicates that lettuce plants produced higher yield when $30 \mu\text{mol m}^{-2} \text{s}^{-1}$ of green light was supplemented from red and blue light under the total light energy ratio 211:30:53 (R:G:B) maintaining 72% of red, 10% of green and 18% of blue LED light. Supplementation of excessive green light ($\geq 50 \mu\text{mol m}^{-2} \text{s}^{-1}$) lettuce shoot fresh mass declined. Therefore, it is recommended to apply AC-ED to non-renewed solution either thrice weekly or continuously for efficient detoxification of accumulated allelochemicals to improve the growth and yield of lettuce under two or more successive cultivations in recycled hydroponics. It is also recommended to supplement maximum $30 \mu\text{mol m}^{-2} \text{s}^{-1}$ of green light to red and blue light for higher yield of lettuce.