Evaluation of Hyper-Thermophilic Aerobic Compost Produced from Sewage Sludge on Rice Yield

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学位論文題目 Evaluation of Hyper-Thermophilic Aerobic Compost Produced from Sewage Sludge on Rice Yield

（有機性汚泥由来高温好気発酵堆肥水稲栽培における最適施肥に関する比較解析）

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論 文 の 要 旨

Abstract of thesis

This study first evaluated the fertilizer potential of hyper-thermophilic aerobic compost (HTAC) produced from sewage sludge by a novel technology, hyper-thermophilic aerobic composting, and submerged plants *Ceratophyllum (C.) demersum* and *Egeria densa*. Sewage sludge contains large amount of nutrients that can be recovered and used for crop growth. hyper-thermophilic aerobic composting could produce organic fertilizer from sewage sludge during a shorter period. Compared with chemical fertilizer, HTAC contains not only mineralized nutrients, but also organic nutrients that can be slowly decomposed to release nutrients and simultaneously improve soil structure. However, there are no research reported the safety and quality of the compost produced through this process. Submerged plants are usually used to reduce water turbidity, remove excess nitrogen and phosphorus in lakes to avoid eutrophication. However, its character of fast growth also would threaten the ecological balance of lakes. If the large amount of submerged plants generated annually over the world could be treated properly, using it to solve eutrophication in lakes would become a more sustainable way.

Therefore, this study aimed to utilize biomass wastes as fertilizers to raise the crop yield and recycling nutrients resource appropriately. The fertilizer potentials of HTAC and the submerged plants were evaluated. Seed germination test using seeds of Komatsuna was conducted to evaluate the phytotoxicity of HTAC. Komatsuna cultivation using soilless culture was performed to evaluate the fertilizer quality of HTAC. The two years' rice growth experiment was conducted by applying HTAC to further elucidate the optimum fertilization amount, long-term application effect and environmental impact by applying HTAC on farmland. The fertilizer potential of submerged plants *C. demersum* and *Egeria densa* on rice growth and yield were evaluated by mixing with HTAC at different ratio with the same nitrogen content of 180 kg N ha^{-1}.

The dissertation is divided into 5 chapters.

In chapter 1, the author gave a literature review on current status of research on organic fertilizers. Then the objective and structure of the thesis was explained.

In chapter 2, the author conducted seed germination test to evaluate the phytotoxicity of HTAC by calculating germination index (GI) value. The liquid extract was diluted according to their electric conductivity (EC) value. Only EC 2.9 treatment was achieved GI higher than 80%. Thus, HTAC had no phytotoxicity when it was diluted by 20 times. Results also showed that EC 2.9 treatment had the longest stem length and highest germination rate, which proved that HTAC not only has no phytotoxicity, but also can improve the elongation of plant stem. However, the lengths of root in all HTAC treatment conditions were shorter

than that in distilled water treatment, which might be resulted from the high ammonium concentration in HTAC. Thus, more attention should be paid on ammonium toxicity when applying HTAC on farmland. Komatsuna cultivation by using HTAC was also conducted in a soilless culture. The characters of roots and leaves of cultivated Komatsuna were measured to indicate the fertilizer quality of HTAC. With the amount of fertilizer increasing, the length of root decreased, in consistent with the results in seed germination test. The results again indicated that ammonium nitrogen might limit the elongation of radicle. The fresh weight of stem and root in R3 (10.64 g L^{-1} HTAC) was significant higher than other treatments, thus the optimum dosage of HTAC for soilless cultivation of Komatsuna was 10.64 g L^{-1} in this study.

In chapter 3, the author studied the two years' field experiments to elucidate the optimum dosage and environmental impact of HTAC through 115 days' cultivation. This research first reported the effect of HTAC on rice growth and the surrounding environment. The results in first year (2016) indicated that HTAC can enhance the rice yield significantly. The relationship between rice yield and HTAC fertilization amount fitted the following quadratic equations: $y = -1.858\times10^{-5}x^2 + 0.017x + 2.667$ (R^2= 0.969). As the rice yield of R2 (Chem. 60) was 5.02 t ha^{-1}, the amount of HTAC which can achieve same rice yield with R2 calculated by this modified quadratic equation was 170.0 kg N ha^{-1}. According to the environmental quality standard values for water in lakes and marshes, the TN and TP in effluent water should be less than 1 mg L^{-1} and 0.1 mg L^{-1}. Before the summer drainage, the TP and TN concentration in R5 (HTAC 250) and R6 (HTAC 500) was higher than this standard. Thus when considering plant quality, rice yield and environmental friendliness, 180 kg N ha^{-1} (R4), which showed similar rice yield with that when chemical fertilizer applied, was deemed as the optimal fertilization amount of HTAC for rice growth. The N and P concentration in the surface water at this fertilization amount also can reach to environmental quality standard value before discharging the water. The long-term application effect of HTAC was further investigated by applying it for second year's field experiment. The similar results were obtained with that in first year experiment.

In chapter 4, the author studied the effect of mixture of HTAC and submerged plants *C. demersum* and *Egeria densa* with nitrogen content of 180 kg N ha^{-1} on rice growth and yield to evaluate the fertilizer potential of submerged plants. The stem height, tillers number and rice yields in test groups fertilized with the mixture of HTAC and submerged plants significantly increased compared with control (none fertilizer). On the other hand, the number of panicles in R7 (180 kg N ha^{-1} of *Egeria densa*), R8 (120 kg N ha^{-1} of *Egeria densa*, 60 kg N ha^{-1} of HTAC) and R9 (60 kg N ha^{-1} of *Egeria densa*, 120 kg N ha^{-1} of HTAC) was 14.75, 13.00, 14.50, respectively. In R8, especially low value was observed, and at the same period the plant height in R8 was higher than R7 and R9. Thus, when applying *C. demersum* with HTAC as organic fertilizer, it is necessary to optimize the mixing ratio with HTAC. According to the results, submerged Plants *C. demersum* and *Egeria densa* can enhance the rice yield significantly compared the none fertilizer treatment, and the results showed that the application of *C. demersum* and *Egeria densa* at different ratio had the same effects on rice yield as HTAC, so the submerged plants can be used as organic fertilizer.

In chapter 5, the results from chapters 2-4 were concisely concluded, and future researches were prospected.

審 査 の 要 旨

Abstract of assessment result

This research utilized HTAC and submerged plants *C. demersum* and *Egeria densa* as fertilizers to raise the crop yield and recycling nutrients resource appropriately. Seed germination test proved that HTAC not only had no phytotoxicity, but also can improve the elongation of plant stem. In the study of Komatsuna cultivation by using HTAC in a soilless culture, the optimum dosage of HTAC for soilless cultivation was confirmed. This research first reported the effect of HTAC on rice growth and the surrounding environment by the two years' field experiments through 115 days' cultivation. Considering plant quality, rice yield and environmental friendliness, 180 kg N ha^{-1} (R4), which showed similar rice yield with that when chemical fertilizer applied, was deemed as the optimal fertilization amount of HTAC for rice growth. Submerged plants *C. demersum* and *Egeria densa* can enhance the rice yield significantly compared with the none fertilizer treatment and had the same effects on rice yield as HTAC, so its can be used as organic fertilizer. Therefore, the data obtained from this thesis provide significant information on biomass utilization.

The final examination committee conducted a meeting as a final examination on 20th July, 2018. The applicant provided an overview of dissertation, addressed questions and comments raised during Q&A session. All of the committee members reached a final decision that the applicant has passed the final examination.

Therefore, the final examination committee approved that the applicant is qualified to be awarded the degree of Doctor of Philosophy in Environmental Studies.