氏　　名	Islam Mohammed Zahidul
学位の種類	博士（工学）
学位記番号	総博甲第１３０号
学位授与年月日	平成３０年９月２０日
学位授与の要件	学位規則第４条第１項
文部科学省報告番号	甲第６２９号
専　攻　名	総合理工学専攻
学位論文題目	Utilization of Untapped Wood Materials for the Next-Generation Sustainable Agriculture （未利用木質資源を用いた次世代持続型農業）
論文審査委員	主査　島根大学教授　吉原　浩 島根大学教授　汪　発武 島根大学教授　酒井　哲弥 島根大学准教授　加藤　定信

論文内容の要旨

Wood was the main source of energy for the world until the mid-1800s. Wood continues to be an important fuel in many countries, especially for cooking and heating in developing countries. It has been practiced for thousands of years for both fuel and as a building material. Recently, the new approach using a high C: N ratio organic material such as untapped wood materials was used to establish high-yield and sustainable agricultural production. Every year, a huge volume of wood waste is engendered in Japan; it is approximately 30 million m^3 in every year. This waste wood is excreted from several different sources, including municipal waste, forest waste, construction, demolition, deforestation, wood processing and manufacturing, pallets and wooden packaging, and any other way. Felicitous management of wood waste should be established as quickly as possible to use wood materials properly. The purpose of this study is to present new perspectives and strategies for efficient and effective use of wood wastes to enhance sustainable systems of agriculture.

Worldwide indiscriminate use of agro-chemicals boosts agricultural productivity since the green revolution of 1960s, with the cost of the environment and society. Therefore, the present day agriculture is challenged to fulfill with twin objectives of achieving food, fodder, fiber, and fuel security as well as sustainability with emphasis on restoring soil resources, improving water quality, mitigating climate change, and preserving soil and natural resources for long-term use. The scientific community all over the world is searching for an “economically viable, socially safe and environmentally sustainable” alternative to the poisonous agro-chemicals. Thus, it is important to find some ways and means to use the natural resources in a manner that does not pollute the environment and at the same time, provides energy and sustainability for plant production.

In this study, the method to recycle unused wood waste for addressing environmental problems, and ensure the efficient utilization of natural resources has been chosen for sustainable agriculture. Based on the characteristics and properties, wood has possibility to be used for sustainable agricultural production. Wood is fundamentally composed of cellulose, hemicelluloses, lignin, and extracts. The chemical composition of wood varies from species to species, but it is approximately 50% carbon, 42% oxygen, 6% hydrogen, 1% nitrogen, and 1% other elements (mainly calcium, potassium, sodium, magnesium, iron, and manganese) by weight. The new approach using a high C: N ratio organic material such as wood that supplies carbon sources exclusively to various fungi, which contribute to the formation of soil aggregation. The aggregate structures, which possess high air and water permeability and water holding capacity, provide essential functions for plants and microorganisms including fungal and bacterial symbionts, and consequently give fast plant growth and high productivity.

The loss of carbon from agricultural soil is a critical issue in conventional agriculture. Fertilizer input generally increases net primary production but does not increase soil carbon content. Thus, the major agricultural component was wood material (high C: N ratio). For experimental investigation, wood wastes, bamboo wastes, sugi chips, konara chips, biochar were applied as carbon sources. Small amounts of oil cake, rice bran, cut weeds as organic sources, and nameko, arbuscular mycorrhizal fungi (AMF), and gliocladium fungi (GF) as fungal sources were applied to vegetable production. Conventional agro-materials as nitrogen, phosphorus, or potassium fertilizer, pH control chemicals, or other agricultural chemicals were not used. The big advantage of great social and environmental significance of this method is that it can suppress or eradicate pests and diseases in crops without the application of any pesticides and fungicides. In these contexts, our experimental results revealed that combined application of sugi chips, konara chips, oil cake, rice bran, nameko, AMF, GF for cabbage production, wood wastes, bamboo wastes, cut weeds, AMF, GF for small green pepper production, and wood chip, biochar, leaf litter, rice bran for sweet corn production showed a significant difference in the plant's growth and yield, and soil minerals (N, P, K and Ca) as compared to plants grown in control. It was observed that application of wood materials to soil influenced the plant's growth and yield, and soil minerals positively but along with organic and fungal sources enhanced this effect significantly, this new approach is able to achieve higher productivity without adverse environmental impact and without the cultivation of more land, which is called sustainable intensification. Other notable significant results are that the vegetables (cabbage, small green pepper, sweet corn) grown in all treatments contained a very small amount of nitrate, high amount of potassium, calcium and sugar compared to conventional practice. These results can substantially contribute to the nutritional status of vegetables. Moreover, in these experiments, wood materials influenced the soil biodiversity and natural biological control significantly.

This study suggests that wood materials have a potential to be new agricultural sources for the next generation sustainable agriculture.

論文審査結果の要旨

現在，環境負荷低減のため，世界的に慣行農業から有機農業への転換が求められているが，現行有機農業による農作物の収量は慣行農業に及ばない。そこでイスラム氏は，有効利用法の開発

が急務となっている未利用木質資源を圃場に投入することにより，細菌類の増殖を抑制する担子菌類をコアマイクロバイオームとし，アーバスキュラー菌根菌等の植物共生生物が持続的にアグロエコシステムに存在可能な環境を構築することで，無化学肥料・無農薬で慣行農業を上回る農作物収量を実現するための研究を行った。

本研究は 3 章からなり，以下にその概要を示す。

1. キャベツの有機栽培における無堆肥化木材チップの施用効果

炭素資材としてスギチップ，コナラチップ，有機資材として少量の油かす，米ぬか，真菌資材としてナメコ菌，アーバスキュラー菌根菌，グリオクラディウム根圏菌を用い，6 種類の実験条件を設定した実験圃場でキャベツを栽培した。その結果，スギチップ，有機資材，真菌資材を組み合わせて投入した試験区におけるキャベツの収量は，無処理区の 5 倍であった。一方，土壌およびキャベツに含まれる硝酸態窒素濃度は，極めて低濃度であった。

2. 持続型農法により栽培されたシシトウの収量に及ぼすアーバスキュラー菌根菌およびグリオクラディウム根圏菌の効果

木質資源などの天然資源を用いた次世代持続型農業を行う際に，アーバスキュラー菌根菌およびグリオクラディウム根圏菌がシシトウの収量に及ぼす影響を調査した。廃木材および廃竹材を炭素資材，刈草を有機資材，アーバスキュラー菌根菌およびグリオクラディウム根圏菌を微生物資材として圃場に投入し，シシトウを栽培した結果，資材を全く投入しなかった無処理区のシシトウ収量の 400 倍の収量が得られた。また，微生物資材を投入しなかった処理区と比較して 4 倍の収量が得られた。本結果より，アーバスキュラー菌根菌およびグリオクラディウム根圏菌を微生物資材として使用することは，農薬および化学肥料を使用しない次世代持続型農業に極めて有効であることが明らかとなった。

3. 木材チップを用いた持続型農法により栽培されたスイートコーンの成長量と収量に及ぼすバイオ炭の効果

木材チップを用いた持続型農法により栽培されたスイートコーンの成長量と収量に及ぼすバイオ炭の効果を調査した。木炭粉，針葉樹チップ，アーバスキュラー菌根菌，グリオクラディウム根圏菌，および少量の米ぬかと落葉を用い，5 種類の実験条件を設定した実験圃場でスイートコーンを栽培した。その結果，木炭粉，針葉樹チップ，および少量の米ぬかと落葉を組み合わせて投入した試験区で，成長量，収量，および土壌元素量において，無処理区との間に有意な差が認められた。本研究結果より，木炭粉および針葉樹チップ等を用いた混合資材は，持続型農業資材として有効であることが明らかとなった。

以上の通り，本論文は優れた研究成果に基づきまとめられたものであり，学位授与の条件を満たしていると判断し，審査委員会全員一致で合格と判定した。