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Special Feature

Biomass × Carbon Recycling

Addressing Social Implementation Challenges to Accelerate Global Deployment

JIRCAS Japan International Research Center For Agricultural Sciences

In This Issue

Foreword

Special Feature

**Biomass × Carbon Recycling:
Addressing Social Implementation Challenges to Accelerate Global Deployment**

JIRCAS TODAY

【Research Highlights】

Breathing Value into Unused Biomass Resources: The Next Stage of Carbon Recycling

Across the world, vast amounts of biomass waste are generated every day in agriculture and food production. In tropical agriculture, particularly in Southeast Asia, rice straw after harvest, cassava pulp after starch extraction, oil palm pruned fronds, felled trunks (Photo 1), and residues from oil extraction are often left in plantations and in factories. These practices contribute to greenhouse gas (GHG) emissions and create breeding grounds for pests and diseases. In response, the Carbon Recycling Project has been working to develop technologies and promote social implementation that convert such unused resources into high-value products with minimal environmental burden, thereby linking them to sustainable industries.

The project has advanced multiple technological approaches to generate energy and materials from agricultural waste, utilizing microorganisms (both anaerobic and aerobic), algae, and other biological resources. Among these, microbial saccharification technology—which converts recalcitrant biomass into sugars and organic acids using only the power of microbes—has attracted significant attention as a cost-effective and flexible method for resource utilization. In recent years, additional functions have also been identified, including hydrogen production and plant growth promotion, expanding the potential applications to energy, fertilizers, and biomaterials.

At the same time, research has continued to broaden the scope of carbon recycling, including CO_2 fixation and resource utilization by algae, and the production of bioplastic feedstocks through methane-assimilating bacteria. The project has also engaged in scientific monitoring of GHG emissions at plantations and in evaluating the environmental benefits of residue utilization, thereby generating essential baseline information that supports policymaking and certification schemes.

The accumulation of these diverse achievements has paved the way for new international initiatives. Starting in FY2025, the “International Deployment of Next-Generation Biomass Upcycling Technologies” project, linked with the Cabinet Office’s BRIDGE program, has been launched, building on the technical maturity achieved so far. This new project will combine microbial saccharification with the multi-biomass treatment process established through the SATREPS program, to demonstrate an advanced upcycling model capable of handling a wide range of feedstocks, including liquid waste and diverse residues (Photo 2).

Untapped resources, when coupled with appropriate technologies and institutional frameworks, can be transformed into the foundation for regional energy, materials, and even new industries. As a bridge between research and social implementation, the Carbon Recycling Project will continue to strengthen international collaboration and provide pathways toward sustainable agriculture and a circular society.

Akihiko Kosugi
Project Leader

Photo 1. Oil palm trunks (OPT) awaiting processing at a plantation in Malaysia

Photo 2. Biomass pellets produced from empty fruit bunches (EFB) and oil palm trunks (OPT)

Green Energy through Enzyme-Free Microbial Saccharification Technology — Converting Waste into Resources —

Agricultural sites generate large amounts of cellulose-based biomass, such as rice straw and palm residues. Much of this biomass is not fully utilized and is incinerated or left unattended, contributing to greenhouse gas emissions and air pollution. Efficiently converting these into resources is one of the key issues for building sustainable agriculture and a recycling-oriented society.

In this project, we are working on developing a technology that directly saccharifies biomass using the microorganisms' own enzyme systems, without requiring external enzymes such as cellulases, which have been considered essential for cellulose decomposition (Photo 1). In conventional enzyme-added processes, enzyme costs account for 20–40% of the total cost, which has been a major barrier to commercialization. In contrast, the microbial saccharification method is innovative in that it eliminates the need to purchase and add enzymes, significantly reducing process costs. The resulting saccharified liquid can be used directly for methane, ethanol, and lactic acid fermentations, producing "green methane" that can be applied to city gas networks and power generation facilities. It is attracting attention both in Japan and overseas as a highly practical technology for directly converting agricultural residues into energy resources.

Photo 1. Microbial saccharification using untreated waste magazines. The microbes' own enzyme systems break down biomass, and the saccharified liquid can be directly used for methane fermentation.

Furthermore, some strains produce hydrogen as a byproduct during the saccharification process (Photo 2). Recirculating this hydrogen and carbon dioxide enables its use in "biomethanation," allowing for higher energy recovery efficiency compared to conventional methane fermentation. This is expected to further improve energy balance and greenhouse gas reduction effects. A system combining microbial saccharification and biomethanation represents a new approach for stable renewable energy supply.

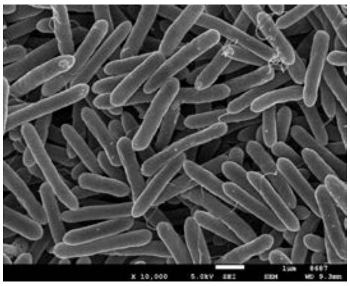


Photo 2. A saccharifying microorganism that efficiently breaks down brewer's spent grain. JIRCAS specializes in strain selection technologies to identify microbes suited to different types of biomass. This strain was also newly identified as a high hydrogen producer.

Some saccharification microorganisms have been confirmed to possess functions such as solubilizing phosphorus in soil or enhancing crop fertilizer absorption efficiency (Photo 3). Utilizing the residues as fertilizer materials could potentially reduce chemical fertilizer use and improve soil health. Preparations are currently underway for field-level demonstrations, aiming to establish a zero-emission resource circulation system that combines energy utilization with agricultural applications.

Through these efforts, this project aims to maximize the value of unused biomass from both energy utilization and fertilizer utilization perspectives. While enhancing the maturity of the technology, we will contribute to circular resource utilization with an eye toward field demonstrations and applications in related fields.

Ayaka Uke
Biological Resources and Post-harvest Division

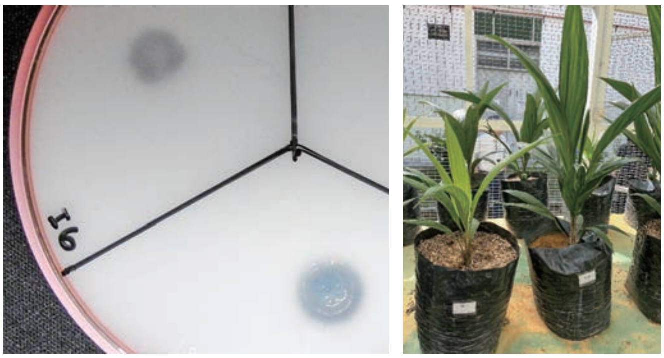


Photo 3. Some saccharifying microorganisms can solubilize soil phosphorus into plant-available forms (left: solubilization test on an insoluble phosphate plate showing halo formation; right: growth promotion test on oil palm seedlings with saccharifying microbes, indicating the potential of saccharified residues as biostimulant materials).

Bioprospecting of Microalgae with High CO_2 Absorption Capacity and Their Utilization as Biofuel

Plants absorb atmospheric CO_2 and release oxygen through photosynthesis, playing a crucial role in the global carbon cycle. Similarly, microscopic cyanobacteria and microalgae found in oceans and rivers also perform photosynthesis. Though invisible to the naked eye, their annual carbon fixation is estimated to be the same as that of terrestrial plants, making them essential to Earth's carbon cycle.

Cyanobacteria and microalgae are promising for climate change mitigation due to their rapid growth and high proliferation. Some species also accumulate lipids through photosynthesis, making them valuable for biofuel production (Figure 1).

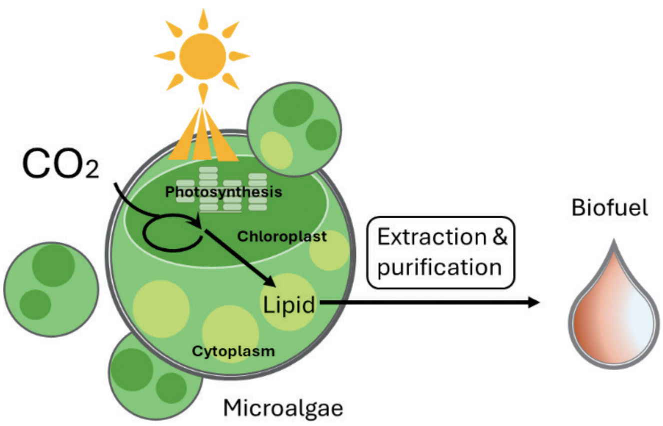


Figure 1. Biofuel production from CO_2 by microalgae

We are developing biofuel production technologies using microalgae, with the aim of effectively utilizing CO_2 emitted from agricultural waste and wastewater generated during food processing. We have focused on selecting algal strains that can efficiently absorb CO_2 under high-concentration conditions, rather than under normal atmospheric levels.

Water samples were collected from natural environments such as lakes and rivers, and the diverse microalgae present were repeatedly cultured under high CO_2 concentrations. As a result, several promising strains were discovered that not only surpass conventional biofuel-producing microalgae in CO_2 absorption capacity but also exhibit strong potential for producing biofuels and chemical feedstocks (Photo 1).

Among these promising strains, those demonstrating particularly high capabilities have shown elevated CO_2 absorption not only under artificial lighting in laboratory conditions but also in outdoor tanks. This indicates strong adaptability to outdoor environments, a key factor for practical application. Furthermore, physiological analysis revealed that these strains utilize CO_2 more efficiently and perform well even in low-light environments.

We are now working to enhance these strains further through mutation. In the future, microalgae-based CO_2 absorption and biofuel production technologies are expected to contribute to effective agricultural waste utilization, greenhouse gas reduction, and improved energy self-sufficiency.

Shimpei Aikawa
Biological Resources and Post-harvest Division

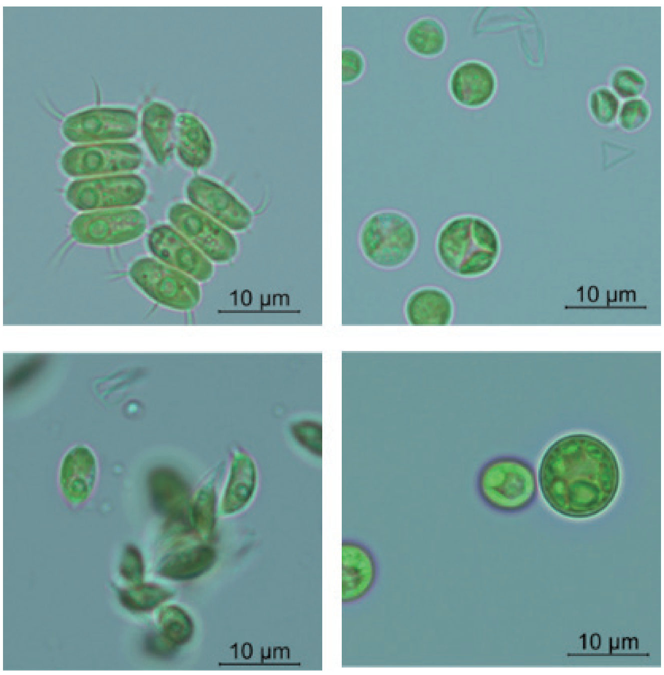


Photo 1. Promising microalgae strains

From C1 Gases to Bioplastics: Developing Sustainable Feedstock Production

Methane gas generated from agricultural waste causes environmental burdens as a greenhouse gas, but it is also a valuable carbon resource. While expectations for biodegradable bioplastics are growing, conventional feedstock production faces barriers such as competition with food resources and high production costs. In this research, we are working on developing innovative production technology for bioplastic raw materials utilizing methane gas derived from agricultural waste.

Methane gas (CH_4) is a representative example of C1 gas containing only one carbon atom, and its chemical conversion has been considered difficult due to the simplicity of its molecular structure. Conventional methane utilization technologies require high-temperature and high-pressure conditions, presenting challenges in efficiency and selectivity, and have not achieved economically viable practical application. Furthermore, since methane is gaseous and poorly soluble in water, it has been technically very difficult for microorganisms to efficiently uptake and utilize it. In biological approaches, in addition to constraints in mass transfer at the gas-liquid interface, the major bottleneck in material production by methanotrophic bacteria has been slow cultivation rates. However, recent research has made it possible to isolate fast-growing bacterial strains that use methane gas as a carbon source by devising cultivation conditions. Therefore, we have isolated new methanotrophic bacteria from soil and successfully isolated excellent strains with particularly high methane fixation ability through ingenious screening methods. By enhancing the methane fixation capacity of these microorganisms, we are advancing the development of technology to efficiently produce PHB (polyhydroxybutyrate), a bioplastic raw material.

Methanotrophic bacteria are useful microorganisms that obtain energy by oxidizing methane while accumulating surplus carbon as PHB within their cells. Electron microscopic observations have confirmed abundant white spherical PHB granules within the cells of the isolated strains, demonstrating their PHB production capability (Photo 1).

The core of this technology development lies in optimizing the cultivation conditions of the isolated methanotrophic bacteria and improving the conversion efficiency from methane to PHB production. While conventional chemical synthesis requires high-temperature and high-pressure conditions, this technology can directly utilize methane gas derived from agricultural waste as raw material under aerobic fermentation conditions, enabling significant reduction in energy consumption and environmental burden. Particularly noteworthy is the expectation of substantial reduction in raw material procurement costs by combining efficient methanotrophic bacteria with biogas derived from oil palm waste wood, which is discharged in large quantities in tropical regions such as Southeast Asia and Africa. By fermenting the organic components contained in the sap extracted from oil palm trunks, biogas with methane as its main component can be efficiently produced. This process enables the effective utilization of locally abundant waste resources and is expected to significantly reduce raw material procurement costs. Additionally, through effective utilization of agricultural waste, this technology contributes to solving environmental problems related to waste disposal and provides a technological foundation for realizing a circular economy.

Through this research, the foundation for technology to efficiently produce bioplastic raw materials from agricultural waste-derived methane gas has been established (Figure 1). Moving forward toward practical application, further optimization of the fermentation process is necessary. We are confident that the widespread adoption of this technology in the future will enable the utilization of agricultural waste as an untapped resource for industrial raw materials, contributing to the construction of a sustainable circular society.

Takamitsu Arai
Biological Resources and Post-harvest Division

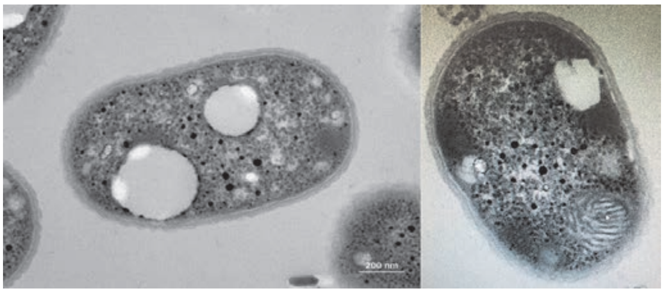


Photo 1. Methane-oxidizing bacteria producing PHB newly isolated from soil

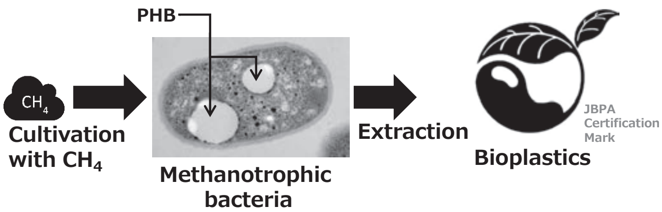


Figure 1. Development of bioplastic production technology from methane

Climate Impact of Agricultural Residue Retention

— GHG Observations at Oil Palm Plantations toward the Social Implementation of Carbon Recycling Technology —

Palm oil, extracted from palm fruit bunches produced on oil palm plantations in Southeast Asia, is the most widely produced and consumed vegetable oil in the world. It is used in approximately 50% of the products found in supermarkets, including not only food products such as instant noodles and frozen foods, but also daily necessities such as detergents and cosmetics, including lipstick, making it an irreplaceable and important agricultural product in our daily lives.

On the other hand, oil palm, a plant native to Africa, is suitable for cultivation in tropical regions around the equator. The global surge in demand for palm oil, driven by factors such as population growth, has led to the conversion of Southeast Asia's tropical rainforests and peat swamp forests, which nurture diverse wildlife and possess high CO_2 fixation capacity, into monoculture oil palm plantations. This has caused various global environmental issues, including biodiversity loss and the disappearance of CO_2 sinks.

The environmental issues arising from the development of oil palm plantations have been addressed to some extent through the introduction of international palm oil certification systems aimed at promoting sustainable production, purchase, financing, and use of palm oil. However, many issues remain unresolved due to the lack of standardized certification criteria, and one of the most prominent of these is the abandonment of biomass residues within plantations.

In oil palm plantations, large leaves pruned during fruit harvesting, empty fruit bunches generated during oil extraction, and tree trunks cut down during reforestation create a massive amount of biomass residues that are left uncollected within the plantation (Photo 1). While these biomass residues are valuable resources that can be utilized as fuel or fertilizer, they can also cause various environmental issues when left uncollected within the plantation.

One such environmental issue is greenhouse gas (GHG) emissions. In collaboration with local research institutions, we conducted observations of GHGs using an automatic multi-channel chamber system. The results revealed that (1) felled oil palm trunks and large pruned leaves were decomposed by termites inhabiting the plantation, (2) the decomposition by intestinal bacteria of termites resulted in the production of CH_4, which has approximately 30 times the greenhouse effect of CO_2, and (3) the amount of CH_4 produced significantly exceeded the amount that the soil can absorb and decompose. In other words, it has become clear that leaving biomass residues within oil palm plantations transformed them into methane gas sources through the decomposition of biomass residues by termites (Photo 2).

These issues are challenges that must be addressed not only by producing countries but also by the international community, including consuming countries. JIRCAS is working to reduce GHG emissions from oil palm plantations and achieve sustainable oil palm plantation management by monitoring the amount of GHGs generated from the accumulation of agricultural residues on farms and developing carbon recycling technologies for the effective utilization of agricultural residues.

Toshiaki Kondo
Biological Resources and Post-harvest Division

Photo 1. Biomass residues left in an oil palm plantation. Oil palm trunks cut down for replanting (left), large leaves pruned during fruit harvesting, and empty fruit bunches generated during oil extraction (right)

Photo 2. Automatic multi-channel chamber system installed in an oil palm plantation in Malaysia with the cooperation of the National Institute for Environmental Studies. Warming experiments that simulate future climate change are also conducted (center).

Exploring Oil Palm Trunks as "Sugar Reservoirs": Carbohydrate Dynamics in Trunks and Their Environmental Responses

In Southeast Asian oil palm plantations, large numbers of oil palm trunks (OPT) are generated during replanting. Although OPT has great potential as an underutilized biomass resource, the mechanisms governing when, where, and how much non-structural carbohydrates—such as sugars and starch—are accumulated within the trunk remain poorly understood. In this study, we aim to clarify the relationships between environmental conditions and trunk carbohydrate dynamics, with the ultimate goal of proposing harvesting (replanting) strategies that maximize carbohydrate content, particularly starch, in the trunk.

A key feature of this research is its focus on Indonesia, the world's largest producer of oil palm, where we selected two study sites with contrasting environmental conditions (for example, the presence or absence of a pronounced dry season). By examining how regional differences affect carbohydrate accumulation patterns at the gene expression level, we seek to provide pathways for OPT utilization that are tailored to local environmental conditions across Indonesia's diverse landscapes.

At the field sites, core samples are collected from the lower part of the trunk beneath the fronds using ladders (Photo 1), and data are accumulated over time. Part of each core sample is preserved in RNA stabilization solution for gene expression analysis (RNA-seq), while the remaining portion is frozen for starch and sugar concentration analyses. This experimental design allows us to directly link molecular-level information (gene expression) with quantitative measurements of carbohydrates (sugars and starch).

From these datasets, important insights into trunk carbohydrate dynamics have begun to emerge. For example, seasonal patterns—periodic increases—have been observed in trunk starch content at certain sites, whereas such seasonality appears less evident for soluble sugars. These results suggest that starch may function as a relatively stable "sink" within the trunk. In addition, decreases in trunk starch content tend to coincide with increases in fruit production, indicating that fruit yield could potentially serve as a practical indicator for identifying optimal harvesting times that maximize trunk starch content (for example, approximately three months before peak fruit production).

In addition, during the course of time-series observations, we found that temporary flooding caused by short-term heavy rainfall (Photo 2) led to pronounced changes in gene expression patterns in trunk tissues. In particular, genes associated with hypoxia responses and ethylene signaling showed marked changes, suggesting that the trunk is highly sensitive to flooding stress. In contrast, similar changes were relatively limited in leaves, highlighting organ-specific differences in environmental responses.

Although the investigation of flooding responses emerged as a derivative theme from the original focus on starch accumulation mechanisms, flooding represents a realistic risk in oil palm plantations under climate change, where extreme rainfall events are expected to increase. Flooding may alter the physiological state of the trunk and thereby influence carbohydrate dynamics, including both soluble sugars and starch. From the perspective of resource utilization, flooding thus represents an important factor that could affect the value of OPT biomass.

Going forward, we will integrate gene expression data obtained during flooding events with concurrent measurements of sugar and starch concentrations to evaluate how flooding stress influences the balance between carbohydrate accumulation and degradation. Through this approach, we aim to refine indicators for identifying harvest timings that maximize resource value, while also contributing to the development of management guidelines for plantations located in flood-prone areas.

Naoki Tani
Forestry Division

Photo 1. Sampling stem core using a ladder and increment borer.

Photo 2. Oil palms exposed to waterlogged conditions.

Turning Waste into Wealth: Japan's Biomass Innovation for a Sustainable Future

Palm oil is an essential part of our daily lives. Used in margarine, soap, and as frying oil for products like instant noodles and potato chips, it is deeply embedded in our lifestyle. Nearly all the palm oil consumed in Japan is imported from Southeast Asia. However, behind its production lies a lesser-known issue: a large volume of unused biomass—such as leaves, trunks, and oil extraction residues—is left unutilized, contributing to environmental degradation.

In palm oil mills and plantations, the production process generates massive amounts of waste, including palm shells, fruit bunches, trunks, leaves, and wastewater. The total volume of this biomass is more than four times the weight of the oil produced. Currently, most of the biomass remains unutilized due to the lack of direct applications and the high cost of processing (Photo 1). As a result, it is often left to decay, leading to greenhouse gas emissions, water pollution, and reduced agricultural productivity. Ignoring this situation not only wastes potentially valuable resources but also threatens the sustainability of palm oil production in Southeast Asia, which supports our daily lives.

Photo 1. A vast quantity of unutilized palm biomass left scattered across palm plantation and oil mill.

To address this challenge, we have launched a new international project in collaboration with domestic and local partners. Our goal is to transform unutilized palm biomass into valuable resources. This project leverages two core technologies of JIRCAS: "Multi-Biomass Treatment Process" and "Microbial Saccharification." Together, these form the foundation of our "Next-Generation Biomass Upcycling Technology," aimed at efficiently producing sustainable energy and materials.

The multi-biomass treatment process enables the low-cost production of high-value pellets that can be used as fuel or in furniture and construction materials from various types of biomass generated during palm oil production using a single system. In addition, the microbial saccharification technology (see "Green Energy through Enzyme-Free Microbial Saccharification Technology," page 4) converts biomass contained in wastewater into soluble sugars, which are then used to produce biomethane.

By transforming unutilized biomass into high-value energy and green materials, we are not only reducing environmental burdens but also nurturing the seeds of new industries. The emergence of these industries is expected to drive a sustainable cycle of biomass utilization, contributing to stable supplies of food and energy (Figure 1). Small-scale demonstrations have already begun on-site, and we plan to further advance the dissemination and commercialization of these technologies through collaboration with private companies.

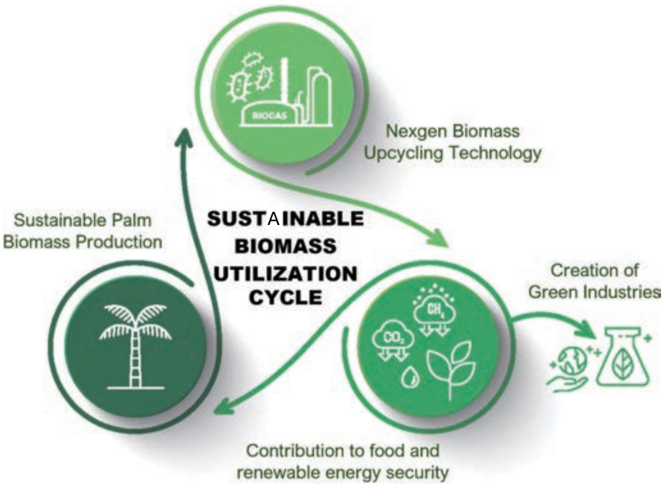


Figure 1. Our vision for a sustainable resource cycle through advanced biomass upcycling

Although this project is still in its early stages and faces technical challenges, it holds great potential for revitalizing local economies and proposing a model for international technology deployment. We aim to contribute to a future that is beneficial to both the planet and our way of life, through the development of systems—led by Japan—that transform discarded biomass into valuable resources.

Satoru Muranaka
Information and Public Relations Office

From Research to Business: Building Resource Circulation with Local Communities and Industry

Across the world, agriculture and food production generate vast amounts of unused biomass every day. In Southeast Asia, oil palm plantations and oil mills produce large volumes of pruned fronds, felled trunks, empty fruit bunches (EFB), and wastewater. Much of this biomass is left untreated in plantations, leading to greenhouse gas (GHG) emissions, water pollution, and other challenges to sustainable production. To make effective use of these resources, technology development alone is not enough; it is essential to establish pathways for social implementation that actively involve local communities and private companies.

Theme 3 of the A2 Carbon Recycling Project has focused on building such pathways, advancing international demonstrations as well as outreach and dissemination in Japan and abroad (Photo 1). This effort has been supported by two major technical achievements. The first is the Multi-Biomass Treatment Process developed under the SATREPS Palm Trunk project, which can convert diverse solid residues such as oil palm trunks (OPT) and EFB into high-value pellets within a single process. The second is Microbial Saccharification Technology, newly established under A2, which converts wastewater and fibrous residues into sugars and organic acids using the power of microbes—without the need for expensive enzymes (see page 4). These products can then be used to produce biomethane and other applications in energy, fertilizer, and materials.

At demonstration facilities built in Malaysia and Thailand, the project has evaluated both the economic feasibility and the environmental benefits of these technologies, while also engaging in discussions with local companies and government agencies to build consensus for practical adoption. The evaluations showed potential for reducing waste treatment costs and lowering energy expenses through fuel self-sufficiency, which increased local interest in implementation. Moreover, pellets produced by the Multi-Biomass Treatment Process have already been adopted by Panasonic for use in furniture materials (Photo 2)—an emblematic achievement showing how on-site innovations can be transformed into commercial products by international companies.

In Japan, the project has presented its achievements at environmental and energy exhibitions and international conferences, expanding networks with a wide range of companies and startups. In particular, the JIRCAS spin-off company JIRCAS Dream Biomass Solutions, Inc. (JDBS) has become an important partner in advancing the commercialization of these technologies. Microbial saccharification also holds great potential for future applications and business development, with growing interest across related sectors.

For social implementation, it is crucial to build sustainable models that balance economic viability, environmental performance, and regional needs. Theme 3 has worked toward this goal through diverse activities, including developing tailored technology packages for local contexts, building partnerships with companies and municipalities, and disseminating information through international exhibitions (Photo 3).

These efforts are carried forward into the “International Deployment of Next-Generation Biomass Upcycling Technologies” project linked with the Cabinet Office’s BRIDGE program, starting in FY2025. In the project, Microbial Saccharification and the Multi-Biomass Treatment Process will be integrated into an advanced upcycling model, to be demonstrated locally in collaboration with companies and government agencies, aiming to establish sustainable resource circulation as a viable business.

The challenge of transforming unused biomass into assets for a circular society is already underway. By linking technologies, industries, and on-the-ground expertise, we will create pathways toward internationally sustainable models that generate a positive cycle between the environment and the economy.

Akihiko Kosugi
Project Leader

Photo 1. Demonstration site of the Multi-Biomass Treatment Process under the SATREPS project. This facility served as a hub for developing technology to convert diverse biomass into high-quality pellets, which were supplied to research institutes and companies in both Japan and Malaysia for application studies.

Photo 2. Image featured on the PALM LOOP special website (top page) of Panasonic Housing Solutions Co., Ltd. The pellets produced through the Multi-Biomass Treatment Process are used in PALM LOOP, a sustainable material made from OPT that serves as an alternative to wood for furniture and building materials.

Photo 3. Project briefing at the demonstration plant in Malaysia during a visit by Malaysian government agencies (2024)

JIRCAS TODAY

【Research Highlights】

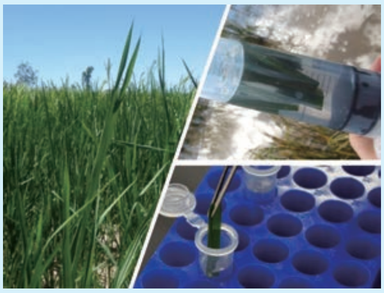
Cryogen-Free RNA Preservation Method Enables Stable Gene Expression Analysis of Field-Grown Plants
—Supporting Crop Development in Developing Regions—

JIRCAS has developed a novel method for analyzing gene expression in plants without the use of cryogenic agents such as liquid nitrogen, which are often difficult to obtain in developing regions.

The newly developed infiltration method enables stable preservation of RNA in plant leaf tissues without freezing, by infiltrating a nucleic acid stabilization solution into the intercellular spaces of leaf cells.

Using this method, JIRCAS successfully analyzed gene expression in rice leaves grown in paddy fields in Madagascar, Africa, and identified the causes of poor plant growth. In addition, a technique was developed to bind extracted RNA to a silica membrane, allowing for stable transport without freezing. These advancements suggest that genomics analysis can now be conducted in developing regions.

The outcomes of this study are expected to greatly accelerate crop development by enabling a better understanding of molecular physiological responses in plants under field conditions in developing regions, and by facilitating the analysis of mechanisms involved in responses to stresses such as nutrient deficiencies and diseases.



The results of this research have been published in the electronic version of *Plant Methods* (December 19, 2024 JST)

Development of Deep-Planting Cultivation Technology for Sustainable Sugarcane Production
—Demonstrating Effectiveness in Thailand and the Philippines Toward Practical Implementation—

JIRCAS, in joint research with Yanmar Agribusiness Co., Ltd. and DM Mitsui Sugar Co., Ltd. in Thailand, has developed a deep-planting cultivation technique that increases both the yield and the number of harvests in ratoon cropping of sugarcane[1] in the drought-prone northeastern region of Thailand.

In conventional sugarcane cultivation, seed canes[2] are typically planted at a shallow depth of about 10–20 cm from the soil surface. In contrast, the deep-planting method involves planting seed canes at a depth of approximately 30 cm. This method results in deeper emergence of shoots from underground stubble after harvest, which tends to produce slightly longer stalks and thicker stalk diameters.

This technique is expected to (1) increase yields in both plant crops[3] and ratoon crops, (2) increase the number of ratoon harvests by suppressing stubble exposure, (3) improve resistance to lodging and drought, and (4) reduce the occurrence of missing plants — areas where no cane grows despite planting — by preventing stubble from being uprooted during mechanical harvesting.

This technique was developed for sugarcane production in northeastern Thailand, but it is also applicable to the Philippines. It is expected to be widely adopted as a technology that can simultaneously improve productivity and reduce environmental impact in sugarcane production across the Asian monsoon region.

Notes:

[1]Ratoon cropping: A cultivation method in which sugarcane regrows from stubble left in the ground after the first-year harvest, allowing for subsequent harvests.

[2]Seed cane: A section of sugarcane stalk used to propagate new plants.

[3]Plant cane cultivation: The practice of planting seed cane in a field to grow and harvest new sugarcane stalks.

JIRCAS TODAY

【Research Highlights】

Soil Carbon Sequestration Effects Revealed from Over 45 Years of Long-Term Field Experiments —Contributing to Both Reduced Environmental Impact and Improved Soil Fertility in Tropical Regions—

JIRCAS, in collaboration with the Department of Agriculture of Thailand, analyzed long-term field trial data spanning over 45 years on the application of chemical fertilizers and organic materials to farmland. The analysis revealed that combining chemical fertilizers with organic materials is effective in increasing soil carbon storage in upland fields.

Using data from long-term field trials conducted for over 45 years at three sites in Thailand, targeting tropical upland crops such as cassava, the research team quantitatively demonstrated the impact of farmland management practices on soil carbon sequestration. The results showed that the combined application of chemical fertilizers and organic materials (such as crop residues and compost) significantly increases soil carbon storage.

These research findings are expected to contribute greatly to the development of tropical soil carbon dynamics models and to the establishment of sustainable agriculture that balances environmental impact reduction with improved soil fertility.

The results of this research have been published in the electronic version of *Land Degradation & Development* (October 3, 2024 JST)

Assessing the Environmental and Economic Benefits of BNI-Enhanced Sorghum —Co-Benefits Expected for Farmers, the Environment, and Government in India—

JIRCAS, in collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), has demonstrated that the introduction of sorghum with enhanced biological nitrification inhibition (BNI) capacity has the potential to simultaneously reduce environmental impact and improve farmers' profits.

Based on farmer surveys and evaluations using the life cycle assessment (LCA) method conducted in Maharashtra, India, it was found that reducing nitrogen fertilizer application while maintaining yield led to decreases in greenhouse gas (GHG) emissions and government fertilizer subsidy expenditures, along with a slight increase in farmers' profits. Even when fertilizer application was maintained to maximize yield, reductions in emissions and increases in profits were still observed.

These findings indicate that the introduction of BNI-enhanced sorghum can reduce nitrogen fertilizer use, GHG emissions, and government subsidy costs, while also improving farmers' income.

Reducing nitrogen fertilizer application in high-use regions, and maintaining current levels in low-use regions while introducing BNI sorghum, is expected to contribute to the development of sustainable agricultural systems.

The results of this research have been published in the electronic version of *Science of the Total Environment* (November 11, 2024 JST)

JIRCAS Mail Magazine (English) Registration Guidance

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