



**Green Asia**

Strategy for Sustainable Food Systems, MIDORI  
Technology Catalog for the Asia-Monsoon Region

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# **Technology Catalog Contributing to Production Potential and Sustainability in the Asia-Monsoon Region**

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**Ver. 2.0**

The International Center for Strategy "MIDORI" (2023), *Technology Catalog Contributing to Production Potential and Sustainability in the Asia-Monsoon Region*, Ver. 2.0, Japan International Research Center for Agricultural Sciences

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## Preface

In May 2021, Japan formulated the Strategy for Sustainable Food Systems, "MIDORI", which aims to enhance agricultural productivity potential and sustainability through innovation as a new approach for sustainable food systems. Among the technologies developed to transform the food systems in Japan, there are technologies applicable to the Asia-Monsoon region, where we share similar features such as high temperature and humidity, paddy-rice based agriculture, and a high proportion of small and medium-sized farmers.

To accelerate testing and disseminating technologies applicable to the region, the Ministry of Agriculture, Forestry and Fisheries (MAFF) assigned the Japan International Research Center for Agricultural Sciences (JIRCAS) to conduct the project "Accelerating application of agricultural technologies which enhance production potentials and ensure sustainable food systems in the Asia-Monsoon region" from 2022. It is currently being implemented at JIRCAS under the project name of "Green Asia".

As part of the activities of Green Asia and in cooperation with other research institutes concerned, we have developed the "Technology Catalog Contributing to Production Potential and Sustainability in the Asia-Monsoon Region", a compilation of applicable technologies which were developed in Japan or through international collaboration over the past 10 years and are expected to contribute to the establishment of sustainable food systems in the region.

We hope that this catalog will serve as a reference to various stakeholders in the Asia-Monsoon region, including government officials, researchers, extension officers, producers, and the private sectors. We also hope that the technologies in this catalog will be demonstrated and implemented on the ground through optimization and coordination in various regions, thereby helping in transformation of the food systems among countries in the Asia-Monsoon region.

# About the Contents of Technology Catalog

The configuration of this catalog is as follows.

Title indicating the name and potential use of the technology

Area of contribution to the sustainable food systems

Agriculture, Forestry and Fisheries Technology Catalog for the Asia-Monsoon region

## Greenhouse gas emission reduction technology with the combination of biogas effluent application and multiple drainage in a rice paddy

Production

Demonstration

Item: Paddy rice

GHG emission reduction

**Outline**

This technology, which combines biogas effluent application and multiple drainage, can reduce the emission of greenhouse gases (GHGs) including methane (CH<sub>4</sub>), and the usage of synthetic fertilizer in rice paddy fields without yield loss when compared with the local conventional practice in which the effluent is unutilized and discharged into rivers.

**Background/effect/note**

This technology, which combines cattle biogas effluent (used as a fertilizer) and multiple drainage practices, can reduce 1) GHG emission and synthetic fertilizer usage in rice paddy fields and 2) environmental pollution associated with the discharge of untreated biogas effluent into rivers. In a triple-rice cropping system in the Mekong Delta, Vietnam, this technology using the multiple drainage practices, i.e., alternate wetting and drying (AWD; a water-depth-dependent irrigation) or midseason drainage followed by intermittent irrigation (MiDi; a day-number-dependent irrigation) (Fig. 1) reduced CH<sub>4</sub> emission by 11%–13% and nitrous oxide (N<sub>2</sub>O) emission by 35%–54% without yield loss (Fig. 2). The proposed technology can be applied to the rice-producing areas using livestock biogas effluent as fertilizer.

AWD and MiDi are water management practices that save water by repeatedly flooding and draining water in paddy fields and reduce CH<sub>4</sub> emission by increasing oxygen concentration in the soil.

**Conventional**

Biogas effluent  
Discharge to rivers

Rice cultivation  
NPK  
Synthetic fertilizer  
Continuous flooding

**Proposed**

Biogas effluent  
Usage

Rice cultivation  
NPK  
Biogas effluent  
Multiple drainage

Fig. 1. The technology proposes to reduce greenhouse gas emission from rice paddy fields without yield loss

Ratio to conventional practice (%)

Metric	Effluent+AWD (%)	Effluent+MiDi (%)
Grain yield	100	100
Straw yield	100	100
Methane	~85	~85
Nitrous oxide	~65	~45
GWP	~85	~85
Yield-scaled GWP	~85	~85

Fig. 2. Comparative analysis of the performance of the proposed combination technology and the conventional practice  
GWP: CO<sub>2</sub>-equivalent of combined CH<sub>4</sub> and N<sub>2</sub>O emissions

**Technical details:**  
[https://www.jircas.go.jp/en/publication/research\\_results/2021\\_a01](https://www.jircas.go.jp/en/publication/research_results/2021_a01)  
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Japan International Research Center for Agricultural Sciences **JIRCAS**

Target process within the supply chain (Production, Input, Processing and Distribution, or Consumption) for utilization of the technology

Present status of achievement in the development of the technology (Demonstration or Implementation)

Target crops or product

Link for details on the technology and information on institute(s) involved in the research.  
Contact e-mail address for inquiry about technology.

Representative institute in Japan involved in the development of the technology

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# “Prolonged midseason drainage” in paddy fields for maintaining agricultural production and decreasing greenhouse gas emissions

Production

Implementation

Item: Paddy rice

GHG emission reduction

## Outline

Prolonging midseason drainage\* (Fig. 1) of paddy fields by a week longer than usual reduces methane (CH<sub>4</sub>) emissions by approximately 30% on average without negatively impacting rice yield and quality.

\*Midseason drainage around the peak of the rice tillering stage generally for 1-2 weeks to improve rice yield and quality.

## Background/effect/note

Methane is a greenhouse gas with the second-largest impact on global warming after carbon dioxide. Methane emissions from paddy soils account for approximately 10% of the global anthropogenic methane emissions. Thus, the reduction of methane emissions is an urgent issue.

The effect of reducing methane emissions from paddy fields by prolonging the midseason drainage period was verified with the cooperation of the agricultural experimental institutes in the eight prefectures at nine locations nationwide in Japan (Fig. 2). Prolonging the midseason drainage by one week reduced average methane emissions from paddy fields by approximately 30% without impacting the yield and protein content of rice (Fig. 3).

Note: As the amount of cadmium absorbed by rice plants may increase in areas with high concentrations of cadmium in the paddy soil, this method is not recommended for such areas. For arsenic in the paddy soil, prolonging mid-season drainage is expected to decrease the absorption of arsenic by rice.



Fig. 1. Paddy field under midseason drainage

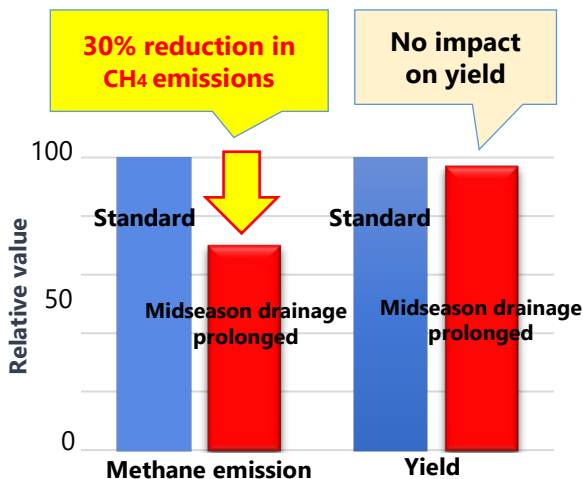


Fig. 3. CH<sub>4</sub> emissions and impacts on rice yield

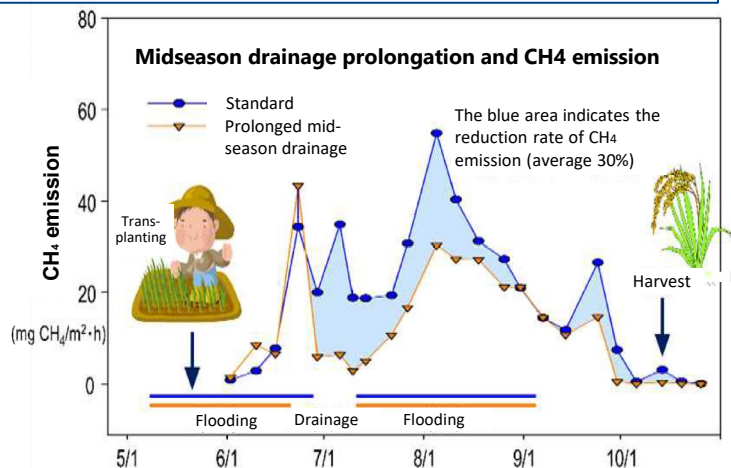


Fig. 2. CH<sub>4</sub> emissions and the effect of prolonged midseason drainage in Fukushima prefecture (example)

### Technical Details:



[https://www.naro.affrc.go.jp/archive/niases/sinfo/result/result29/result29\\_02.html](https://www.naro.affrc.go.jp/archive/niases/sinfo/result/result29/result29_02.html) (Japanese)  
[https://www.naro.go.jp/english/laboratory/niases/files/fftc-marco\\_book2019\\_107.pdf](https://www.naro.go.jp/english/laboratory/niases/files/fftc-marco_book2019_107.pdf) (English)

### Contact

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National Agriculture and Food Research Organization



# Greenhouse gas emission reduction technology with the combination of biogas effluent application and multiple drainage in a rice paddy

Production

Demonstration

Item: Paddy rice

GHG emission reduction

## Outline

This technology, which combines biogas effluent application and multiple drainage, can reduce the emission of greenhouse gases (GHGs) including methane ( $\text{CH}_4$ ), and the usage of synthetic fertilizer in rice paddy fields without yield loss when compared with the local conventional practice in which the effluent is unutilized and discharged into rivers.

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This technology, which combines cattle biogas effluent (used as a fertilizer) and multiple drainage practices, can reduce 1) GHG emission and synthetic fertilizer usage in rice paddy fields and 2) environmental pollution associated with the discharge of untreated biogas effluent into rivers. In a triple-rice cropping system in the Mekong Delta, Vietnam, this technology using the multiple drainage practices, i.e., alternate wetting and drying (AWD; a water-depth-dependent irrigation) or midseason drainage followed by intermittent irrigation (MiDi; a day-number-dependent irrigation) (Fig. 1) reduced  $\text{CH}_4$  emission by 11%–13% and nitrous oxide ( $\text{N}_2\text{O}$ ) emission by 35%–54% without yield loss (Fig. 2). The proposed technology can be applied to the rice-producing areas using livestock biogas effluent as fertilizer.

AWD and MiDi are water management practices that save water by repeatedly flooding and draining water in paddy fields and reduce  $\text{CH}_4$  emission by increasing oxygen concentration in the soil.

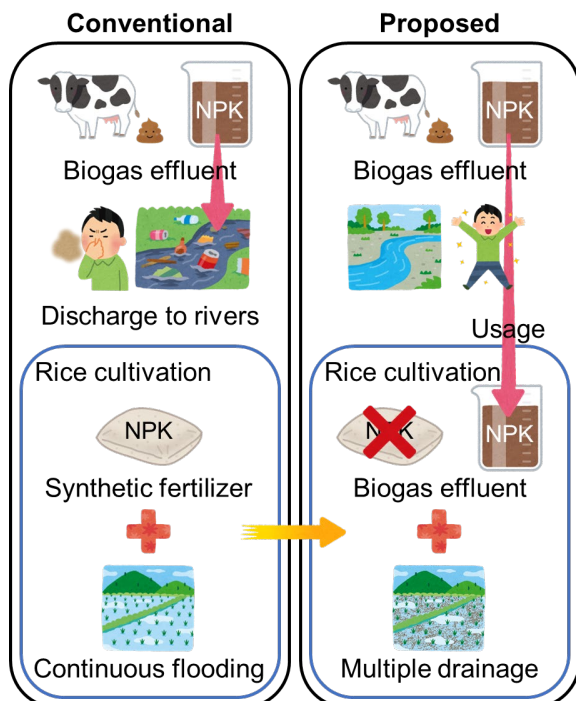


Fig. 1. The technology proposes to reduce greenhouse gas emission from rice paddy fields without yield loss

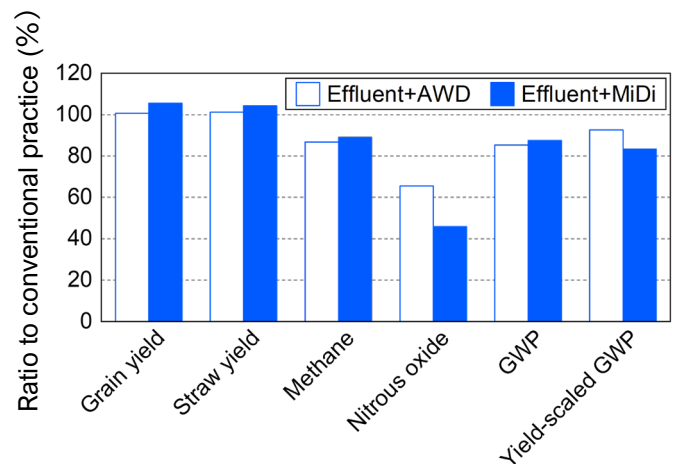


Fig. 2. Comparative analysis of the performance of the proposed combination technology and the conventional practice  
GWP:  $\text{CO}_2$ -equivalent of combined  $\text{CH}_4$  and  $\text{N}_2\text{O}$  emissions



Technical details:

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# A method to estimate the reduction in life cycle greenhouse gas emissions from rice cultivation caused by the use of alternate wetting and drying

Production

Demonstration

Item: Paddy rice

GHG emission reduction

## Outline

A life cycle assessment (LCA) method was developed to estimate greenhouse gas (GHG) emissions from farmers during the life cycle<sup>‡</sup> of rice cultivation using alternate wetting and drying (AWD).

<sup>‡</sup>life cycle: The developed method includes every stage from the production of material and machinery for rice cultivation to harvesting/rice straw management.

## Background/effect/note

Alternate wetting and drying (AWD) saves water and mitigates GHG emissions from paddy field when compared with continuous flooding. In AWD, paddy soil is repeatedly re-flooded after several days of drying (Fig. 1). The LCA method that we developed calculates the life cycle greenhouse gas (LC-GHG) emission by summing up emissions from agricultural material production to rice cultivation stages (Fig. 2). This method allows the evaluation of the impact of AWD, considering potential trade-offs (e.g. decrease in soil CH<sub>4</sub> emissions and increase in N<sub>2</sub>O emissions). Additionally, this method can be used in the Asian-Monsoon region for policy-making and further dissemination of AWD. For example, estimations from the LCA method indicated AWD reduces LC-GHG emission by 41% (Fig. 3). However, this method partly used Intergovernmental Panel on Climate Change (IPCC) guidelines that enable easy calculation but does not reflect country or site differences. The use of field data (CH<sub>4</sub> and N<sub>2</sub>O emissions from soils) at each site (if available) is more desirable than the estimates based on IPCC guidelines.

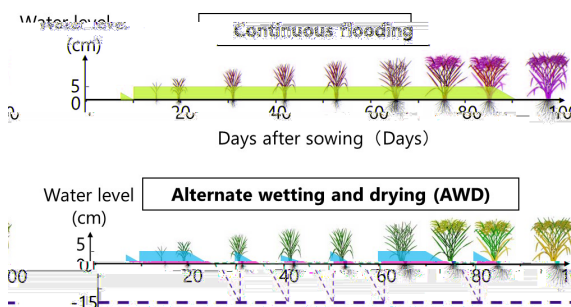


Fig. 1. An example of conventional water management (continuous flooding) and alternate wetting and drying (AWD) during a cropping season

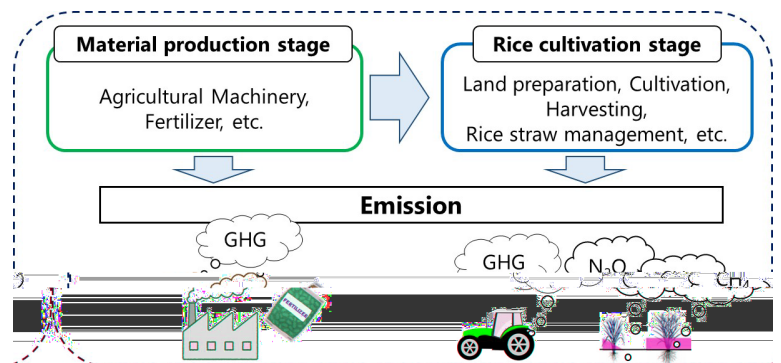


Fig. 2. Life cycle greenhouse gas (LC-GHG) emissions from rice cultivation

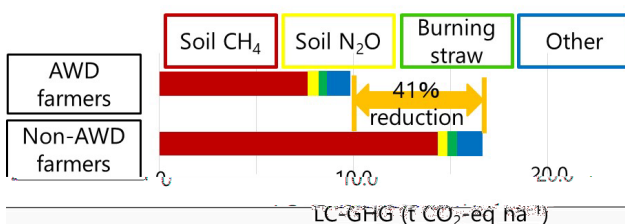


Fig. 3. Comparing greenhouse gas (GHG) emissions between alternate wetting and drying (AWD) farmers and non-AWD farmers

Technical details:

[https://www.jircas.go.jp/en/publication/research\\_results/2020\\_a02](https://www.jircas.go.jp/en/publication/research_results/2020_a02)

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Japan International Research Center for Agricultural Sciences



# Energy-saving low-carbon technology in greenhouse horticulture utilizing thermal energy in irrigation canals

Production

Demonstration

Item: Greenhouse horticulture

GHG emission reduction

## Outline

We developed a technology for collecting and utilizing heat by installing a sheet-type heat exchanger in flowing water, such as an irrigation canal. Energy consumption and greenhouse gas (GHG) emissions from heating/cooling of agricultural greenhouses can be reduced by collecting and utilizing heat from flowing water.

## Background/effect/note

Heavy fuel oil is commonly used for heating agricultural greenhouses and is one of the sources of GHG emissions. On the other hand, heat pumps have become popular for cooling in addition to heating. Recently, heat pumps have been used in order to produce high-quality crops. However, air-source heat pumps are used in most cases. Water has higher thermal conductivity and specific heat than air. The heat exchange efficiency is further improved by the flow. Thus, flowing water is the most suitable heat source for heat pumps. Laboratory experiments determined that the installation of a sheet-type heat exchanger (Figs. 1 and 2) in flowing water improved heat exchange efficiency by approximately 15 and 2.5 times when compared with that in underground and stagnant water, respectively (Fig. 3). Furthermore, construction costs can be reduced as digging boreholes is not necessary during the installation of the heat exchanger in irrigation canals. Additionally, protective materials can be attached on the heat exchanger to reduce damages caused by debris in water.

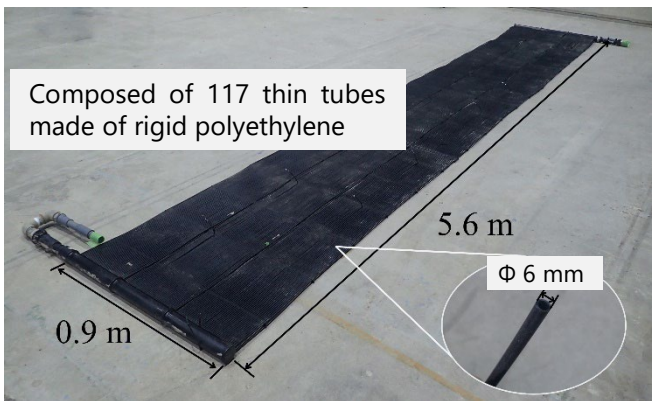


Fig. 1. Sheet-type heat exchanger

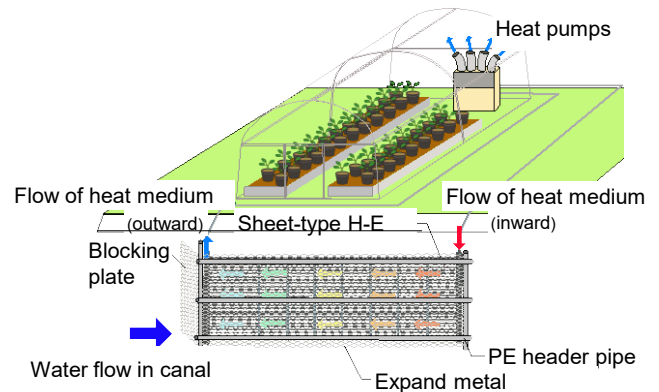


Fig. 2. Schematic view of heat utilization in greenhouse (cooling)

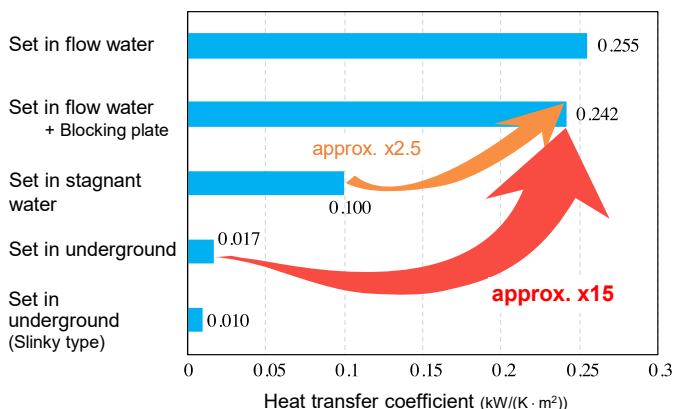


Fig. 3. Comparison of heat exchange efficiency

Technical details:



[https://www.naro.go.jp/english/laboratory/nkk/press\\_release/sheetheatexchanger/index.html](https://www.naro.go.jp/english/laboratory/nkk/press_release/sheetheatexchanger/index.html)

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# Technologies for reducing greenhouse gas emissions from livestock waste

Production

Demonstration and implementation

Item: Livestock

GHG emission reduction

## Outline

Technologies enable the effective reduction of greenhouse gas (GHG) emissions during wastewater treatment and livestock manure composting by improving feed composition and utilizing microorganisms.

## Background/effect/note

GHG emissions from the process of livestock manure composting and wastewater treatment account for 10~15% of GHG emissions derived from the agricultural sector. The GHG emissions in the process can be effectively reduced by using these technologies.

- ① Feeding fattening pigs with a low-protein diet supplemented with amino acids reduces GHG emissions from the manure management process by 40% when compared with a conventional diet without affecting rearing performance. - Implementation
- ② The GHG emissions can be significantly reduced by introducing a carbon fiber reactor to a swine wastewater treatment facility and maintaining an organic matter treatment capacity equivalent to that of the conventional activated sludge treatment method (Fig. 1). - Demonstration
- ③ During the composting of livestock manure, nitrite accumulation can be eliminated by adding mature compost containing nitrite-oxidizing bacteria to suppress the emission of nitrous oxide as a potent GHG (Fig. 2). - Demonstration

### Activated sludge tanks (aeration tanks)

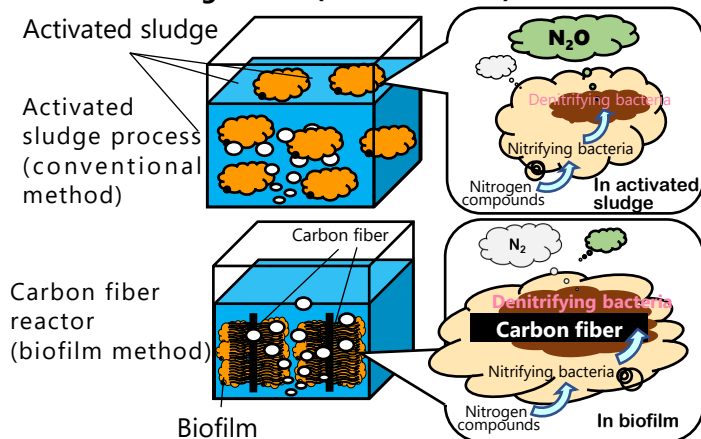


Fig. 1. Differences between the conventional activated sludge method and the carbon fiber reactor (biofilm method) [conceptual diagram]

### Technical details:

- ① [https://www.naro.go.jp/publicity\\_report/press/laboratory/nilgs/073580.html](https://www.naro.go.jp/publicity_report/press/laboratory/nilgs/073580.html) [Japanese]
- ② <https://www.naro.go.jp/english/laboratory/nilgs/press-release/CFreactor/index.html> [English]
- ③ [https://www.naro.go.jp/english/laboratory/niaes/files/fftc-marco\\_book2019\\_067.pdf](https://www.naro.go.jp/english/laboratory/niaes/files/fftc-marco_book2019_067.pdf) [English]

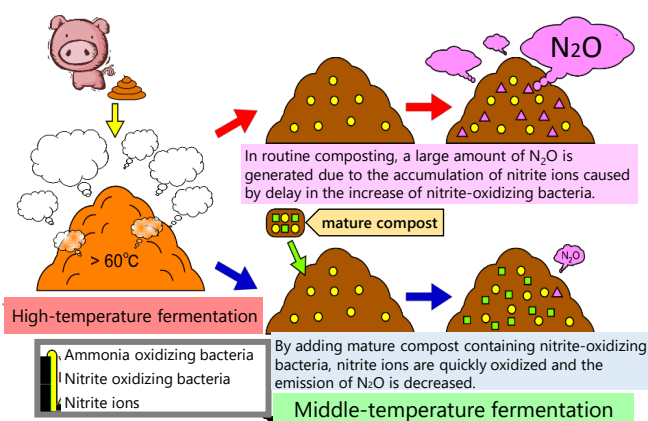


Fig. 2. Effect of mature compost addition on the reduction of greenhouse gas emissions [conceptual diagram]

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National Agriculture and Food Research Organization



# Mitigation of methane emissions from local cattle using cashew nut shell liquid feeding

Production

Demonstration

Item: Livestock

GHG emission reduction

## Outline

Cashew nut shell liquid (CNSL) feeding can decrease the enteric CH<sub>4</sub> emission from Vietnamese local cattle (Lai Sind, Fig. 1) by 20% by inhibiting the methanogen activity in the rumen.

## Background/effect/note

Livestock production, especially ruminant production, is reported to be one of the major sources of greenhouse gas (GHG) emissions in Southeast Asian countries.

Here, we demonstrated that the average enteric methane emission per kg dry matter intake from Vietnamese local cattle (Lai Sind) decreased by 20.2~23.4% with CNSL feeding (Fig. 2). Additionally, CNSL feeding decreased the abundance of methanogens and increased the abundance of propionate-producing bacteria in the rumen, which can improve the production of the cattle (Fig. 3).

This technology can be widely applied for zebu cattle (*Bos indicus*), which are common in the tropical region.



Fig. 1. Vietnamese local cattle (Lai Sind) and methane emission measurement

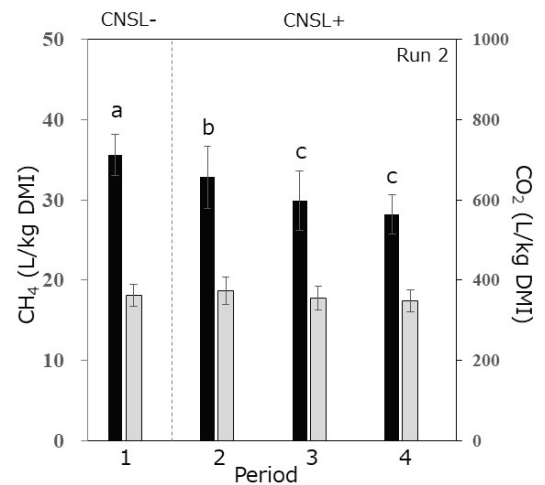


Fig. 2. Enteric methane (CH<sub>4</sub>, black) and carbon dioxide (CO<sub>2</sub>, grey) emissions per kg dry matter intake (DMI) from Lai Sind cattle with continuous CNSL feeding (4 periods of 5 days/period)

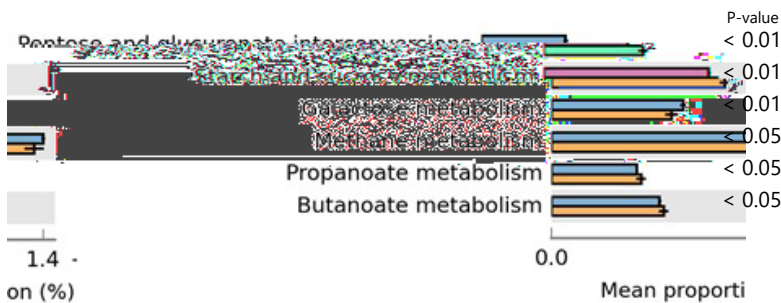


Fig. 3. Effect of cashew nut shell liquid (CNSL) feeding on the function of the rumen microbiome  
Orange: CNSL+, Blue: CNSL-  
Propanoate metabolism is significantly stimulated due to CNSL feeding.



Technical details:

[https://www.jircas.go.jp/en/publication/research\\_results/2020\\_a01](https://www.jircas.go.jp/en/publication/research_results/2020_a01)

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# Low-cost, high-efficiency production of CH<sub>4</sub> and H<sub>2</sub> from agricultural residues through microbial saccharification and bio-methanation

Procurement

Demonstration

Item: Agricultural residues

GHG emission reduction  
Biomass utilization

## Outline

Microbial saccharification technology enables the efficient production of biogas and biohydrogen from agricultural residues. CO<sub>2</sub> and H<sub>2</sub> generated from microbial saccharification by saccharifying bacteria (Fig. 1) and methane fermentation can facilitate energy recycling of unused agricultural residues without greenhouse gas (GHG) emissions.

## Background/effect/note

Agricultural waste generated from food and agricultural industries is difficult to decompose and is a source of GHG emissions. Microbial saccharification (Fig. 2) is a novel enzyme-free saccharification method that can saccharify and solubilize agricultural residues using only microorganisms without cellulolytic enzymes. In this method, agricultural residues are efficiently decomposed into sugars and organic acids and can be converted into CH<sub>4</sub> and H<sub>2</sub>. Additionally, CO<sub>2</sub> and H<sub>2</sub> generated through microbial saccharification and methane fermentation can produce methane again through the bio-methanation process to facilitate energy recycling of unused agricultural residues without GHG emissions.



Fig. 1. Electron micrograph of saccharifying bacteria

Technical details:



[https://www.jircas.go.jp/en/publication/research\\_results/2020\\_c03](https://www.jircas.go.jp/en/publication/research_results/2020_c03)

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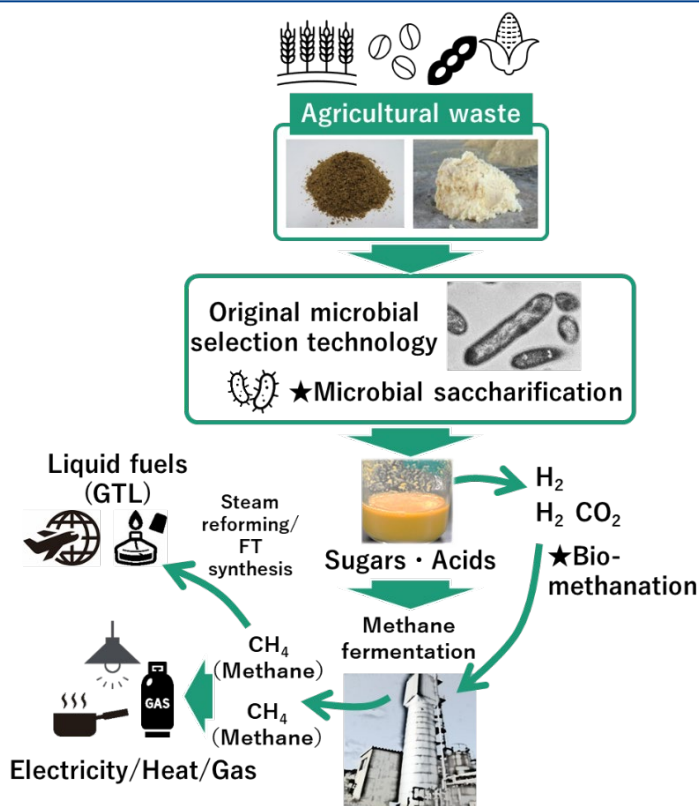


Fig. 2. Overview of low-cost, high-efficiency CH<sub>4</sub> and H<sub>2</sub> production technology through microbial saccharification and bio-methanation

GTL: Gas to Liquid

Japan International Research  
Center for Agricultural Sciences



# Utilization by “Multi-Biomass Treatment Process” of unused biomass discharged from the palm oil industry

Procurement

Demonstration

Item: Oil palm

GHG emission reduction  
Biomass utilization

## Outline

A multi-biomass treatment process that can treat various types of biomasses in the same process, for the production of sustainable fuel pellets and wood substitutes (Fig. 1) from unused biomass (oil palm trunks, empty fruit bunches, and fronds) discharged from the oil palm industry has been developed.

## Background/effect/note

To promote the sustainable utilization of diverse and enormous amounts of unused biomass discharged from the oil palm industry, we have developed a manufacturing technology called “Multi-Biomass Treatment Process” that facilitates the conversion of oil palm trunks, empty fruit bunches, fronds, and fibers into energy and wood substitutes (Fig. 2). The technology has been demonstrated at a full-scale level at a pilot plant in Johor, Malaysia (Fig. 3). Currently, we have started a procurement test for sustainable fuel pellets and furniture materials from oil palm trunks and empty fruit bunches with the cooperation of a palm oil mill in Sarawak.



Fig. 1. Furniture pellets made from oil palm trunks

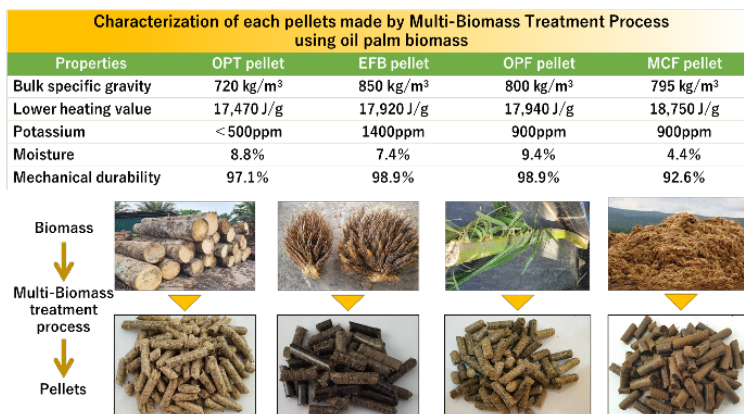


Fig. 2. Biomass pellets are produced by the Multi-Biomass Treatment Process. Sustainable and high-quality pellets can be produced in the same process.



Fig. 3. Demonstration pilot plant in Kluang, Johor, Malaysia

Technical details:



[https://www.jircas.go.jp/en/publication/research\\_results/2019\\_c03](https://www.jircas.go.jp/en/publication/research_results/2019_c03)  
[https://www.jircas.go.jp/en/publication/research\\_results/2015\\_c07](https://www.jircas.go.jp/en/publication/research_results/2015_c07)

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Japan International Research  
 Center for Agricultural Sciences





# Biological nitrification inhibition maintains wheat yield with reduced nitrogen fertilizer application

Production

Demonstration

Item: Wheat

GHG emission reduction  
Chemical fertilizer reduction

## Outline

Biological nitrification inhibition (BNI)-enabled wheat, in which BNI capacity was introduced from wild wheat by intergeneric crossing, suppresses soil nitrification, maintains high productivity under reduced nitrogen (N) application, and consequently reduces environmental loads, such as nitrous oxide (N<sub>2</sub>O) emissions and aquatic pollution in wheat cultivation.

## Background/effect/note

BNI is the mechanism that inhibits soil nitrification and reduces the conversion of ammonium from fertilizer to nitrate by releasing substances from crops. BNI-enabled wheat (Fig. 1) exhibited improved nitrogen use efficiency with enhanced BNI (introduced from wild wheat by intergeneric crossing) capacity. As the productivity under low N conditions is improved, grain yield and quality were not significantly different with a 60% reduction in N fertilizer application (Fig. 2). BNI-enabled wheat can reduce lifecycle GHG emissions (Fig. 3) and aquatic pollution from nitrate, which is easily leached from the soil, due to the decreased N application and the suppression of soil-nitrifying activity. The expression of BNI capacity is dependent on soil conditions (pH etc.).

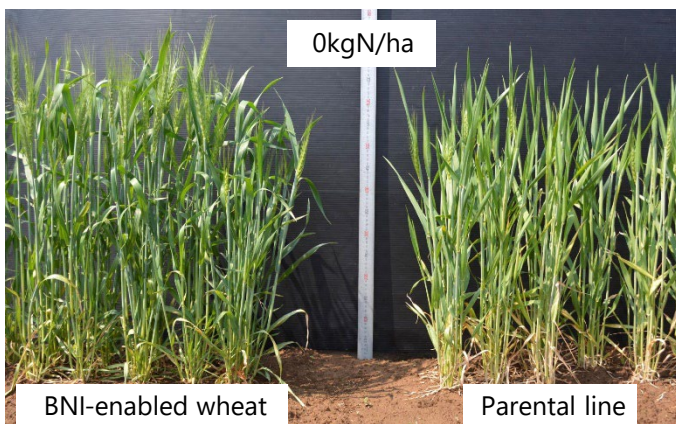


Fig. 1. Biological nitrification inhibition (BNI)-enabled wheat exhibits improved productivity under low nitrogen conditions in the field.

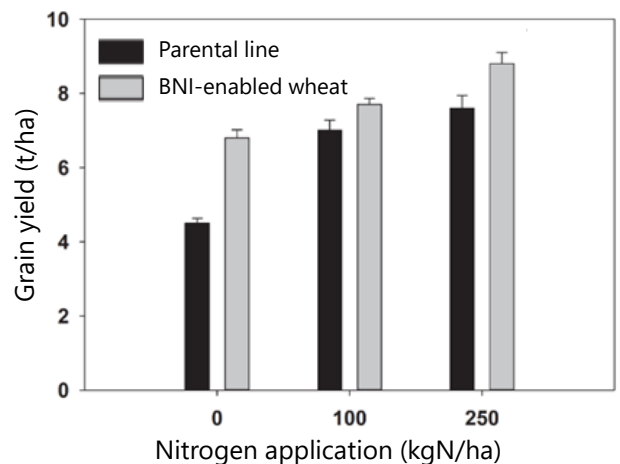


Fig. 2. Grain yield with different nitrogen application amounts

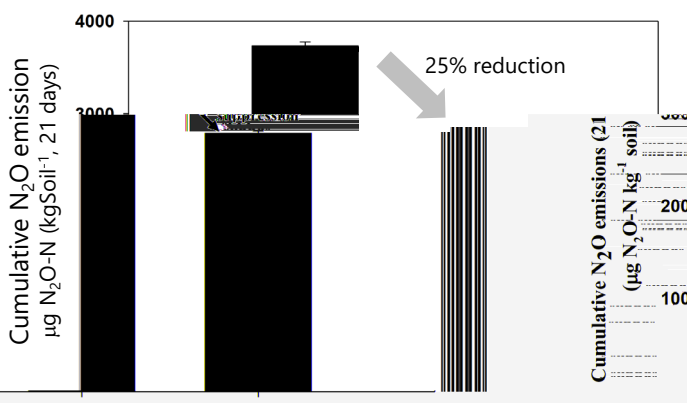


Fig. 3. N<sub>2</sub>O emissions from rhizosphere soil

## Technical details:



JIRCAS research highlights (FY2021)

[https://www.jircas.go.jp/en/publication/research\\_results/2021\\_a04](https://www.jircas.go.jp/en/publication/research_results/2021_a04)

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Japan International Research Center for Agricultural Sciences



# "Paddy Field Dam" that reduces flood damage downstream while maintaining agricultural production

Production

Implementation

Item: Paddy rice

Climate disaster mitigation

## Outline

We developed a simple device (a weir plate "Damkeeper") for controlling the water level of paddy fields to easily suppress paddy water runoff without negative impacts on rice growth and yield. "Paddy Field Dam" is expected to alleviate flood damage in the downstream area by temporarily storing stormwater during heavy rainfall.

## Background/effect/note

"Paddy Field Dam" that temporarily impounds stormwater in paddy fields has received attention as a countermeasure against flood damage, which has increased in recent years. As the "Paddy Field Dam" uses farmers' land to store water, the anxiety of farmers must be addressed and their understanding of the device is essential. We found out the characteristics of inundation damage to paddy rice (Fig. 1), which proved you can use "Paddy Field Dam" to reduce flood damage even during the rice growing period. We also developed a weir plate-type device that can be easily placed for controlling the water level of the paddy fields as one of the variations of "Paddy Field Dam" devices (Fig. 2). A local demonstration in paddy fields revealed that this device enhances the water storage capacity of the paddy fields during heavy rain (Fig. 3). The "Paddy Field Dam" is expected to have larger effects with larger application areas.

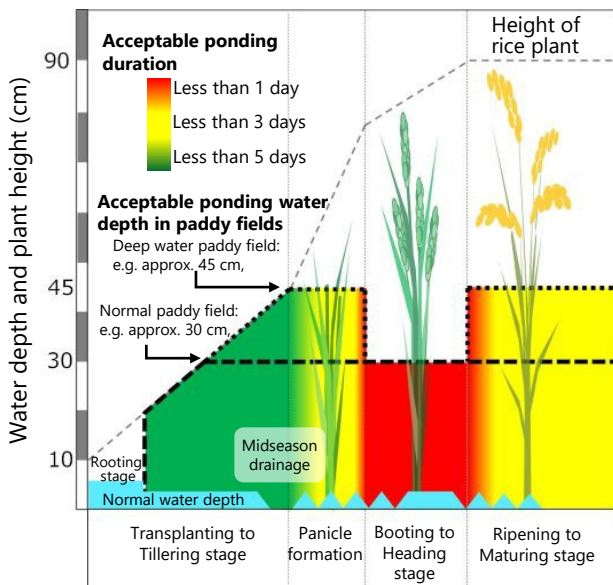


Fig. 1. Growth stages of rice and threshold of ponding water depth that rice plants tolerate

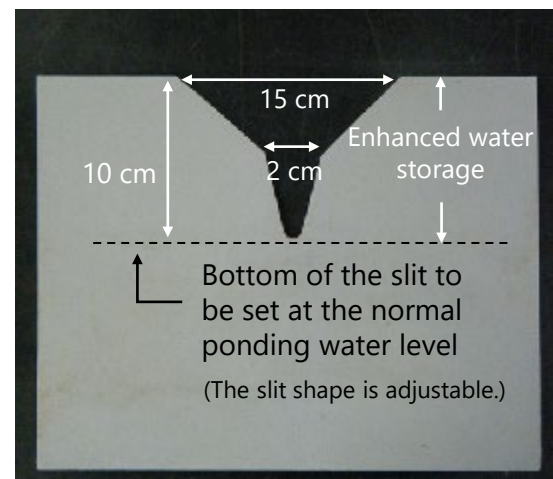


Fig. 2. Structure of the weir plate "Damkeeper" (water level control device)

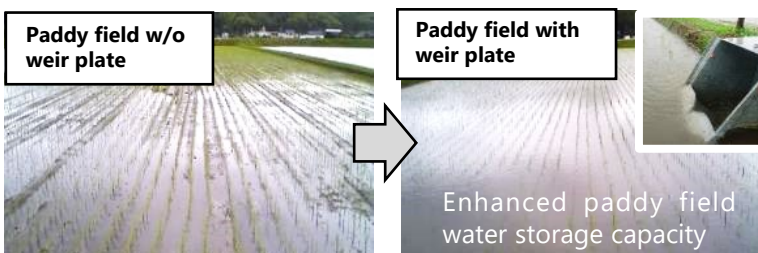


Fig. 3. Demonstration of "Paddy Field Dam" (immediately after heavy rain)



Technical Details:  
<https://www.naro.go.jp/english/to-pics/laboratory/nkk/136445.html>

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# Monitoring saline intrusion in rivers near paddy fields using satellite data

Production

Demonstration

Item: Paddy rice

Climate disaster mitigation

## Outline

Salinity cannot be directly estimated from satellite imagery. However, the strong correlation between electrical conductivity and river turbidity can be used to indirectly estimate seasonal changes in river salinity. This technology enables the implementation of proactive measures to prevent saltwater intrusion into rice paddies.

## Background/effect/note

River turbidity is high in upstream areas near the ocean (Fig. 1). Freshwater from river water becomes turbid due to the strong repulsion between negatively charged suspended particles. The mixing of cations with the entry of seawater suppresses the repulsion between particles, and the suspended particles agglomerate (flocculate). Based on this correlation between electrical conductivity and turbidity (Fig. 2(a)), the electrical conductivity of river water can be indirectly estimated from the green band reflectance of Sentinel-2 satellite data (Fig. 2(b)). The use of satellite imagery is an effective method in understanding the spatial and temporal changes in saline intrusion, which will facilitate the implementation of proactive measures to prevent saltwater intrusion into rice paddies (Fig. 3).

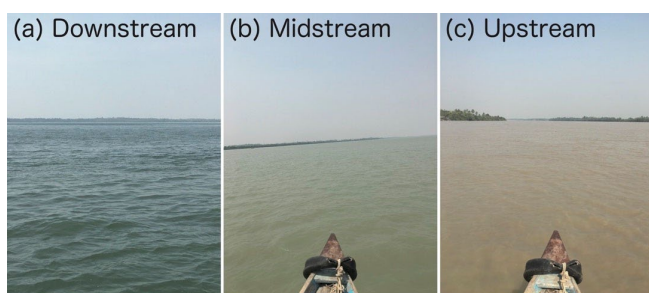


Fig.1. Photographs of river water conditions in the (a) downstream, (b) midstream, and (c) upstream reaches of Ywe River on 9 March 2018

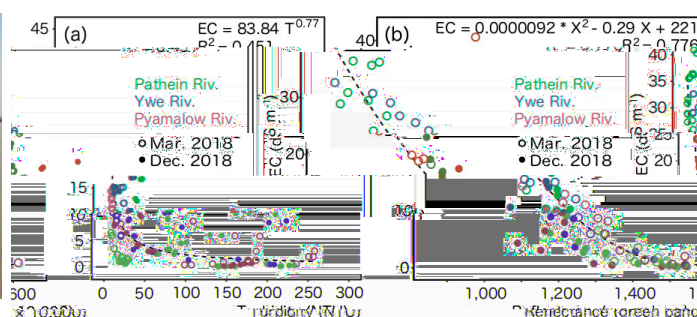


Fig. 2. Correlation between (a) turbidity and electrical conductivity (EC), and (b) EC and green band reflectance retrieved from Sentinel-2

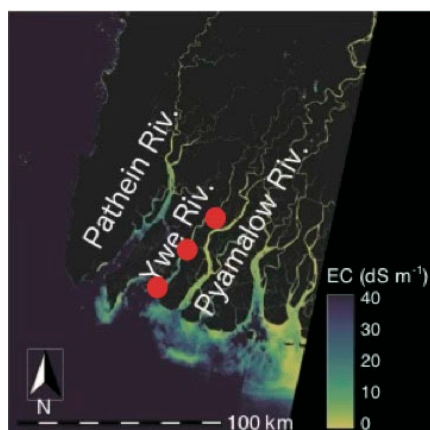


Fig. 3. Electrical conductivity (EC) map derived from the reflectance of the green band in the satellite image (March 12, 2018). The red dots are locations where the images shown in Fig. 1 were captured.



Technical details:  
[https://www.jircas.go.jp/en/publication/research\\_results/2020\\_a03](https://www.jircas.go.jp/en/publication/research_results/2020_a03)

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Japan International Research Center for Agricultural Sciences



# “Disaster prevention support system for irrigation pond” to predict flood risk and share disaster information

Production

Implementation

Item: Disaster prevention

Climate disaster mitigation

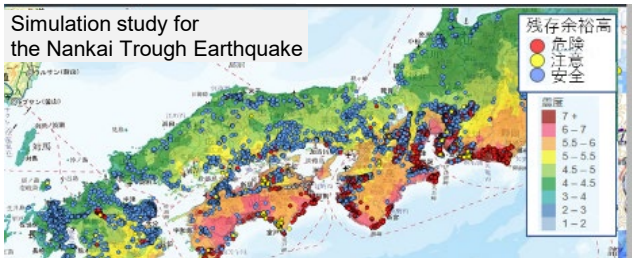
## Outline

We developed a system that visualizes the risk of irrigation pond failure in the event of an earthquake or heavy rain and enables sharing of the state of pond damage for people involved in disaster prevention. This system enables alleviation of human damage caused by irrigation pond failure and ensures the reach of rapid support to the disaster responders.

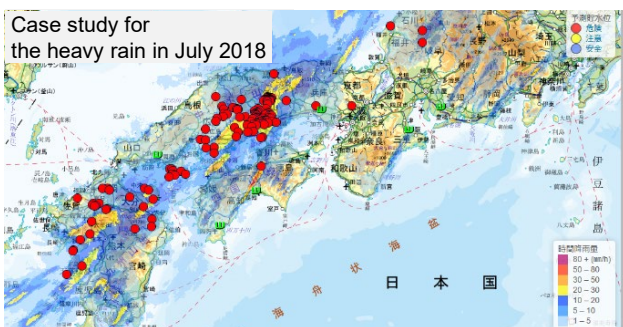
## Background/effect/note

During the Great East Japan Earthquake in March 2011 and the heavy rainfall in July 2018, several irrigation ponds collapsed, resulting in severe secondary disaster in the downstream areas. To prevent secondary disaster, the measures to predict the pond failure and communicate the hazard information was needed.

The “Disaster prevention support system for irrigation pond” (Fig. 1) is useful for predicting the real-time risk of pond damage during disasters and sharing information and photographs of the damage with personnel involved in disaster prevention, such as national and municipal governments (Fig. 2). This enables the implementation of rapid emergency measures and disaster response.



**Hazard prediction in the event of an earthquake**



**Hazard prediction in the event of heavy rain**

Irrigation pond hazards labeled "Dangerous (red)," "Alert (yellow)", and "Safe (blue)"

Fig. 1. Disaster prevention support system for irrigation pond



Fig. 2. Irrigation Pond Management App

Technical Details:



[https://www.naro.go.jp/english/laboratory/nkk/press\\_release/smartphone/index.html](https://www.naro.go.jp/english/laboratory/nkk/press_release/smartphone/index.html)

[https://www.naro.go.jp/english/laboratory/nkk/press\\_release/pondapp/index.html](https://www.naro.go.jp/english/laboratory/nkk/press_release/pondapp/index.html)

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National Agriculture and Food  
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# Underdrain-drilling machine “Cut Drain”: Easy construction of subsurface drainage without additional materials

Production

Implementation

Item: Field crop

Climate disaster mitigation

## Outline

Deep drainage cavities can be constructed continuously by towing the “Cut Drain” with a tractor without using additional materials, such as pipes. In Japan, drilling unit developed and practically applied for this purpose is sold by a domestic tractor manufacturer and is used and popularized for drainage improvement in flat and clayish agricultural lands.

## Background/effect/note

The “Cut Drain” constructs cavities underground by towing the drilling unit with a tractor to resolve the poor drainage in the farmland (Figs. 1–3). Additionally, the “Cut Drain” eliminates salt through underground infiltration in semi-arid lands and has been demonstrated as a simple and low-cost technology to reduce salt hazard in Uzbekistan. The technology is also useful for subdrainage in low-level wetlands and salt-damaged areas in Asia, Africa, and other regions.

However, the application of “Cut Drain” is limited to the clay soil type. The development of inexpensive grade units is currently under consideration for overseas countries.



Fig. 1. Drilling unit of “Cut Drain”



Fig. 2. Drilling unit in operation

Technical details:



<https://www.naro.go.jp/english/topics/laboratory/nkk/137842.html>

[https://www.jircas.go.jp/sites/default/files/publication/manual\\_guideline/manual\\_guideline\\_-\\_55.pdf](https://www.jircas.go.jp/sites/default/files/publication/manual_guideline/manual_guideline_-_55.pdf) (JIRCAS)

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Fig. 3. How to create a water conduction hollow without pipes

# International differential system to protect the rice production against rice blast diseases

Production

Demonstration

Item: Rice

Chemical pesticide reduction

## Outline

An international differential system for rice blast control was developed by combining "standard differential strains" and "standard differential rice cultivars" collected and cultivated in collaboration with research institutes in Asia and Africa. By using this system, it is possible to identify the distribution of rice blast strains that are prevalent in a target area and rice cultivars with appropriate resistance, leading to a reduction in the amount of agricultural chemicals used.

## Background/effect/note

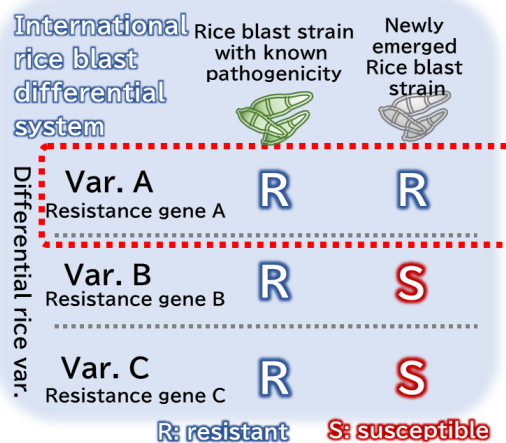
Rice blast is a serious disease that reduces rice production by 30-60% without proper control. For rice blast control, we collected and selected standard strains of rice blast in Asia and Africa. We also developed 23 standard rice cultivars with resistance genes in collaboration with the International Rice Research Institute (IRRI). The international rice blast differential system combines the standard strains and the standard cultivars.

The system can ascertain pathogenicity of a newly emerged rice blast (Fig. 1). It can also clarify effective resistance genes, which can be used for breeding resistant cultivars.

Though each country restricts imports of rice blast fungi across borders in terms of plant protection, the standard differential rice cultivars can be shared.

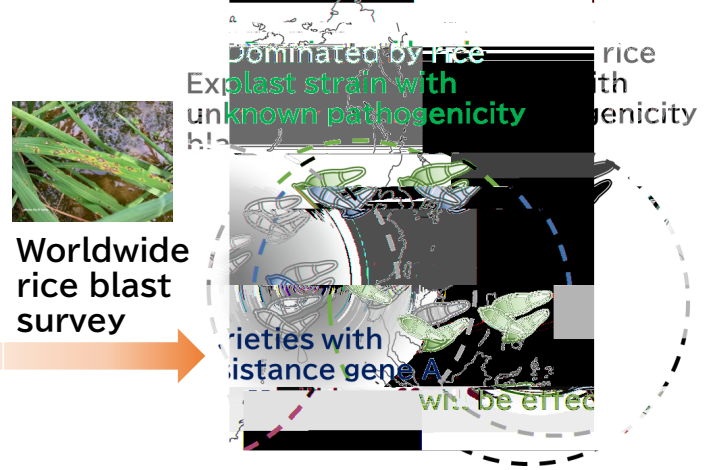
In Indonesia, Vietnam, Laos, and Bangladesh, "rice blast differential strains" have been selected and the system is available.

### Clarification of pathogenicity of newly emerged rice blast strain



The differential system identifies an effective resistance gene. For a known rice blast strain, resistance gene A, B, and C are effective. For a newly emerged rice blast strain, only gene A is effective.

### Monitoring newly emerged rice blast strain



Based on the information from the differential system, distribution of a newly emerged rice blast strain can be grasped, which will enable proactive measures against rice blast.

Fig. 1 An example of effective utilization of the international rice blast differential system



Technical details:  
[https://www.jircas.go.jp/en/publication/research\\_results/2020\\_b11](https://www.jircas.go.jp/en/publication/research_results/2020_b11)  
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Japan International Research Center for Agricultural Sciences



# Propagation and distribution system of healthy seedcane as control measures against sugarcane white leaf disease

Production → Implementation → Item: Sugarcane → Chemical pesticide reduction

**Outline**  
 We developed a system and manual on field management techniques for propagation of healthy seedcane to control sugarcane white leaf disease (SCWLD) (Fig. 1), distribution methods for the production, procedures to detect pathogens using the loop-mediated isothermal amplification (LAMP) method, and procedures to produce disease-free seedlings using the growth point culture method.

**Background/effect/note**  
 SCWLD is one of the most devastating insect-borne diseases affecting sugarcane production in Asia. We considered that the use of healthy seedcane is highly effective in controlling SCWLD. Hence, a manual for the propagation and distribution of healthy seedcane was developed for sugar mills and institutions that produce and distribute seedcane to farmers (Fig. 2). Verification test demonstrated sufficiently low rate of healthy seedcane even though the number of diseased plants increased up to 10-fold in the third generation (Fig. 3). The insecticides that can be used to control the vector are based on information available in Thailand. Users are advised to check and confirm current pesticide treatment regulations in their respective countries.



Fig. 1. A field abandoned due to widespread sugarcane white leaf disease (SCWLD)

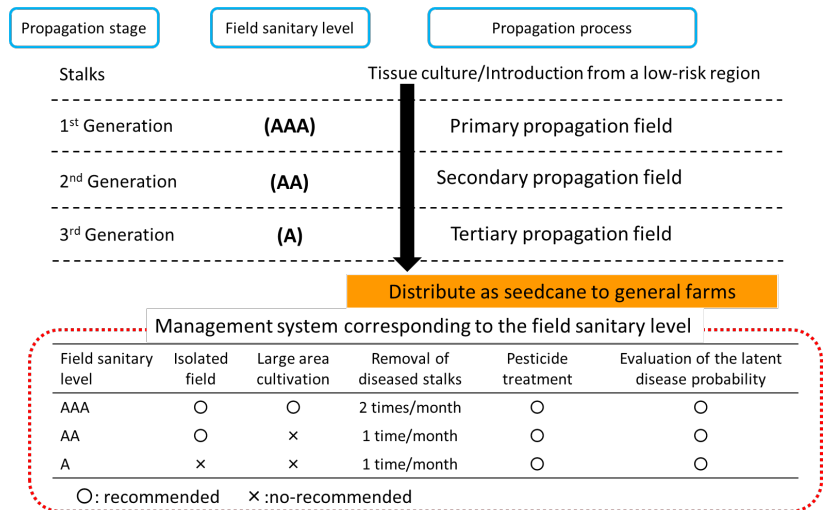


Fig. 2. Overview of the healthy seedcane propagation system

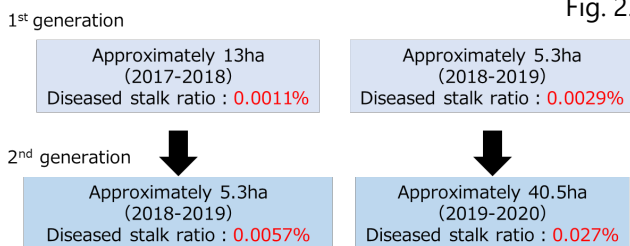


Fig. 3. Results of the healthy seedcane propagation verification test  
 Observations for two generations showed lower disease prevalence (0-20%, mean 5.8%, median 5%) as compared to newly planted fields.



Technical details:  
[https://www.jircas.go.jp/en/publication/research\\_results/2020\\_b10](https://www.jircas.go.jp/en/publication/research_results/2020_b10)

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# Smart production systems contributing to productivity improvement in paddy rice cultivation

Production

Demonstration and implementation

Item: Paddy rice

Labor productivity enhancement

## Outline

Smart agricultural technologies, such as automated rice transplanters, multi-robot work systems\*, and yield-monitoring combine harvesters\*\* have been developed. These technologies contribute to significant improvements in the productivity of paddy rice cultivation.

\* A system with which an operator can drive multiple agricultural machines at the same time

\*\* A combine harvester with functions of weighing unhulled rice and determining water content of the grains

## Background/effect/note

Automation technologies for agricultural machines have been developed to achieve efficient production (Fig. 1). They are especially important because the number of farmers has decreased. Smart agricultural machines reduce the workload of operators, improve work efficiency, and decrease the number of farm workers. Additionally, smart agricultural machines enable variable rate fertilizer application in fields with uneven fertility and crop growth. Furthermore, performing tasks, such as record and data aggregation management of farms, crops, and work history become easy by linking with the agricultural management system. Consequently, the efficiency of farm management can be improved.

Automated rice transplanter



Multi-robot work system



Yield combine



Map-based variable rate fertilizer applicator



Fig. 1. Examples of smart agricultural production systems

Technical Details: [Japanese]

[https://www.naro.go.jp/publicity\\_report/press/laboratory/iam/075850.html](https://www.naro.go.jp/publicity_report/press/laboratory/iam/075850.html)

[https://www.naro.go.jp/project/results/4th\\_laboratory/tarc/2017/17\\_003.html](https://www.naro.go.jp/project/results/4th_laboratory/tarc/2017/17_003.html)

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Movie: [English]

<https://www.youtube.com/watch?v=yGizlqBcl80&list=PLW99yTRNzVkPpBMyGubqVY3TeqSurjusE&index=3>

<https://www.youtube.com/watch?v=ZxVm6QgLc8&list=PLW99yTRNzVkPpBMyGubqVY3TeqSurjusE&index=19>



National Agriculture and Food Research Organization





# Smart agricultural machinery in compliance with the Common Communications Standard (ISOBUS)

Production

Demonstration and implementation

Item: Agricultural machinery

Labor productivity enhancement

## Outline

ISOBUS realizes electronic inter-operability beyond the frames of agricultural machinery manufacturers. Digital transformation (DX) of agricultural operations, such as variable fertilizing and spot chemical application are likely to be promoted through the practical use of agricultural machines compliant with ISOBUS.

## Background/effect/note

In Europe and the United States, tractors and working machines compliant with ISOBUS have become standards (Fig. 1). The compliant working machines can electronically connect and exchange various data with each other beyond the frames of the manufacturers (Fig. 2). This will enable agricultural operations, such as variable fertilizing and spot application of chemicals based on image data acquired by drones, operation log acquisition, etc. DX of agricultural operations will also be promoted through data linkage with the cloud platform.

NARO developed the first domestic product of Electronic Control Unit (ECU) for working machines which acquired ISOBUS certification. This technology was transferred to a Japanese agricultural machinery manufacturer who developed a general-purpose ECU (Fig. 3) applicable to various types of agricultural machines and 3 types of ISOBUS-compliant agricultural machines. The general-purpose ECU has been commercially available since April 2022.



Fig. 1. ISOBUS certification marks

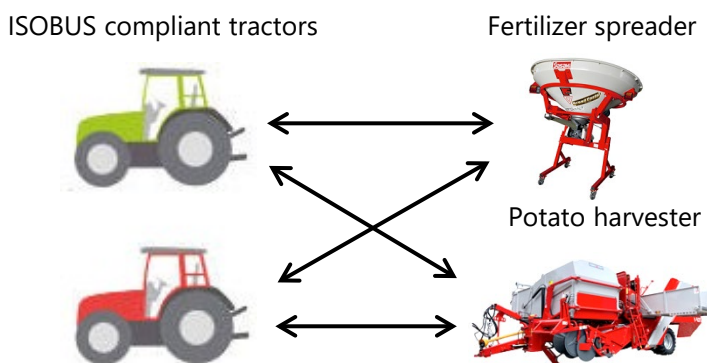


Fig. 2. Image of data exchange through electrical connections between the tractors and the other machines



Fig. 3. Commercially available general-purpose electronic control unit (ECU)

Technical details:



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[https://www.naro.go.jp/publicity\\_report/press/laboratory/iam/152162.html](https://www.naro.go.jp/publicity_report/press/laboratory/iam/152162.html) (Japanese)

[https://www.naro.go.jp/english/laboratory/iam/press\\_release/19july/index.html](https://www.naro.go.jp/english/laboratory/iam/press_release/19july/index.html) (English)

## A simple shoot-tip grafting practical method for virus-free passion fruit propagation at the farm level

Production

Implementation

Item: Passion fruit

Labor productivity enhancement

### Outline

A practical technology for virus-free propagation of passion fruit seedlings at the farm level has been developed using a simple shoot-tip grafting.

### Background/effect/note

In Asia, passion fruit (*Passiflora edulis*) is produced mainly in Indonesia, India, and Vietnam. Recently, passion fruit production is gaining attention as an alternative crop to tackle climate change in Japan. However, the occurrence of *Passiflora* latent virus (PLV) diseases is a major problem concern (Fig. 1). Virus infection can spread easily due to vegetative propagation via cuttings. Thus, securing virus-free plants is difficult due to infection of the mother stock used for propagation. We established a method for virus-free propagation of passion fruit from PLV-infected plants using a simple shoot-tip grafting method that can be easily introduced into the field without any aseptic technique and facility (Fig. 2). This method may be effective against other viruses and viral infection related symptoms of unknown cause in the production countries for the propagation of healthy seedlings.



Fig. 1. Viral infection-like symptoms observed in the leaves and fruits of passion fruit

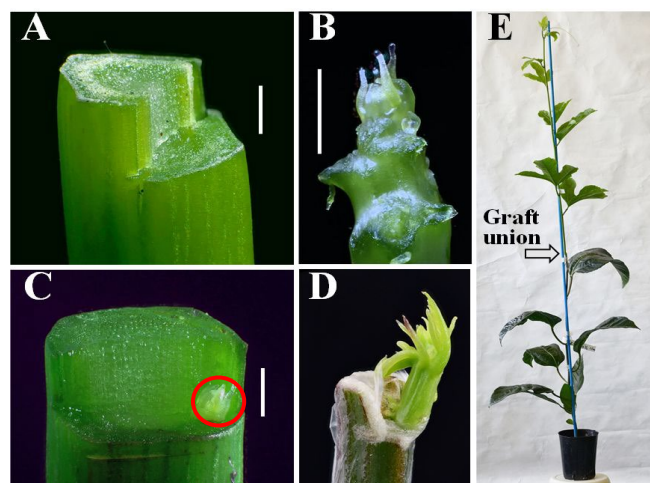


Fig. 2. In vivo shoot-tip grafting of passion fruit (bar = 1 mm)

- A: Preparation of a rootstock.
- B: The shoot-tip is used as a scion (0.2–1.0 mm)
- C: The excised shoot-tip attached on the cambium of the rootstock and covered with laboratory film to prevent drying.
- D: Sprouting of the scion in approximately one month.
- E: After approximately two months, the growing scion is ready for virus detection.



Technical details:

[https://www.jircas.go.jp/en/publication/research\\_results/2021\\_c02](https://www.jircas.go.jp/en/publication/research_results/2021_c02)

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Japan International Research  
Center for Agricultural Sciences



# Information and communication technology-based water management system for reducing agricultural water usage, agricultural labor, and electricity

Production

Implementation

Item: Paddy rice

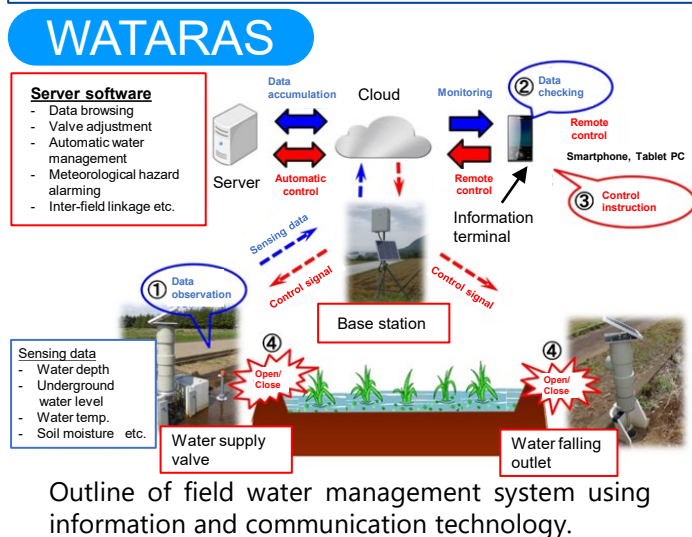
Resource management  
Labor productivity enhancement

## Outline

We developed the following two information and communication technology (ICT)-based systems: Water for Agricultural Remote Actuated System (WATARAS), for remote automated water supply and drainage management of paddy fields; Irrigation and Drainage Automation System (iDAS), for optimizing regional agricultural water allocation. The effective introduction of both systems enables optimum water supply and significant savings in labor costs and energy consumption.

## Background/effect/note

The depopulation and the aging population of rural areas and the decline in the number of farmers have contributed to the insufficient management efforts of paddy fields and irrigation facilities and the wastage of water and power. The ICT-based water management from irrigation facility to paddy field enables the reduction of ① water management labor for paddy fields by approximately 80%, ② regional water consumption, and ③ the power consumption of pumps required for water use (Fig. 1). It is noted that those systems should be constructed to match existing infrastructure (e.g. paddy fields, water channels, information and communication) and cost-effectiveness that may vary depending on the country.



## Technical Details:

- <<Episode 22>> Easy Water Management of Paddy Fields with Smartphones  
<https://www.naro.go.jp/laboratory/brain/english/press/stories/155708.html>
- (Research results) Development of an efficient water distribution management control system through field-water utilization facility cooperation using ICT.  
[https://www.naro.go.jp/english/laboratory/nkk/press\\_release/idas/index.html](https://www.naro.go.jp/english/laboratory/nkk/press_release/idas/index.html)
- (Video) Easy Water Management of Paddy Fields with Smartphones [Japanese]  
<https://www.youtube.com/watch?v=tdwMKx-a2hs&list=PLW99yTRNzVkJNDB0HaClwbaqGa-m4ikBF2&index=13>
- (Video) Automated Water Management and Control System with ICT from irrigation facility to paddy field [Japanese]  
<https://www.youtube.com/watch?v=j1mrcuGSV1Y>

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National Agriculture and Food  
Research Organization

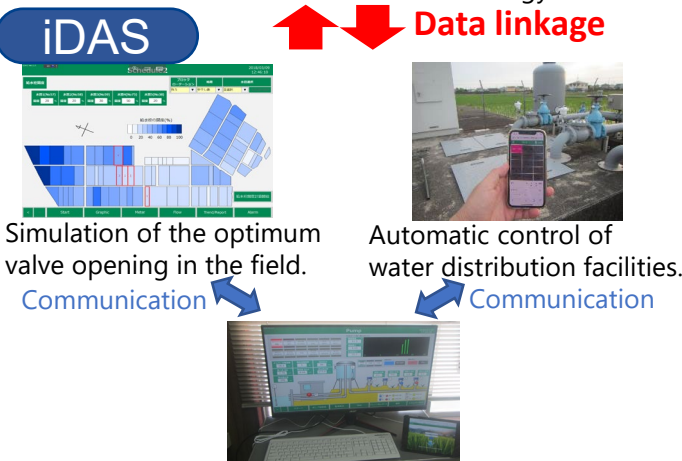


Fig. 1. Management system for efficient agricultural water supply from irrigation facility to paddy field

# Identification of wood species and provenance of timber to promote trade of legal timber

Production

Demonstration and implementation

Item: Timber

Resource management

## Outline

We improved the identification technology for the timber produced in the Southeast Asian region (Fig. 1) to prevent illegal logging. Identification technology is based on the database and the combination of microscopic observation, DNA analysis, chemical analysis, and tree ring analysis.

## Background/effect/note

Timber produced in Southeast Asia is estimated to consist of hundreds types of species, and contains wood with a high possibility of illegality during the process of production. The Forestry and Forest Products Research Institute established a comprehensive database comprising approximately 180 types of commercially traded tree species groups originating from Southeast Asia. This database is based on wood samples obtained from around 30,000 specimens representing approximately 8,000 species worldwide<sup>1)</sup>. Leveraging this database, the identification of wood species (primarily at the genus level) and estimation of their origin are accomplished through microscopic observation<sup>2)</sup>. To enhance the accuracy of identification, we developed a DNA analysis for meranti (*Shorea* spp.)<sup>3)</sup>, a chemical composition analysis for ramin (*Gonystylus* spp.) (Fig. 2), and a country-of-origin discrimination method based on tree ring analysis for teak (*Tectona grandis*). Since applicable identification methods vary by tree species, careful selection of analysis methods based on microscopic estimation results is necessary.

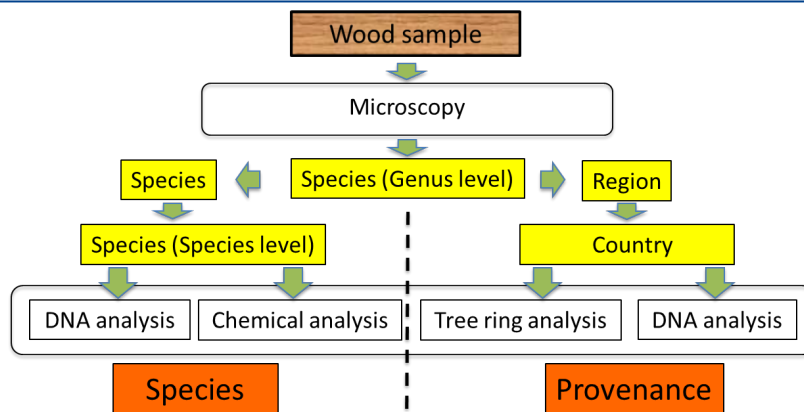
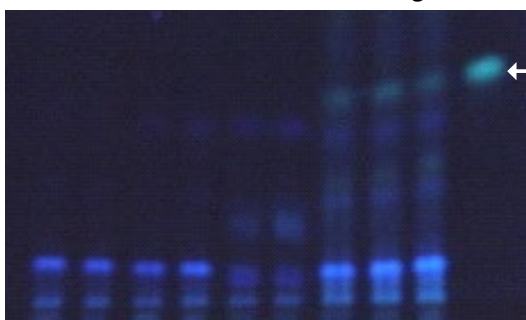


Fig. 1. Flow to identify wood species and origins



1 2 3 4 5 6 7 8 9 10  
 1-6 : Wood species similar to ramin  
 7-9 : Ramin (*Gonystylus banacanus*)  
 10 : Standard sakuranetin  
 Ramin can be identified by sakuranetin.

Fig. 2. Identification of ramin wood by thin layer chromatography (TLC)

Technical details:



- 1) <https://db.ffpri.go.jp/WoodDB/index-E.html>
- 2) <https://www.kaiseisha-press.ne.jp/ISBN9784860992446.html>
- 3) <https://doi.org/10.1007/s10265-010-0348-z>

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Forestry and  
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# A simple calculation method of biological indices for blood cockle resource management through aquaculture fishing ground selection and harvest time determination

Production

Demonstration

Item: Blood cockles

Resource management

## Outline

To properly conduct blood cockles resource management in Southeast Asia, where its production has been drastically decreasing, we improved the calculation method of indicators of bivalve growth conditions, including the sharpness index and condition factor. This facilitates the identification of optimal aquaculture fishing grounds that can ensure a high survival rate of spat, determine appropriate harvest time when production can be increased, ultimately enhancing the utilization efficiency of natural spat.

## Background/effect/note

The blood cockle, *Tegillarca granosa* (Fig. 1), is rich in minerals and vitamins and is an indispensable ingredient to the local people. Presently, the production of blood cockle in Southeast Asia is alarmingly decreasing because of environmental deterioration. Therefore, appropriate resource management and technical measures to recover the resource are required. We developed simple biological indices that can easily evaluate the fishing ground environment and growth condition of the blood cockle by improving the sharpness index and the condition factor (Fig. 2). These indices can be calculated by simply measuring three variables: shell length, shell width, and total weight, facilitating ease of monitoring of the environmental and growth conditions, enabling selection of optimal aquaculture fishing grounds (Fig. 3) and identification of appropriate harvest times.

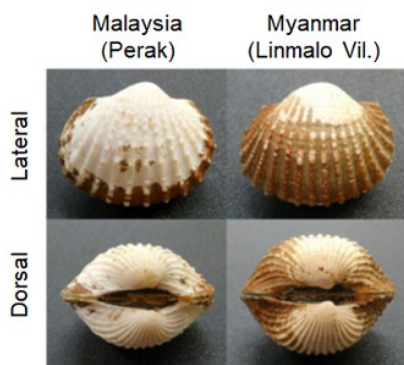


Fig. 1. Blood cockle (*Tegillarca granosa*)

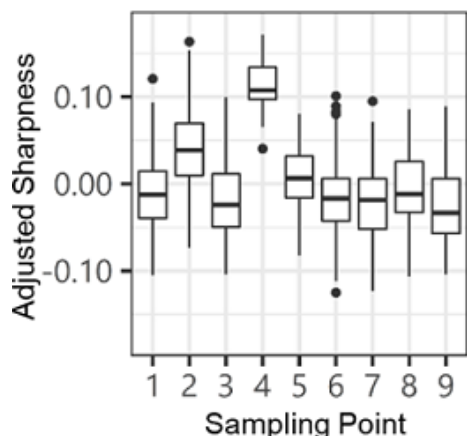
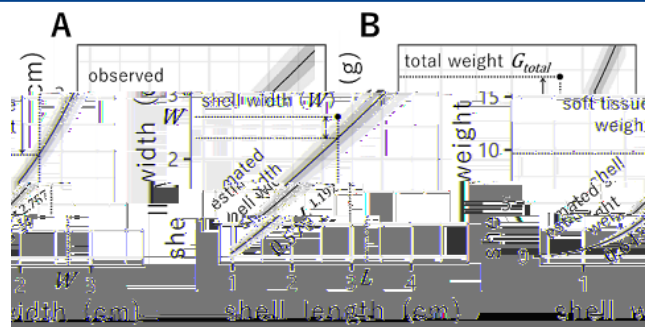


Fig. 3. Comparison of adjusted sharpness indices. Smaller values indicate a more suitable environment for cultivation of blood cockles.



$$SI_{adj} = \frac{W - 0.570L^{1.192}}{L} \dots \dots \text{(Eq. A)}$$

$$CF = \frac{G_{total} - 0.643W^{2.757}}{G_{total}} \dots \dots \text{(Eq. B)}$$

$SI_{adj}$ : Adjusted sharpness index,  $W$ : Shell width (cm),  $L$ : Shell length (cm),  $CF$ : Condition factor,  $G_{total}$ : Total wet weight (g)

Fig. 2. Derivation of estimate equations for the adjusted sharpness index (A) and the condition factor (B). Each plot was superimposed with the allometry curve (black line) and 68% (light grey) and 95% (grey) prediction intervals.



Technical details:

[https://www.jircas.go.jp/en/publication/research\\_results/2020\\_c10](https://www.jircas.go.jp/en/publication/research_results/2020_c10)  
[https://www.jstage.jst.go.jp/article/jarq/57/2/57\\_165/\\_article/-char/ja/](https://www.jstage.jst.go.jp/article/jarq/57/2/57_165/_article/-char/ja/)

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# Utilizing coconut fiber for the recovery of tropical sea cucumber resources

Production

Demonstration

Item: Tropical sea cucumber

Resource management

## Outline

In tropical waters, sea cucumber resources are overexploited, and the release of seedlings (juveniles) has not been extended enough to recover the resources. We conducted experiments in Solomon Islands and demonstrated the technical feasibility of collecting wild seedlings of tropical sea cucumbers. Moreover, we found that coconut fiber is an efficient material for collecting the seedlings.

## Background/effect/note

Wild seedling collection is a method of naturally attaching juveniles of invertebrates to materials moored in the sea. Examples of wild seedling collection have been reported for two *Apostichopus* species of temperate sea cucumbers, but not for tropical sea cucumbers. A tank experiment using hatchery-produced juveniles of the tropical sea cucumber, *Stichopus horrens*, showed that seedling collection efficiency of coconut fiber and mesh fabric was higher than that of oyster shells. Subsequently, simple seedling collectors filled with coconut fiber (Fig. 1) were moored in the sea for three months (Fig. 2), and multiple species of juvenile sea cucumbers were collected (Fig. 3). The collectors can be made cheaply using husks of commonly consumed coconuts and can be easily installed. Thus, we anticipate widespread adoption among the local fishing community to replenish the sea cucumber resources.



Fig. 1 Removing coconut fiber from the husk



Fig. 2 Deploying wild seedling collectors by snorkeling

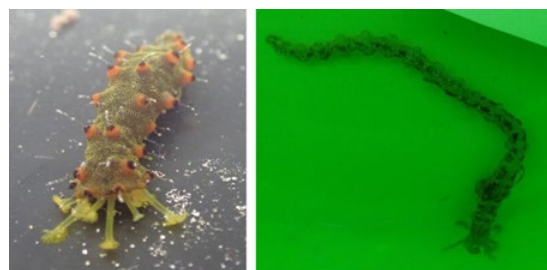


Technical details:

<https://www2.fra.go.jp/xq/seika/seika32/>

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Stonefish *Actinopyga lecanora*      *Synapta maculata*



Dragonfish *Stichopus cf. horrens*



Unidentified species

Fig. 3 Juvenile sea cucumbers attached onto the wild seedling collectors

# Smartphone application to collect coastal fisheries and environmental information for adaptation to changes in the marine environment (FishGIS)

Production

Demonstration

Item: Fisheries

Resource management

## Outline

Local fishers can quickly share information on changes in the marine environment and catches due to climate change among stakeholders through reporting of images such as catches and ocean colours, and the location where they were taken, using their smartphones.

## Background/effect/note

The marine environment has considerably changed worldwide in recent years, and the species composition of catches is also changing. To adapt to changes in the marine environment and achieve sustainable fisheries, it is important to detect changes in the marine ecosystem and immediately share this information with stakeholders. Therefore, as part of the PICES/MAFF project "Building Local Warning Networks for the Detection and Human Dimension of Ciguatera Fish Poisoning in Indonesian Communities", funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan through the Fisheries Agency of Japan (JFA) from the Official Development Assistance (ODA) Fund, a research team consisting of researchers from the Japan Fisheries Research and Education Agency (Japan), Canada, China, South Korea, Russia and the USA developed a smartphone application for collecting coastal fisheries and environmental information (Fig. 1). With this application, local fishers can collect fish size distribution data from catch images (Fig. 1, left) and water quality parameters from ocean colour images (Fig. 1, right), as well as share the reported results with local stakeholders (e.g., fishers' groups, government officials). Thus, this application is a useful tool to facilitate fisheries resource assessment and management in Southeast Asia.

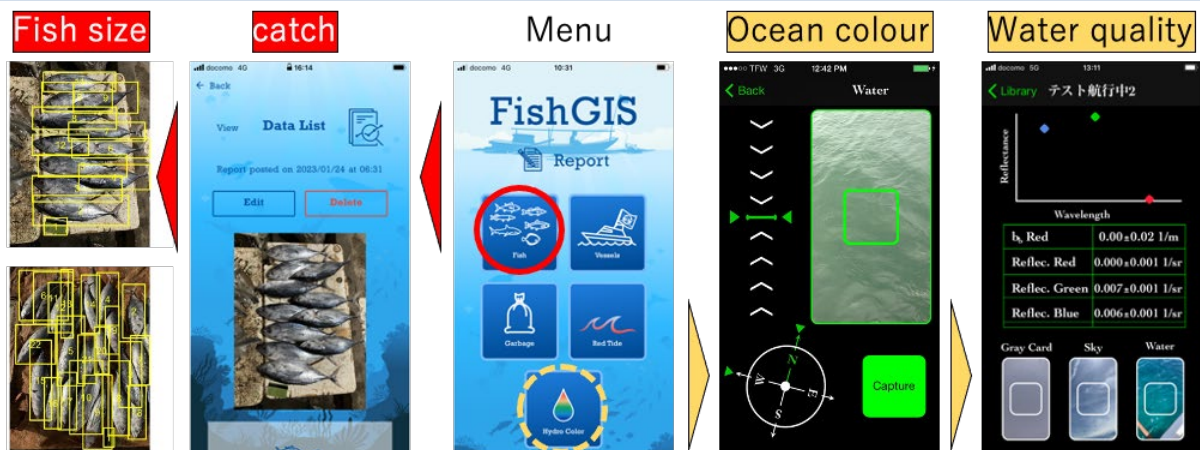


Fig.1. Examples of coastal fisheries and environmental information collected by FishGIS

Technical details:



<https://meetings.pices.int/projects/FishGIS>  
<https://meetings.pices.int/projects/Ciguatera>  
<https://apps.apple.com/jp/app/fishgis/id1550904014>  
<https://play.google.com/store/apps/details?id=com.gfken.fishgis>

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# An improvement method of selective logging criteria for dipterocarp timber species to maintain healthy tropical rainforests

Production

Demonstration

Item: Dipterocarp timber

Resource management  
Forest conservation

## Outline

To maintain healthy tropical rainforests (Fig. 1), it is necessary to set appropriate selective logging criteria† to maintain healthy seed production through outcrossing pollination\*. A method based on tree diameter was developed to estimate the ratio of outcrossing pollen of four timber species in Dipterocarpaceae. This method enables desirable selective logging criteria for each timber species, and thus promoting sustainable forest management.

† Selective logging criteria: Criteria for tree diameter, etc., to determine whether or not trees can be felled.

\* Outcrossing pollination: Pollination by pollen from the same species but different individual.

## Background/effect/note

The minimum cutting size of the selective logging criteria for dipterocarp timbers in Malaysia is 50 cm in diameter; however, it remains unknown whether healthy seed production occurs in secondary forests after harvesting according to this criterion. Therefore, we have developed a method to estimate the ratio of outcrossing pollen after selective logging using simulation with pollen dispersal pattern and the amount of flowering of the four timber species as parameters. The current minimum cutting size maintains approximately 30–80% of outcrossing pollen ratios in fast-growing species, while that in slow-growing species is reduced to < 20% (Fig. 2, Table 1). Thus, it is necessary to establish a more stringent selection criterion for the slow-growing species.



Fig. 1 Malaysian lowland dipterocarp tropical rainforest

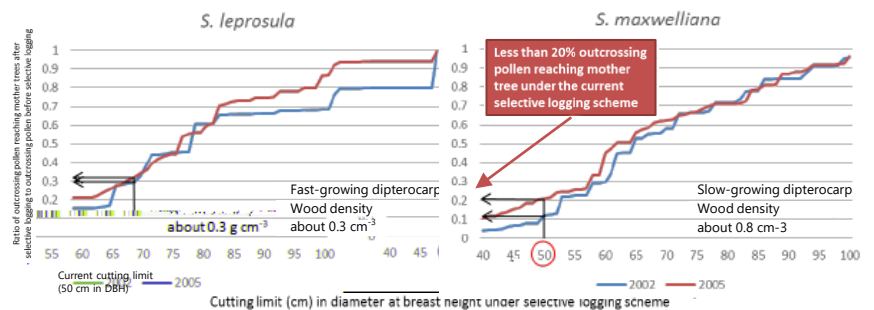


Fig. 2. Simulating the ratio of outcrossing pollen reaching mother trees after selective logging to outcrossing pollen without selective logging for four dipterocarp timber species. The simulation was conducted using the selective logging criteria (tree diameter cutting limit) of 40 cm and at every 1-cm increment thereafter.

Table 1. Ecological difference between the experimental timber species and improvement plan in response to the simulation results

Timber species		Ecological feature		Healthy seed production		Simulation results
Classification	Example	Wood density	Longevity	Current criteria	Improvement plan	Percentage of outcrossing pollination
Fast-growing sp.	<i>S. leprosula</i> , <i>S. parvifolia</i>	Low	Short	Healthy mating	Current criteria	Approx. 30% Approx. 80%
Slow-growing sp.	<i>S. curtisii</i> , <i>S. maxwelliana</i>	High	Long	Reducing healthy mating	More strict criteria	Less than 20% Less than 20%

Technical details:



[https://www.jircas.go.jp/en/publication/research\\_results/2016\\_c04](https://www.jircas.go.jp/en/publication/research_results/2016_c04)

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# Easy-to-do monitoring method for soil erosion risk to maintain high productivity and water and soil conservation functions of forests

Production

Implementation

Item: Forest

Forest conservation

## Outline

We have developed a method for visually assessing soil erosion risk in forests in 10% increments based on forest floor cover percentage (the proportion of the forest floor covered by understory vegetation or litter), which is strongly correlated with soil erosion (sediment transport, Fig.1). By utilizing this indicator, we can effectively implement sustainable forest management to maintain high productivity.

## Background/effect/note

Good soil conservation is essential for the fulfillment and maintenance of the multifunctional role of the forests. However, owing to the time-consuming and costly nature of observing soil erosion, monitoring surveys could not be conducted at many sites. In Japan, this method has been incorporated into the soil erosion survey of the Forestry Agency's Forest Resource Monitoring Survey (National Forest Inventory) and is being conducted every five years at more than 13,000 monitoring points. Moreover, the Food and Agriculture Organization (FAO) has verified this method in Vietnam and publicized and promoted it as a low-cost forest conservation survey method.

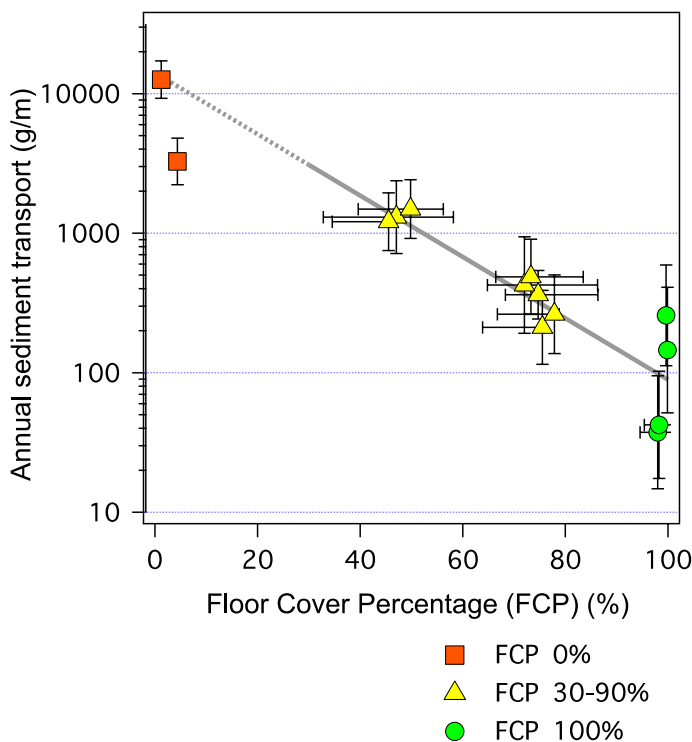


Fig.1. Relationship between forest floor coverage percentage (FCP) and sediment transport. Error bars indicate standard deviations.

A 10% decrease in forest floor cover results in a 66% increase in fine-grained sediment transport. With minimal experience, it is possible to master the technique of visually determining floor coverage percentage in 10% increments. (Compiled from Miura et al. 2015)

Technical details:



<https://www.rinya.maff.go.jp/j/keikaku/tayouseichousa/> (Forestry Agency)

<https://www.fao.org/3/i4509e/i4509e.pdf> (FAO)

<https://www.fao.org/3/i4498e/i4498e.pdf> (FAO)

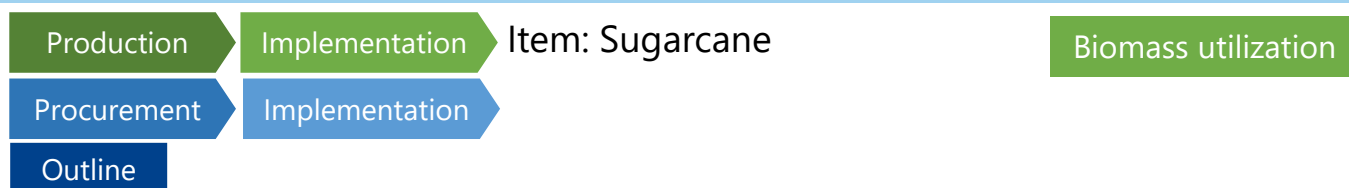
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Forestry and Forest Products Research Institute



# TPJ04-768: A new sugarcane cultivar with high fiber (bagasse) productivity



A new sugarcane cultivar with high fiber production and the same amount of sugar production as conventional cultivars was developed in Thailand. The use of this cultivar is expected to increase the production of bioenergy and other products using fiber.

### Background/effect/note

In the sugarcane industry, electricity generation using fiber is increasing along with sugar production. To expand the utilization of fiber, a new cultivar (TPJ04-768) was developed in Thailand using an interspecific crossing between sugarcane and its wild species (*Saccharum spontaneum*) (new cultivar number 0317/2558, Department of Agriculture, Thailand). The sugar yield of this cultivar was comparable to that of the conventional cultivar KK3 although the sugar content was slightly lower. Moreover, the production of fiber (bagasse\*) in this cultivar is approximately 1.5 times higher than that in KK3 in Northeast Thailand (Figs. 1 and 2). Thus, TPJ04-768 is a suitable raw material for biofuel and other biomass applications. TPJ04-768 is more suitable than KK3 for multiple ratoon cultivation based on its decreased yield reductions in ratoon cropping. Machine harvesting may be required due to the thin and large number of stalks of the cultivar (Table 1). Breeding of similar cultivars can be applied to other Asian countries to promote fiber utilization in the sugar industry.

\* Bagasse is the fibrous material that remains after crushing sugarcane stalks to extract the juice. This material is used as a raw material for electricity production.



Fig. 1. The growth at second ratooning in Kosum Phisai of Northeast Thailand (December 2014)

Left: TPJ04-768, Right: KK3

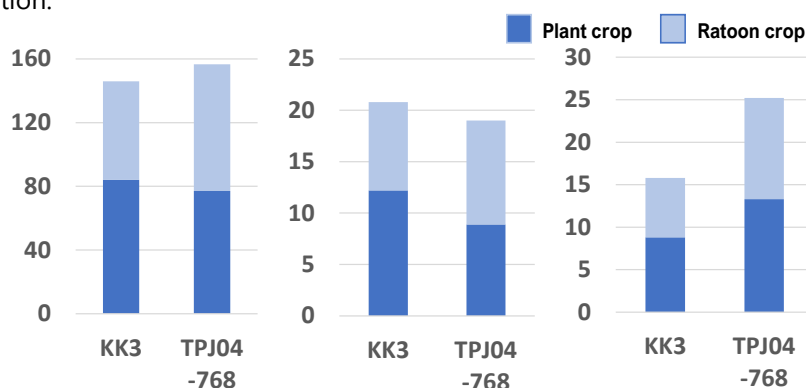


Fig. 2. Yield of TPJ04-768 at plant and ratoon crop (t/ha) in Khon Kaen of Northeast Thailand  
Left: Cane yield, Middle: Sugar yield, Right: Fiber yield

Table 1 Characteristics of the yield components of TPJ04-768 (at harvesting of ratoon crop of Fig. 2)

Variety	Stalk no. (no. /ha)	Diameter (cm)	CCS (%)	Fiber (%)
KK3	42468	2.84	14.0	11.3
TPJ04-768	51282	2.22	12.7	15.0

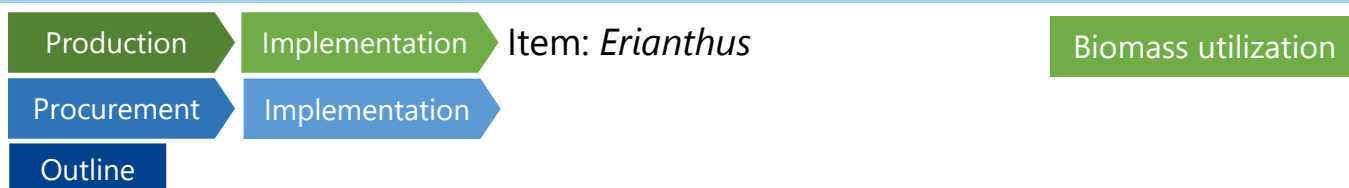


Technical details:  
[https://www.jircas.go.jp/en/publication/research\\_results/2015\\_b10](https://www.jircas.go.jp/en/publication/research_results/2015_b10)  
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Japan International Research Center for Agricultural Sciences



# JES1: A new *Erianthus* cultivar for biomass production



**Outline**  
 A new *Erianthus* cultivar (JES1) has been developed for biomass production in Japan. This cultivar can be cultivated perennially with ratoon cultivation. The harvested biomass of this cultivar can be used as a raw material for the production of biomass pellet fuel and other products.

**Background/effect/note**  
*Erianthus arundinaceus*, a perennial grass that is widely distributed in Asian regions, can be used as a new biomass crop owing to its high biomass productivity. The novel *Erianthus* cultivar JES1 was registered in Japan in 2019 (Fig. 1). This cultivar can be grown in the Kanto region (37°N) and southward in Japan and produce an annual dry matter yield of more than 20 t/ha (Fig. 2). After planting, the cultivar can be grown continuously for ratoon cultivation for more than five years, allowing low-cost cultivation. Practical cultivation of JES1 has been implemented in Sakura City, Tochigi Pref. (Figs. 3 and 4). The biomass has been converted into pellets (Fig. 5) used for bioenergy production. The use of *Erianthus* as breeding or material resources can be applied to other Asian regions that are considering the use of biomass crops.



Fig. 1. Plant: Growth habitat of JES1 (Kumamoto Pref., Japan)

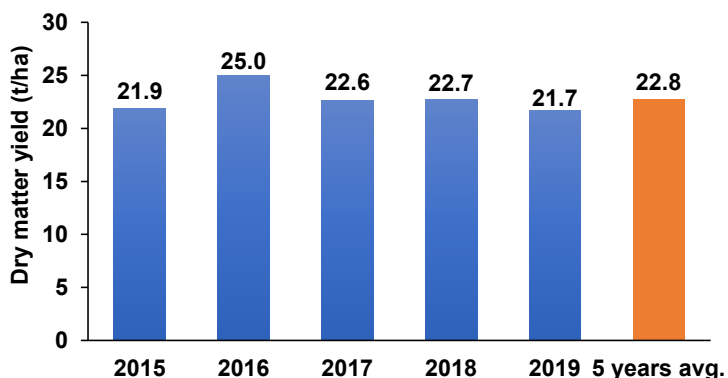


Fig. 2. Dry matter yield of JES1 in a practical field in Sakura City, Tochigi Pref. in Japan



Fig. 3. Practical cultivation of JES1 in Sakura City, Tochigi Pref., Japan



Fig. 4. Harvesting via forage harvester



Fig.5. Pellets produced from dry matter of JES1



Technical details:

[https://www.jircas.go.jp/en/publication/research\\_results/2015\\_b07](https://www.jircas.go.jp/en/publication/research_results/2015_b07)  
<https://www.naro.go.jp/english/topics/laboratory/nilgs/077373.html>

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National Agriculture and Food Research Organization



# Aquaculture feed with the black soldier fly larvae easily grown from fruit residues as a protein source

Procurement

Demonstration

Item: Freshwater aquaculture fish

Biomass utilization

## Outline

Protein-rich and low-cost feeds from black soldier fly (BSF: *Hermetia illucens*) larvae (Fig. 1(a)), easily grown from fruit residues, have better protein assimilation efficiency than conventional fishmeal (FM) feeds for the climbing perch (*Anabas testudineus*) that is one of main targets for aquaculture in Laos (Fig. 1(b)). In the current situation of FM price hike, the feed from BSF is expected to reduce cost.

## Background/effect/note

In Laos, aquaculture promotion is required to increase protein supply to the public. However, the high cost of imported aquaculture feeds hinders the dissemination. Therefore, we incorporated the BSF larvae into feeds with/without FM for the climbing perch (Table 1) and evaluated fish growth (Table 2) and protein assimilation (Table 3). Results showed that fish growth by BSF feed was similar to that by FM feed, and that protein assimilation was better in BSF feed than in FM feed. These observations indicate that BSF larvae can be a practical substitute for FM, agricultural residues can be efficiently utilized to breed BSF larvae, and the feed cost can be reduced by incorporating BSF. As both the climbing perch and the black soldier fly are widely distributed in Southeast to West Asia, it is expected that BSF feed will be utilized as aquaculture feed in other areas.



Fig. 1. Black soldier fly larvae (a) and the climbing perch (b)

Table 2. Growth performance of the climbing perch given the experimental feeds

Growth index	Fishmeal	Mixed meal	Black soldier fly
Total length at stocking (mm) *	46.3 ± 7.4	46.3 ± 7.4	46.3 ± 7.4
Total length at harvest (mm)**	159.9 ± 13.6	164.1 ± 11.7	160.9 ± 12.8
Body weight at stocking (g)*	2.2 ± 1.2	2.2 ± 1.2	2.2 ± 1.2
Body weight at harvest (g) **	85.1 ± 25.5	92.0 ± 22.3	83.5 ± 22.2
Feed Conversion Ratio ***	3.4 ± 0.2	3.2 ± 0.4	3.2 ± 0.1

Values are the mean ± standard deviation, \*n = 180, \*\*n = 60, \*\*\*n = 3.

Table 3. Body composition (moisture, crude protein, crude fat, crude ash) (% dry weight) and protein assimilation (protein efficiency ratio, protein retention) at stocking and harvest of the study

Contents	At stocking	At harvest		
		Fishmeal	Mixed meal	Black soldier fly
Moisture	77.6 ± 0.2 (6)	63.4 ± 1.5 (18)	62.8 ± 1.0 (18)	63.1 ± 0.8 (18)
Crude protein	14.9 ± 0.3 (6)	18.1 ± 0.3 (6)	17.8 ± 0.8 (6)	17.2 ± 0.6 (6)
Crude fat	2.8 ± 0.1 (6)	12.0 ± 0.9 <sup>a</sup> (12)	12.3 ± 1.7 <sup>a</sup> (12)	14.4 ± 2.2 <sup>b</sup> (12)
Crude ash	3.8 ± 0.6 (6)	5.4 ± 1.0 <sup>a</sup> (18)	5.7 ± 0.7 <sup>a</sup> (18)	4.1 ± 0.8 <sup>b</sup> (18)
<b>Protein assimilation indices</b>		Fishmeal	Mixed meal	Black soldier fly
<b>Protein efficiency ratio</b>		0.9 ± 0.1 <sup>a</sup> (3)	1.1 ± 0.1 <sup>a</sup> (3)	1.3 ± 0.1 <sup>b</sup> (3)
<b>Protein retention</b>		16.4 ± 0.7 <sup>a</sup> (3)	18.8 ± 2.3 <sup>ab</sup> (3)	21.9 ± 0.8 <sup>b</sup> (3)

\*Values are the mean ± standard deviation, \*numbers in parentheses are the number of samples.

\*\* Different capital letters indicate significant difference (Tukey's HSD test, p < 0.05).

Table 1. Proximate contents of the experimental feeds (% dry matter)

Feed	Fishmeal	Mixed meal	Black soldier fly
Crude protein	32.5	30.0	25.0
Crude fat	6.7	7.6	8.9
Crude ash	11.1	9.5	7.3
Crude starch	22.8	28.0	27.7

Fishmeal: fishmeal only, Mixed meal: fishmeal and black soldier fly mixed meal, Black soldier fly: black soldier fly only

Technical details:



[https://www.jircas.go.jp/en/publication/research\\_results/2019\\_c05](https://www.jircas.go.jp/en/publication/research_results/2019_c05)

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Center for Agricultural Sciences



# A new aquaculture method of giant tiger prawn to improve profitability by utilizing unused biological resources as supplementary live feeds

Production

Demonstration

Item: Penaeidae

Biomass utilization

## Outline

A new method to use filamentous green alga (*Chaetomorpha* sp.) and microsnail (*Stenothyra* sp.) as supplementary live feed for giant tiger prawns in the early stages of aquaculture was developed. The weight of giant tiger prawns cultured by this method increased significantly and the profit was approximately 1.5 times higher than conventional methods. *Chaetomorpha* sp. and *Stenothyra* sp. are expected to be utilized in shrimp aquaculture due to their availability as untapped biological resources, and their suitability for cultivation in intensive shrimp ponds.

## Background/effect/note

Penaeidae shrimp production in intensive aquaculture systems contribute to the economic development of developing tropical countries. However, decreasing shrimp productivity and profitability have been reported owing to deterioration in artificial feed quality and the soaring prices of artificial feed. We examined the profitability of giant tiger prawns produced with *Chaetomorpha* sp. and *Stenothyra* sp. as supplemental live feeds in 9m x 9m experimental ponds (Fig. 1). Giant tiger prawns were fed with 8% *Chaetomorpha* sp. and 2% *Stenothyra* sp. to total feed consumption in the early stage of cultivation, and we observed the differences in their growth from the fourth week (Fig. 2), and the production and profit were increased by about 1.3 and 1.5 times, respectively (Table 1). These untapped biological resources could be utilized for intensive aquaculture of other Penaeidae species and could improve the profitability of tropical Penaeidae farmers.

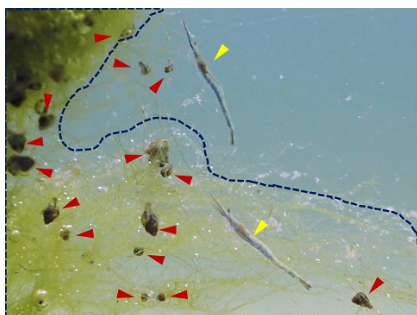


Fig. 1. Post-larvae (Total length: ~9 mm,  $\Delta$ ), *Chaetomorpha* sp. (area within dark blue broken line) and *Stenothyra* sp. ( $\blacktriangle$ )

Table 1. Results of giant tiger prawn aquaculture experiments in concrete aquaculture ponds

	Control area	Experimental area
Total prawn production (kg WW)	33.0	43.9 *
Artificial prawn feed cost (USD) (a)	83.55	98.59 *
Feed efficiency (%)	54.1	61.1 *
Miscellaneous costs (USD) (b)	—	12.11
Prawn Sales (USD) (c)	155.73	215.97 *
Profit (prawn sales minus costs) (USD) (c-a-b)	72.18	105.27 *

\* in the same column indicate significant differences between control and experimental area (n=3) (t-test, p<0.05). Miscellaneous costs are the costs spent on the propagation of supplementary live feed organisms. The increase in artificial feed cost is due to the increase in feed consumption. WW: wet weight.

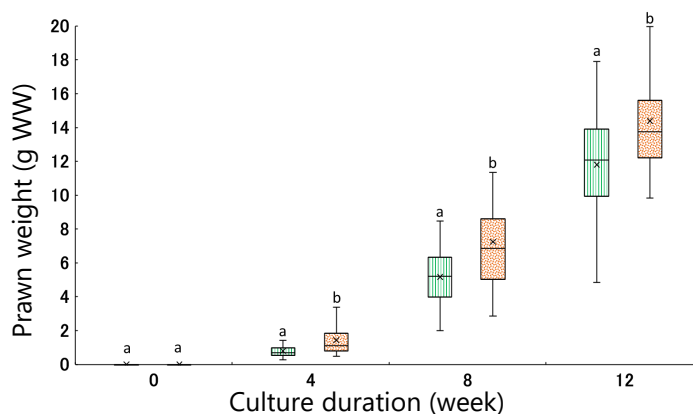


Fig. 2. Changes in wet weight of giant tiger prawn under control (□) and treatment (▣) conditions

Control: Artificial feed only

Experiment: Artificial feed + *Chaetomorpha* sp. + *Stenothyra* sp.

Different lowercase letters within the same sampling week indicate a significant difference between treatments at a significance level of 0.05 adjusted for multiplicity.



Technical details:

[https://www.jircas.go.jp/en/publication/research\\_results/2020\\_c09](https://www.jircas.go.jp/en/publication/research_results/2020_c09)

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# Simple and highly sensitive detection kits for foot-and-mouth disease virus that can be used in the Asia-Monsoon region

Production

Implementation

Item: Livestock

Transboundary disease prevention

## Outline

The foot-and-mouth disease virus (FMDV) antigen detection kit can be used in the field without the need for any special equipment to rapidly detect FMDV antigens in the lesions of the tongue and oral cavities of cattle, pigs, goats, and sheep with foot-and-mouth disease (FMD) with high sensitivity.

## Background/effect/note

Considering the importance of initial disease control during FMD outbreaks, rapid first-line on-site testing is useful for preventing highly contagious FMD (Fig. 1).

The detection kit is expected to prevail not only in Japan but also in countries with insufficient social infrastructure and large areas of national land.

Additionally, a monoclonal antibody-based typing kit that can be used to detect and distinguish all seven serologically different types of FMDV has already been developed. If implemented, this kit would enable simple and quick serotyping. Detailed information on the FMD epidemic situation in neighboring countries will be available through a survey using the detection kit.

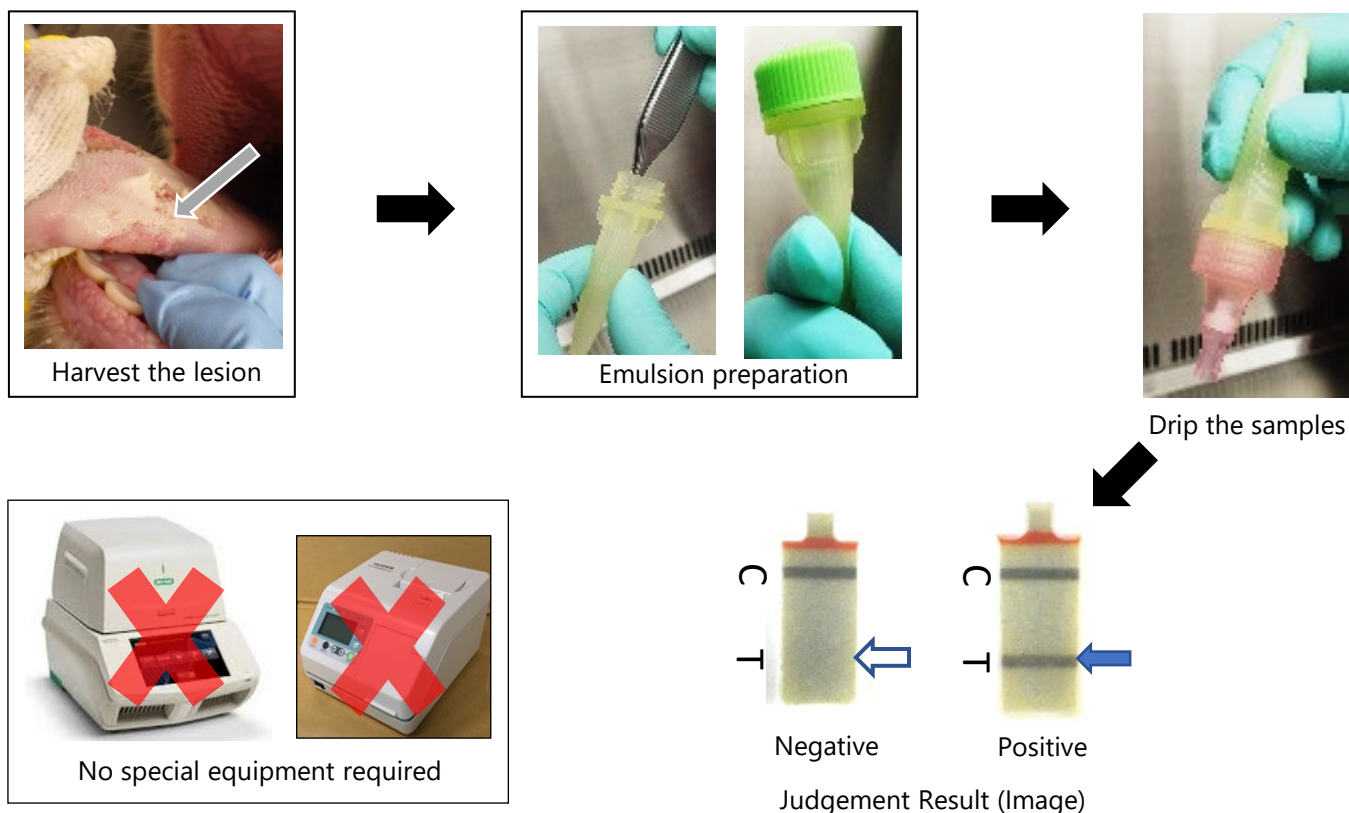


Fig. 1. Flow of detecting foot-and-mouth disease virus using the kit



Technical details:

[https://www.naro.go.jp/project/results/4th\\_laboratory/niah/2019/19\\_051.html](https://www.naro.go.jp/project/results/4th_laboratory/niah/2019/19_051.html) [Japanese]

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National Agriculture and Food  
Research Organization



# Maintaining an acidic condition can prevent liquefaction of fermented rice noodles

Processing and distribution

Implementation

Item: Fermented rice noodles

Food loss reduction

## Outline

Maintenance of acidic condition (approximately pH 4) of fermented rice noodles can suppress the growth of amylase-producing bacteria, which cause liquefaction of the product under the post-manufacturing ambient storage conditions. This technique is effective for reducing food loss and waste.

## Background/effect/note

Fermented rice noodles are traditional foods widely produced and consumed in Thailand. Similar products are common in Laos, Vietnam, Cambodia, Myanmar, and China. These noodles are prepared from fermented rice flour containing lactate and retain quality without rotting for a few days at ambient temperature. However, these noodles may occasionally undergo severe liquefaction, causing economic and food losses (Fig. 1).

This is attributed to bacterial amyolytic enzymes ( $\alpha$ -amylase) that are activated when the pH of the noodles increases to  $\geq 6.0$ . However, liquefaction can be prevented by maintaining the product under an acidic condition (approximately pH 4) (Fig. 2).

In addition to the technology to control liquefaction of the product, the use of a booklet (Fig. 3) that explains the production process and cooking method in simple local language will improve the profitability of producers, reduce food loss, and promote dietary education.



Fig.1. Fermented rice noodles recalled from the market before selling due to the liquefaction

Technical details:



[https://www.jircas.go.jp/en/publication/research\\_results/2019\\_c01](https://www.jircas.go.jp/en/publication/research_results/2019_c01)

<https://www.jircas.go.jp/ja/publication/kanomjeen>

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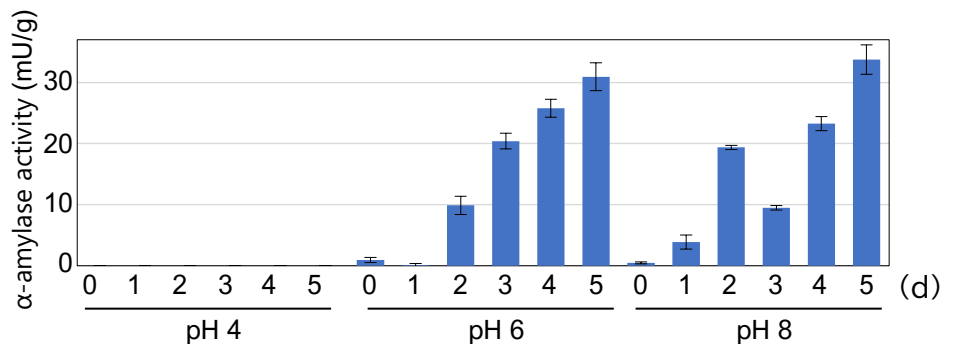


Fig. 2. Time-dependent change in  $\alpha$ -amylase activity (cause for the liquefaction) in fermented rice noodles treated with buffers at pH 4.0, 6.0, and 8.0



Fig. 3. Introduction of pH monitoring methods for fermented rice noodles in the form of a booklet written in Thai

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For inquiries concerning each technology, please contact the e-mail address in each catalog sheet.

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