Green Asia

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

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

Ver. 1.1

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1-1 Ohwashi, Tsukuba, Ibaraki 305-8686
Japan

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.

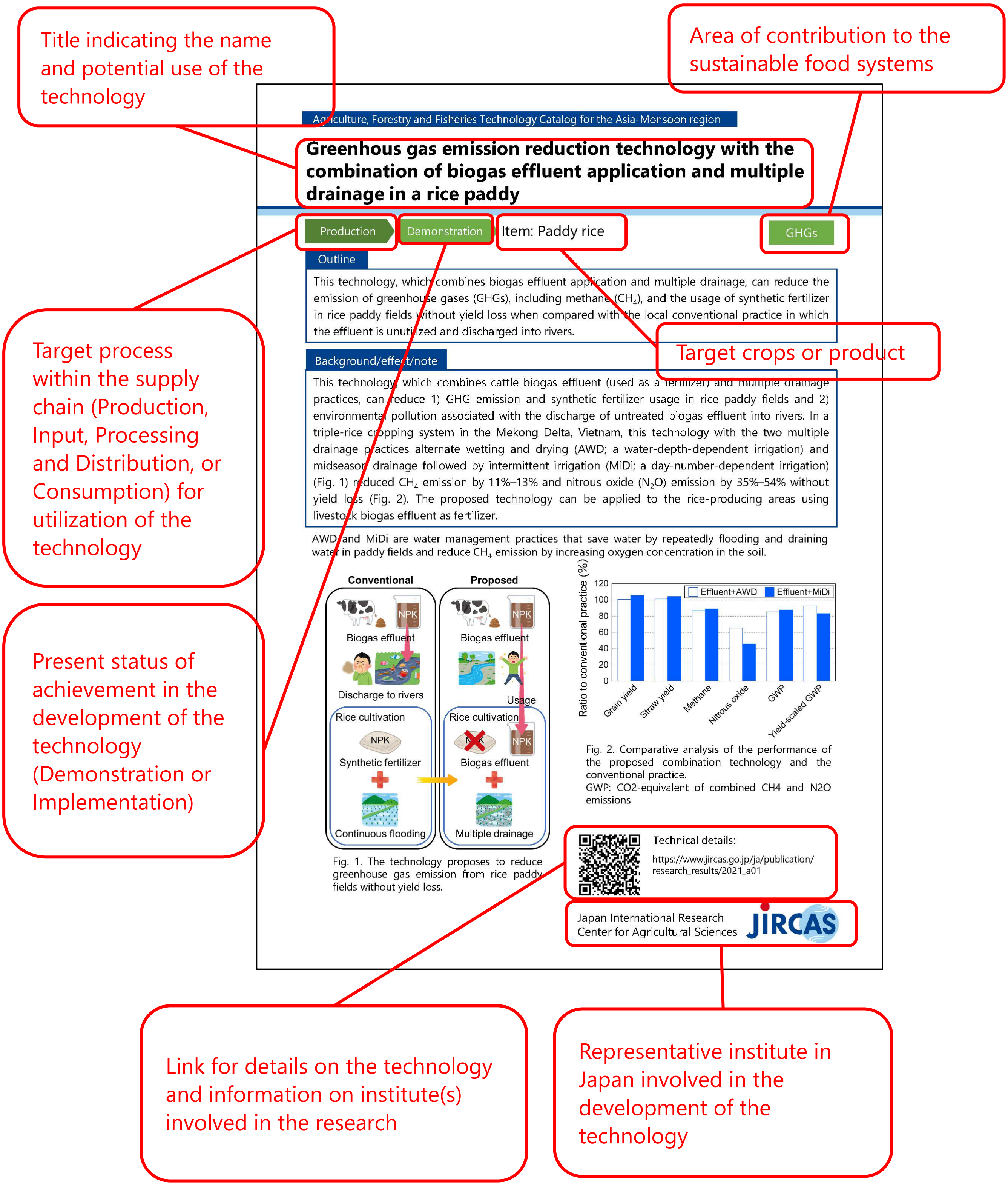
To accelerate testing and disseminating technologies applicable to the region, the Ministry of Agriculture, Forestry and Fisheries (MAFF) assigned the Japan International Research Center for Agricultural Sciences (JIRCAS) to conduct the project “Accelerating application of agricultural technologies which 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.



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

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

Production | Demonstration | Item: Paddy rice | GHGs

Outline

This technology, which combines biogas effluent application and multiple drainage, can reduce the emission of greenhouse gases (GHGs), including methane (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.

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 with the two multiple drainage practices alternate wetting and drying (AWD; a water-depth-dependent irrigation) and midseason drainage followed by intermittent irrigation (MiDi; a day-number-dependent irrigation) (Fig. 1) reduced CH_4 emission by 11%–13% and nitrous oxide (N_2O) 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_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: CO2-equivalent of combined CH4 and N2O emissions

Technical details:
https://www.jircas.go.jp/ja/publication/research_results/2021_a01

Japan International Research Center for Agricultural Sciences

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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_4) 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

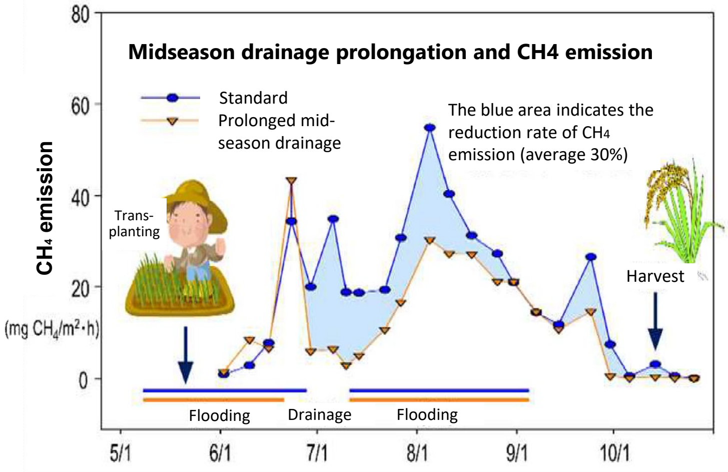

Fig. 2. CH_4 emissions and the effect of prolonged midseason drainage in Fukushima prefecture (example)

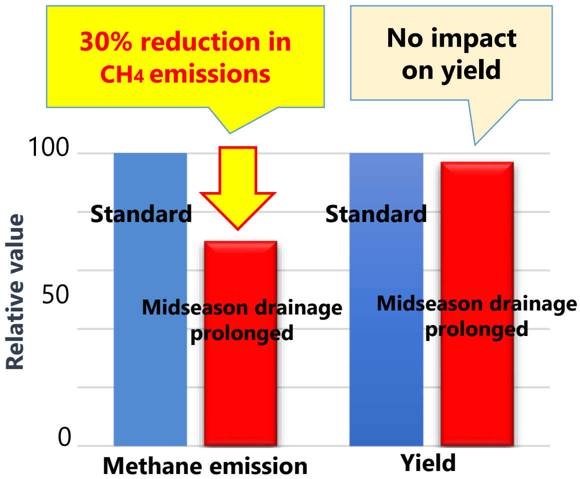

Fig. 3. CH_4 emissions and impacts on rice yield

Technical Details:

https://www.naro.affrc.go.jp/archive/niaes/sinfo/result/result29/result29_02.html (Japanese)

https://www.naro.go.jp/english/laboratory/niaes/files/fftc-marco_book2019_107.pdf (English)

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 (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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AWD and MiDi are water management practices that save water by repeatedly flooding and draining water in paddy fields and reduce CH_4 emission by increasing oxygen concentration in the soil.

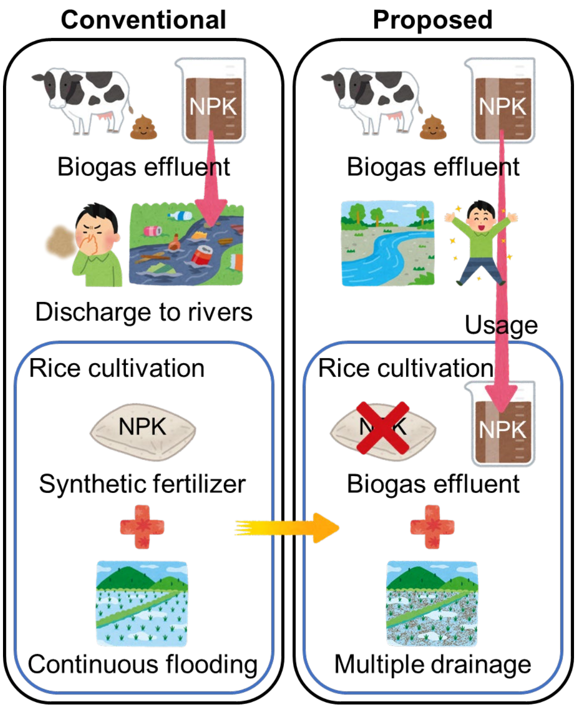


Fig. 1. The technology proposes to reduce greenhouse gas emission from rice paddy fields without yield loss

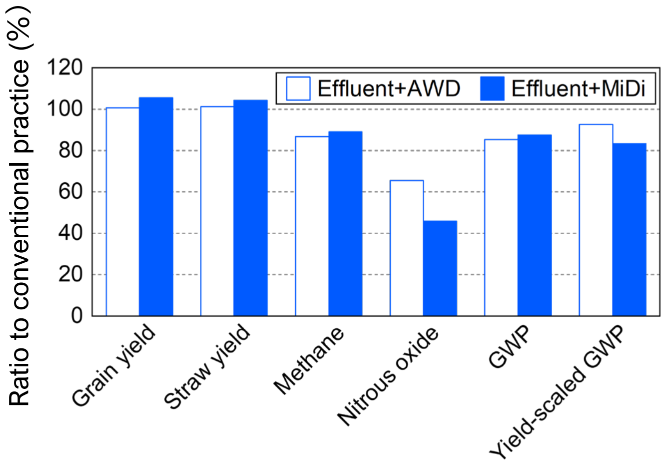


Fig. 2. Comparative analysis of the performance of the proposed combination technology and the conventional practice
GWP: CO_2-equivalent of combined CH_4 and N_2O emissions

Technical details:
https://www.jircas.go.jp/en/publication/research_results/2021_a01

Japan International Research Center for Agricultural Sciences

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‡ of rice cultivation using alternate wetting and drying (AWD).

‡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_4 emissions and increase in N_2O 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_4 and N_2O emissions from soils) at each site (if available) is more desirable than the estimates based on IPCC guidelines.

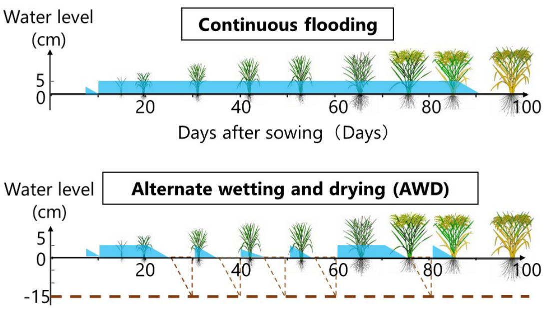


Fig. 1. An example of conventional water management (continuous flooding) and alternate wetting and drying (AWD) during a cropping season

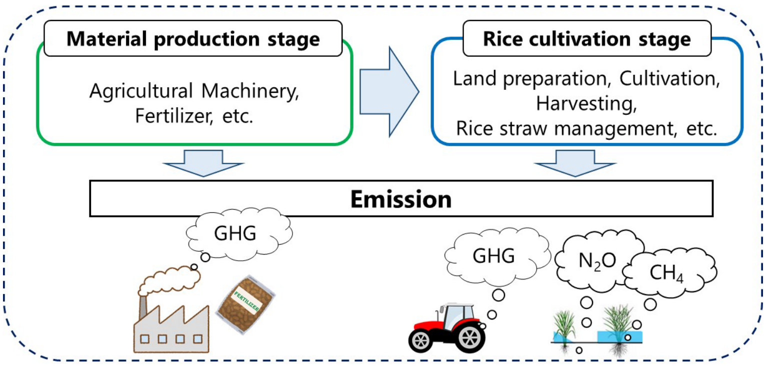


Fig. 2. Life cycle greenhouse gas (LC-GHG) emissions from rice cultivation

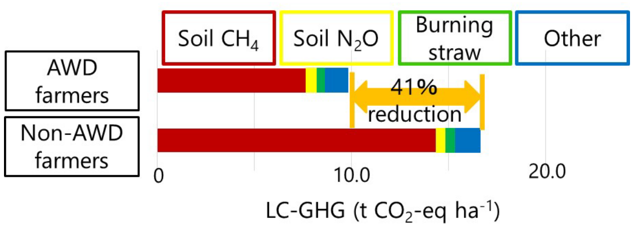


Fig. 3. Comparing greenhouse gas (GHG) emissions between alternate wetting and drying (AWD) farmers and non-AWD farmers

Technical details:

https://www.jircas.go.jp/en/publication/research_results/2020_a02

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.

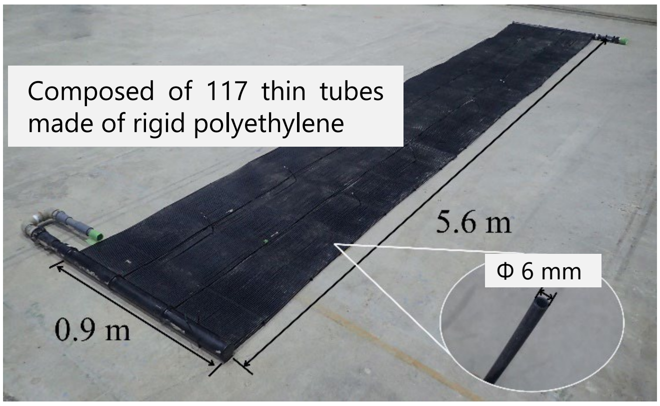


Fig. 1. Sheet-type heat exchanger

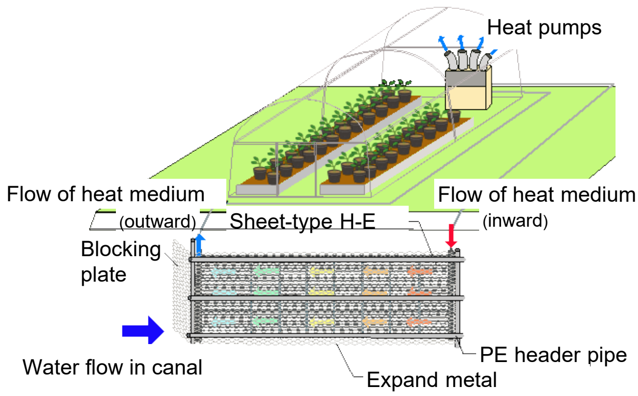


Fig. 2. Schematic view of heat utilization in greenhouse (cooling)

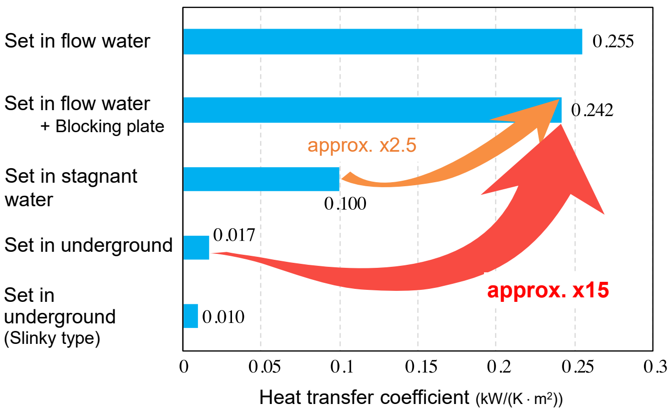


Fig. 3. Comparison of heat exchange efficiency

Technical details:
https://www.naro.go.jp/english/laboratory/nkk/press_release/sheetheatexchanger/index.html

National Agriculture and Food Research Organization

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

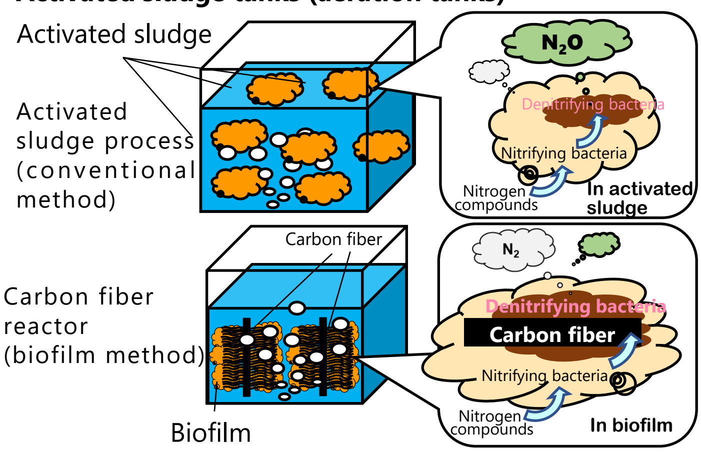


Fig. 1. Differences between the conventional activated sludge method and the carbon fiber reactor (biofilm method) [conceptual diagram]

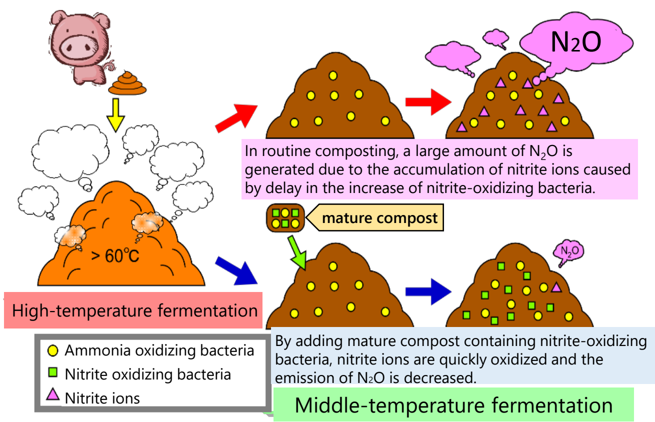


Fig. 2. Effect of mature compost addition on the reduction of greenhouse gas emissions [conceptual diagram]

Technical details:

①
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 [English]

National Agriculture and Food Research Organization
農研機構 NARO

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_4 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

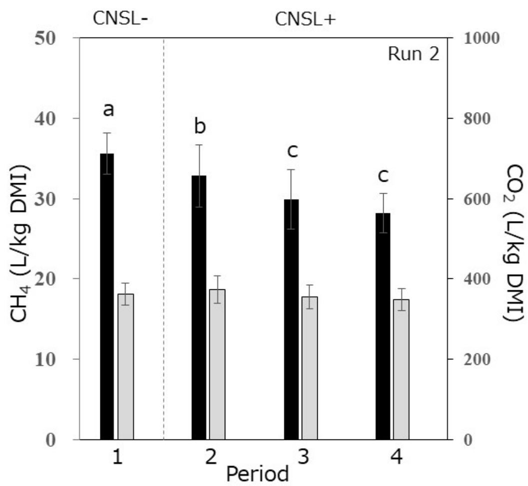


Fig. 2. Enteric methane (CH_4, black) and carbon dioxide (CO_2, grey) emissions per kg dry matter intake (DMI) from Lai Sind cattle with continuous CNSL feeding (4 periods of 5 days/period)

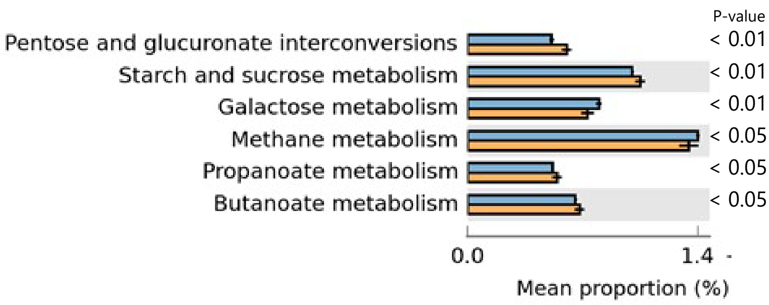


Fig. 3. Effect of cashew nut shell liquid (CNSL) feeding on the function of the rumen microbiome
Orange: CNSL+, Blue: CNSL-
Propanoate metabolism is significantly stimulated due to CNSL feeding.

Technical details:

https://www.jircas.go.jp/en/publication/research_results/2020_a01

Japan International Research Center for Agricultural Sciences

Low-cost, high-efficiency production of CH_4 and H_2 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_2 and H_2 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_4 and H_2. Additionally, CO_2 and H_2 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

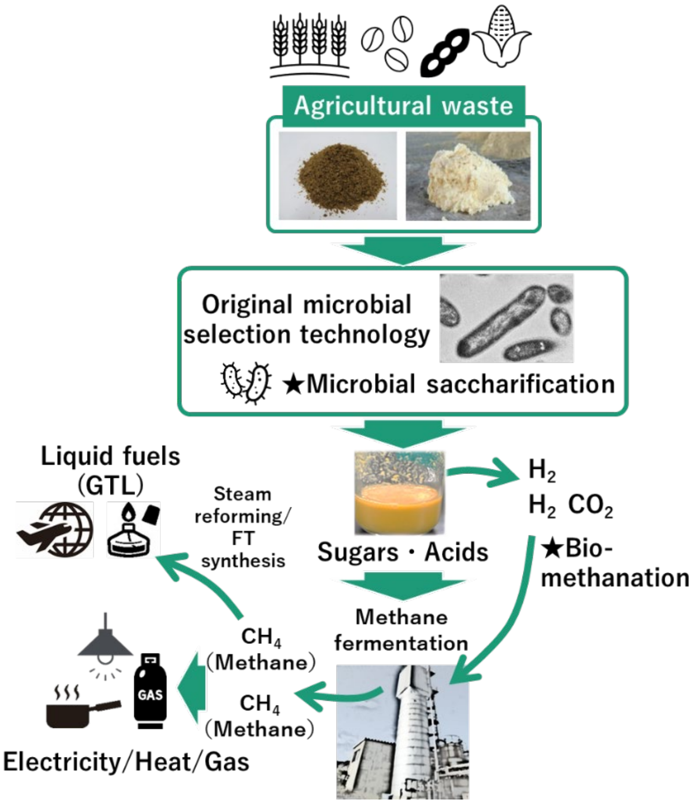


Fig. 2. Overview of low-cost, high-efficiency CH_4 and H_2 production technology through microbial saccharification and bio-methanation
GTL: Gas to Liquid

Technical details:

https://www.jircas.go.jp/en/publication/research_results/2020_c03
https://www.jircas.go.jp/en/publication/research_results/2014_c05

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

Characterization of each pellets made by Multi-Biomass Treatment Process using oil palm biomass

Properties	OPT pellet	EFB pellet	OPF pellet	MCF pellet
Bulk specific gravity	720 kg/m³	850 kg/m³	800 kg/m³	795 kg/m³
Lower heating value	17,470 J/g	17,920 J/g	17,940 J/g	18,750 J/g
Potassium	<500ppm	1400ppm	900ppm	900ppm
Moisture	8.8%	7.4%	9.4%	4.4%
Mechanical durability	97.1%	98.9%	98.9%	92.6%

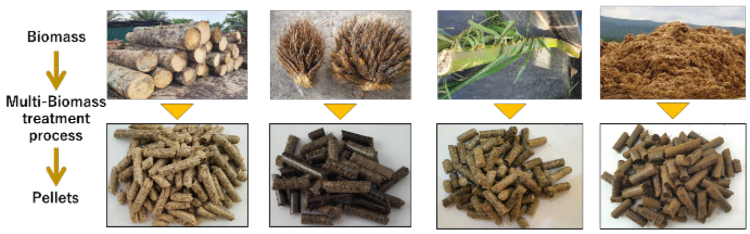


Fig. 2. Biomass pellets are produced by the Multi-Biomass Treatment Process. Sustainable and high-quality pellets can be produced in the same process.

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/2015_c07

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_2O) 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.).

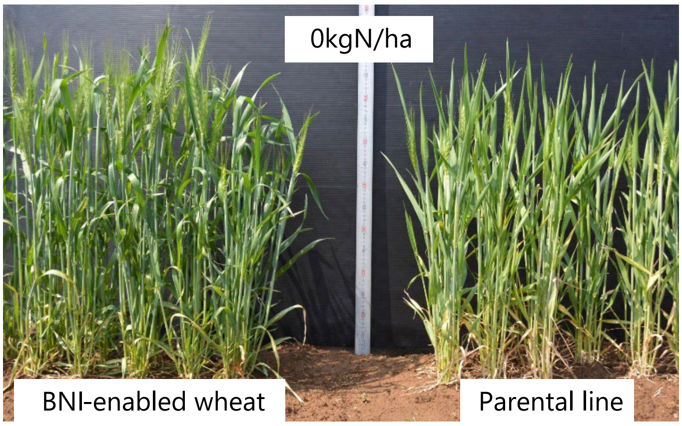


Fig. 1. Biological nitrification inhibition (BNI)-enabled wheat exhibits improved productivity under low nitrogen conditions in the field.

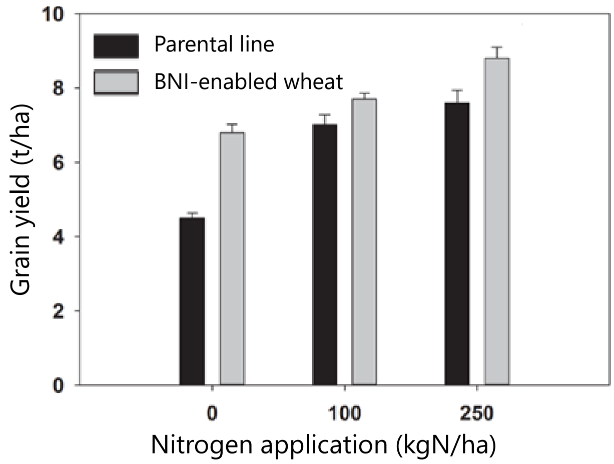


Fig. 2. Grain yield with different nitrogen application amounts

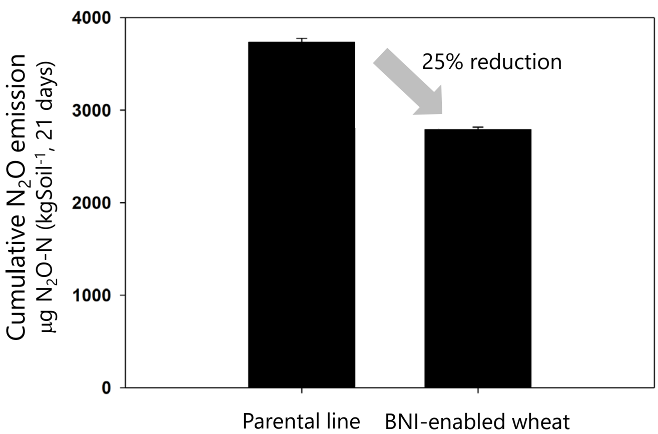


Fig. 3. N_2O emissions from rhizosphere soil

Technical details:

JIRCAS research highlights (FY2021)

https://www.jircas.go.jp/en/publication/research_results/2021_a04

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.

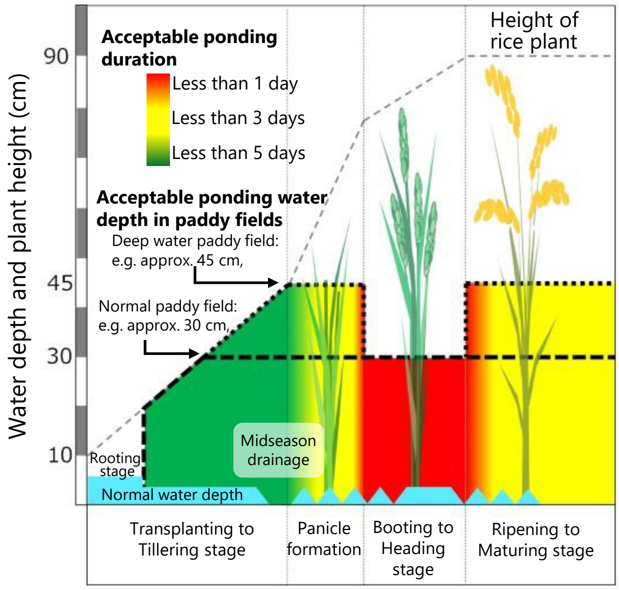


Fig. 1. Growth stages of rice and threshold of ponding water depth that rice plants tolerate

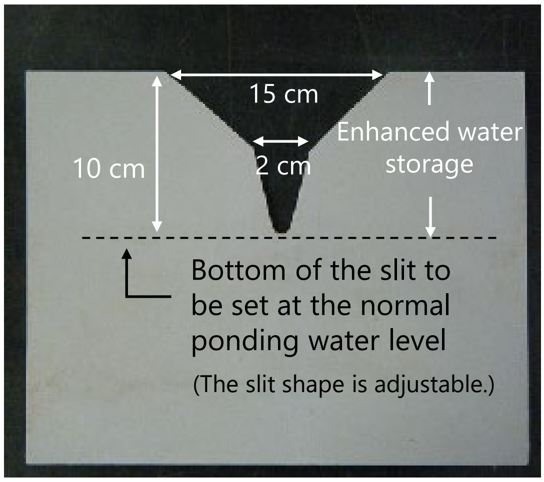


Fig. 2. Structure of the weir plate "Damkeeper" (water level control device)

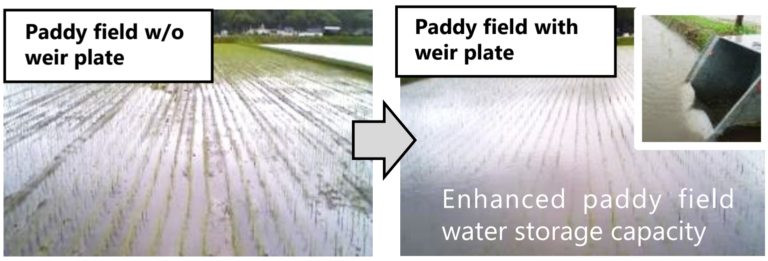


Fig. 3. Demonstration of "Paddy Field Dam" (immediately after heavy rain)

Technical Details:
https://www.naro.go.jp/english/topics/laboratory/nkk/136445.html

National Agriculture and Food Research Organization

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).

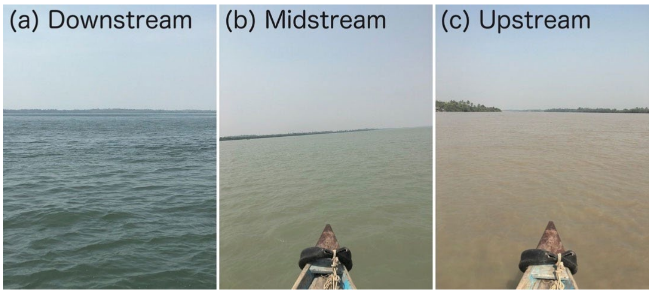


Fig.1. Photographs of river water conditions in the (a) downstream, (b) midstream, and (c) upstream reaches of Ywe River on 9 March 2018

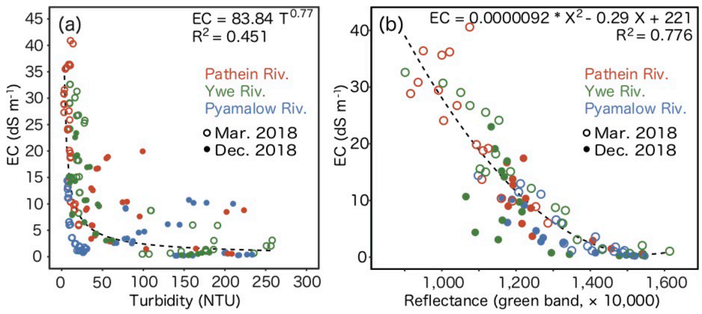


Fig. 2. Correlation between (a) turbidity and electrical conductivity (EC), and (b) EC and green band reflectance retrieved from Sentinel-2

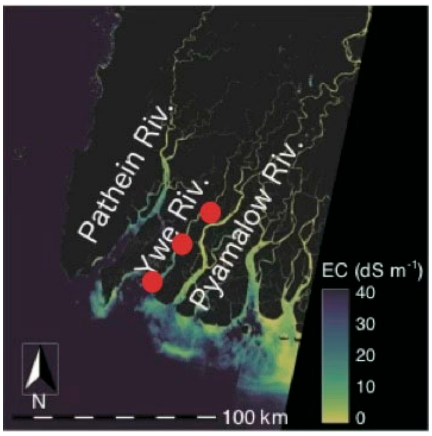


Fig. 3. Electrical conductivity (EC) map derived from the reflectance of the green band in the satellite image (March 12, 2018)
The red dots are locations where the images shown in Fig. 1 were captured.

Technical details:

https://www.jircas.go.jp/en/publication/research_results/2020_a03

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

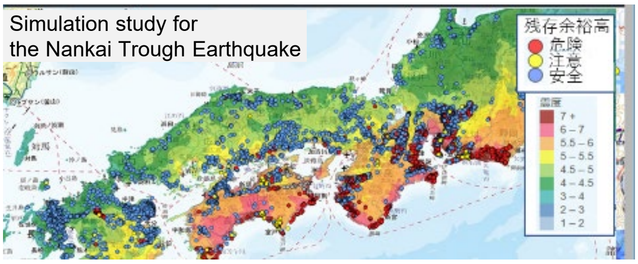
Outline

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.

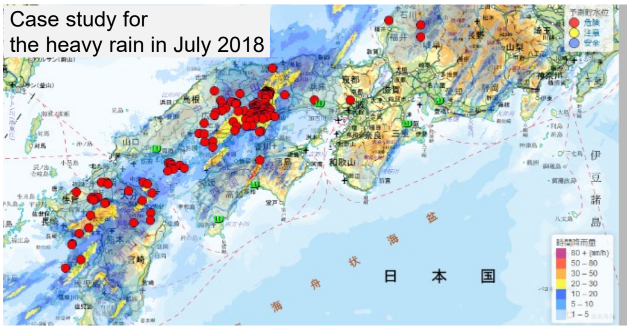
Background/effect/note

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/pondapp/index.html

National Agriculture and Food Research Organization

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

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

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 (JIRCAS)

National Agriculture and Food Research Organization

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.

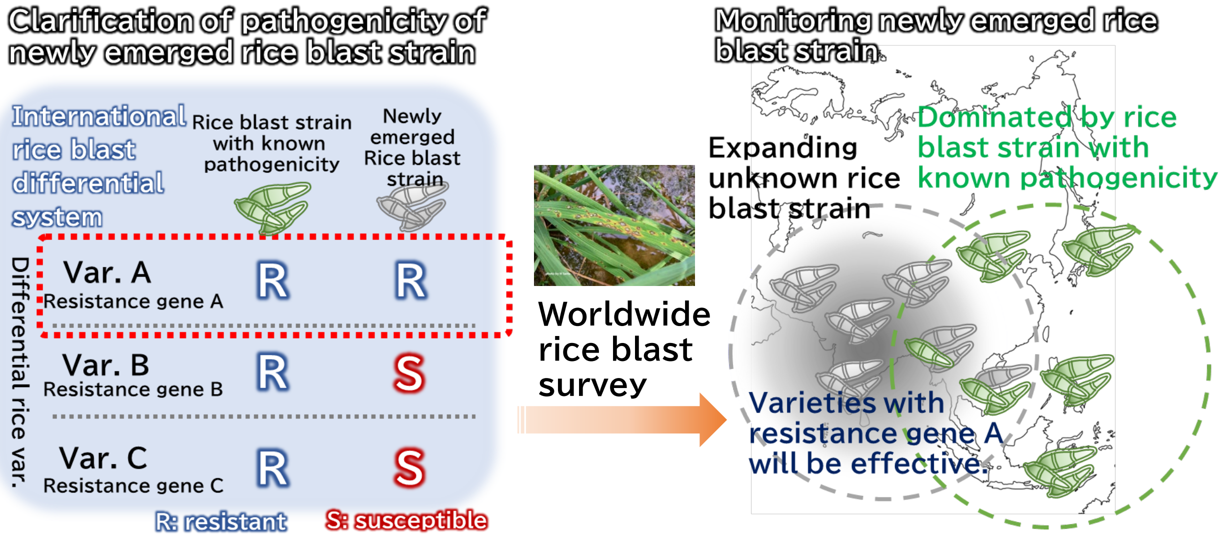
Background/effect/note

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.



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.

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

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

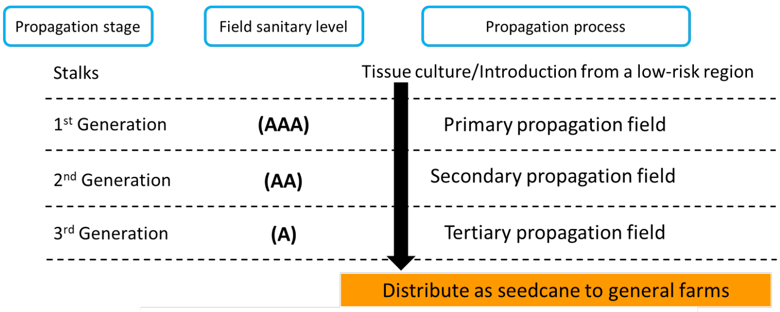
Outline

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)



Management system corresponding to the field sanitary level

Field sanitary level	Isolated field	Large area cultivation	Removal of diseased stalks	Pesticide treatment	Evaluation of the latent disease probability
AAA	〇	〇	2 times/month	〇	〇
AA	〇	×	1 time/month	〇	〇
A	×	×	1 time/month	〇	〇

〇: recommended ×:no-recommended

Fig. 2. Overview of the healthy seedcane propagation system

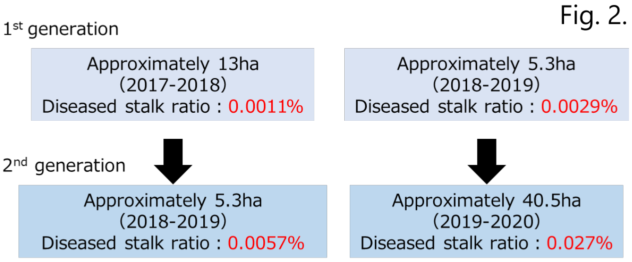


Fig. 3. Results of the healthy seedcane propagation verification test

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

Japan International Research Center for Agricultural Sciences

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.

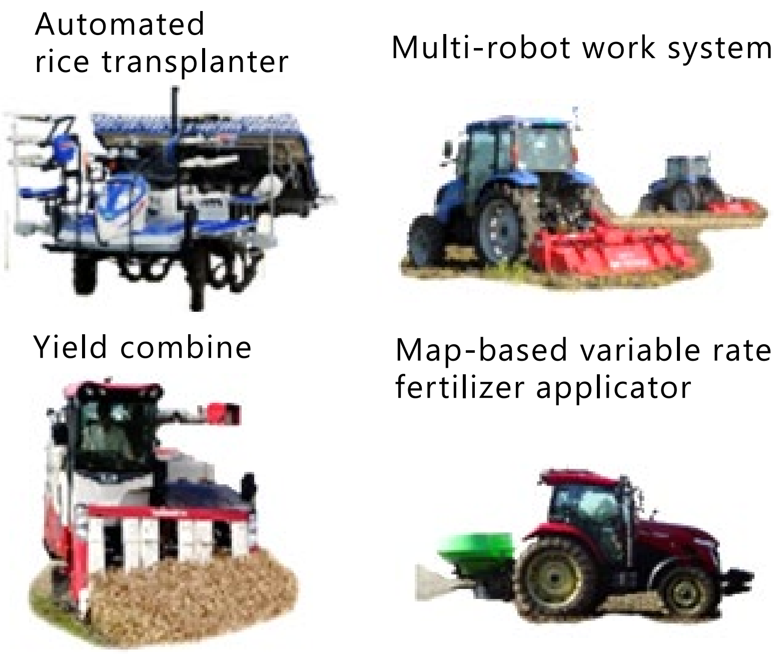


Fig. 1. Examples of smart agricultural production systems

Technical Details: [Japanese]
https://www.naro.go.jp/publicity_report/press/laboratory/iam/075850.html
https://www.naro.go.jp/project/results/4th_laboratory/tarc/2017/17_003.html

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
農研機構 NARO

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

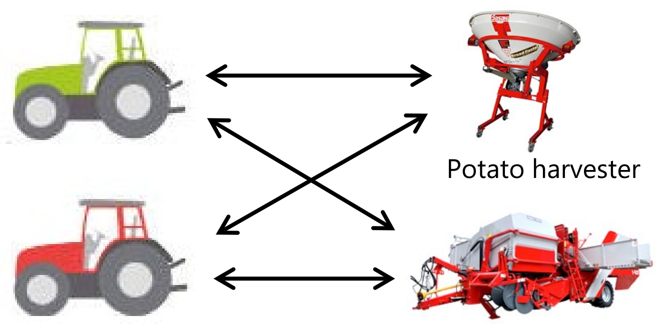


Fig. 2. Image of data exchange through electronical connections between the tractors and the other machines

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

Technical details:

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 (English)

National Agriculture and Food Research Organization

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

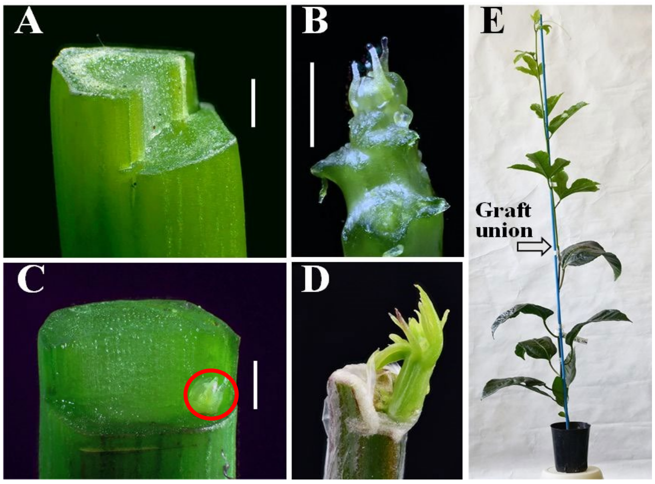


Fig. 2. In vivo shoot-tip grafting of passion fruit (bar = 1 mm)

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

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

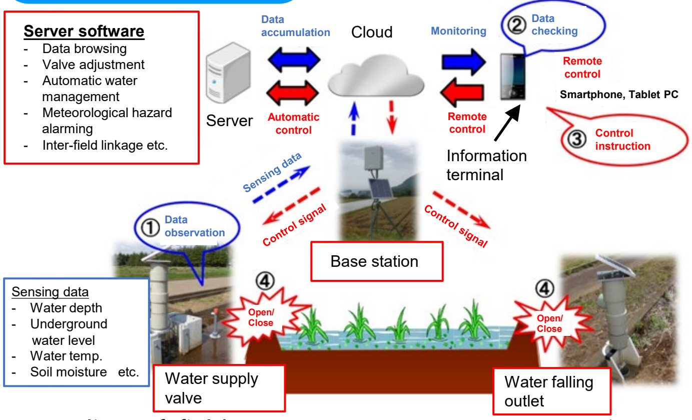
Outline

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.

WATARAS



Outline of field water management system using information and communication technology.

iDAS

Data linkage

Simulation of the optimum valve opening in the field.

Automatic control of water distribution facilities.

Communication

Communication

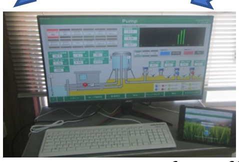


Fig. 1. Management system for efficient agricultural water supply from irrigation facility to paddy field

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
(Video) Easy Water Management of Paddy Fields with Smartphones [Japanese]
https://www.youtube.com/watch?v=tdwMKx-a2hs&list=PLW99yTRNzVkNDB0HaClwbaqGa-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

National Agriculture and Food Research Organization

農研機構 NARO

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

Production | Implementation | Item: Sugarcane | Biomass utilization

Procurement | Implementation

Outline

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

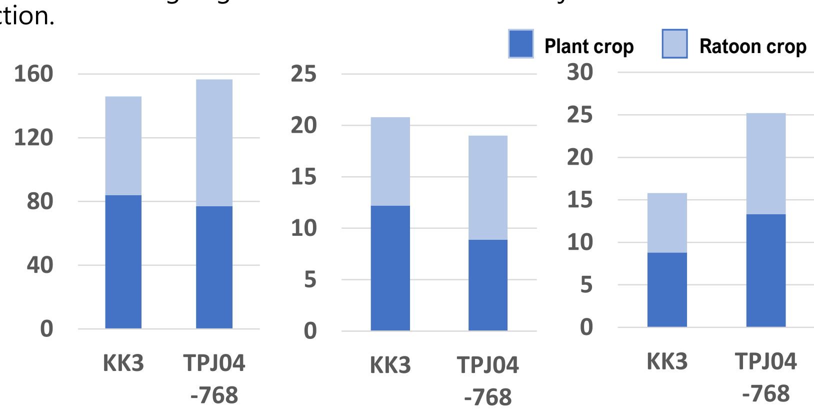


Fig. 2. Yield of TPJ04-768 at plant and ratoon crop (t/ha) in Khon Kaen of Northeast Thailand
Left: Cane yield, Middle: Sugar yield, Right: Fiber yield

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

Japan International Research Center for Agricultural Sciences

JES1: A new *Erianthus* cultivar for biomass production

Production | Implementation | Item: *Erianthus* | Biomass utilization

Procurement | Implementation

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)

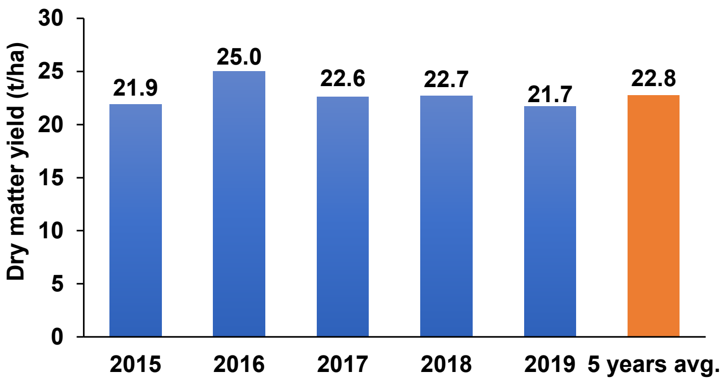


Fig. 2. Dry matter yield of JES1 in a practical field in Sakura City, Tochigi Pref. in Japan

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.naro.go.jp/english/topics/laboratory/nilgs/077373.html

Japan International Research Center for Agricultural Sciences
JIRCAS
National Agriculture and Food Research Organization
農研機構 NARO

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.

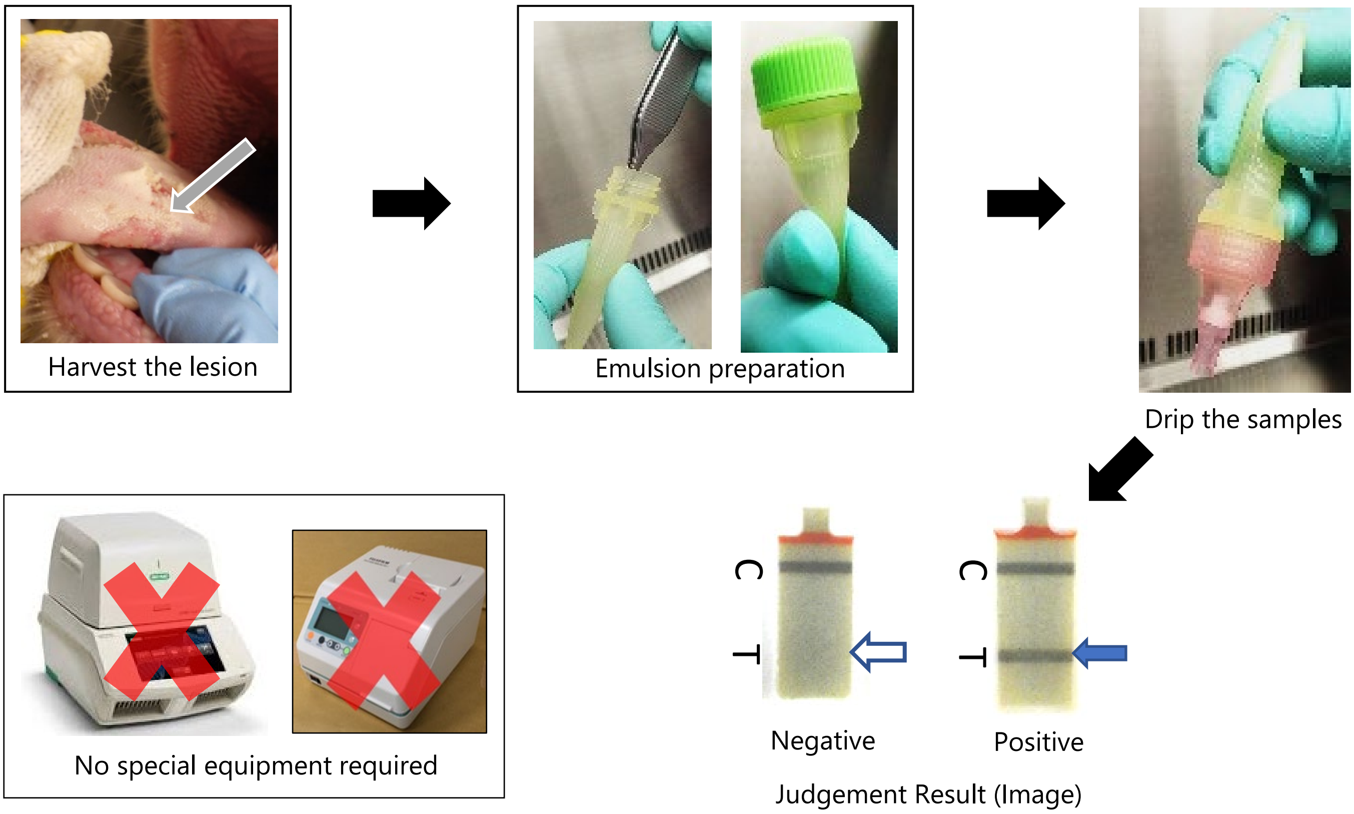


Fig. 1. Flow of detecting foot-and-mouth disease virus using the kit

Technical details:

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

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 amylolytic enzymes (α-amylase) that are activated when the pH of the noodles increases to ≥ 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

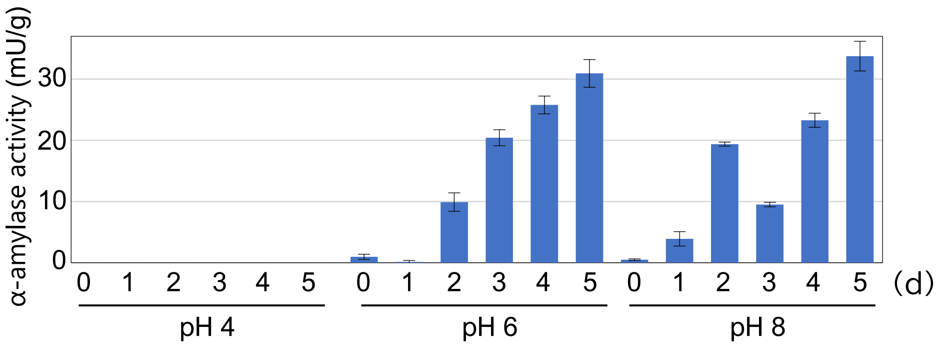


Fig. 2. Time-dependent change in α-amylase activity (cause for the liquefaction) in fermented rice noodles treated with buffers at pH 4.0, 6.0, and 8.0

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

Technical details:

https://www.jircas.go.jp/en/publication/research_results/2019_c01
https://www.jircas.go.jp/ja/publication/kanomjeen

Japan International Research Center for Agricultural Sciences

JIRCAS

For inquiries concerning each technology, please contact the following.

Japan International Research Center for Agricultural Sciences (JIRCAS)
The International Center for Strategy “MeaDRI”
Mail info-greenasia@jircas.affrc.go.jp

Japan International Research Center for Agricultural Sciences (JIRCAS)

1-1 Ohwashi, Tsukuba, Ibaraki 305-8686, Japan

Tel. +81-29-838-6313　Fax: +81-29-838-6316

https://www.jircas.go.jp/en/greenasia/techcatalog