

Proposals for post-disaster reconstruction of agriculture

NARO's new technologies supporting reconstruction
- Revitalization of agriculture by post-disaster reconstruction -

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National Agriculture and Food Research Organization
(NARO)

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I. General

1. Introduction

The Great East Japan Earthquake claimed many precious lives and property in an instant and left enormous damage and deep scars in the realm of agriculture, which is a key industry in the disaster-affected regions, and in rural societies in these regions. There is no time to lose in reconstructing the lives of farmers and local residents through the reconstruction of agriculture in the disaster-affected regions.

Immediately after the occurrence of the Great East Japan Earthquake, the National Agriculture and Food Research Organization (NARO) started its investigation of damage to farmland and agricultural facilities and has provided technical support for restoration at the request of the Ministry of Agriculture, Forestry and Fisheries (MAFF). In addition, in collaboration with relevant organizations and farmers, NARO has made efforts to implement measures against salinization and liquefaction and to develop techniques to clean up farmland contaminated by radioactive substances.

Even before the disaster occurred, Japan's agriculture has been subjected to several difficulties, such as a pronounced shortage of people engaged in agriculture, the rising age of farmers, a decrease in income, and an increase in abandoned agricultural land. In addition, agriculture has been required to become more competitive in response to globalization of the economy. Agriculture in the disaster areas cannot be truly reconstructed without resolving problems inherent to Japan's agriculture; in addition, the rapid rebuilding of the agricultural infrastructure and production activities after the damage caused by the disaster is required.

Revitalizing agriculture and regional communities by turning agriculture into a growth industry and making it attractive to young people will be a route to reconstruction and development of agriculture in the disaster-afflicted regions.

On the basis of a master plan for reconstruction of agriculture and rural communities (MAFF, August 2011) and basic policy and an action plan for the Revitalization of Japan's Food, Agriculture, Forestry, and Fisheries (The Council to Promote the Revitalization of Food, Agriculture, Forestry, and Fisheries, October 2011), NARO supports the realization of reconstruction of the

disaster-affected regions as a disaster-resilient, new food-supply base using advanced agricultural technologies in collaboration with relevant organizations, farmers, etc.

This report introduces the advanced agricultural technologies that NARO has developed and presents a new vision of agriculture utilizing advanced agricultural technologies and processes for reconstruction.

This proposal report is compiled by NARO's headquarters with the cooperation of the National Institute of Agrobiological Sciences (NIAS), the National Institute for Agro-Environmental Sciences (NIAES), the Forestry and Forest Products Research Institute (FFPRI) and the Japan International Research Center for Agricultural Sciences (JIRCAS).

2. Prospects of post-disaster reconstruction of agriculture

As an indication of the aims of post-disaster agriculture reconstruction, NARO proposes five scenarios according to diverse agricultural locations and conditions and regional resources in the disaster-afflicted regions.

① Advanced uses of paddy fields toward the second Green Revolution

In flat plains of the disaster-affected regions, most of the land is covered by paddy fields, and productivity is expected to be greatly increased by improvement of farming conditions, such as improvement of irrigation and drainage, consolidation of cultivated lands into larger blocks, and increase in scale. In addition, introduction of underground water level controlling system that enables both underdrainage and subirrigation allows expansion of the system for the cultivation of new crops. For instance, it enables the advanced use of paddy fields such as the stable production of soybean, barley, wheat as well as rice, and the outdoor cultivation of vegetables. Moreover, by promoting labor saving through introduction of a new direct sowing technique for paddy rice, adopting very high-yielding cultivars for forage, and agricultural machinery using information technology (IT), regional crop rotation systems affording extremely high land and labor productivity will be established. These efforts will realize agricultural innovation, known as the second Green Revolution.

② Highly productive and highly profitable greenhouse horticulture

Coastal areas of the disaster regions have cool summers, and also have warm winters and high solar radiation. Greenhouse horticulture makes maximum use of such a climate and will afford highly productive and highly profitable agriculture.

In areas where early resumption of farming with low investment is required, a combination of soil-less culture technologies and profitable crops such as summer and autumn strawberry can lead to profitable farming. In areas where large-scale greenhouse horticulture can be adopted, on the other hand, production of high-quality crops and profitable farming will be achieved by introducing large-scale greenhouses, automation of harvesting, energy-saving techniques, and techniques using natural energy. In addition, the development of rationally planned, large-scale greenhouse horticultural parks, efficiently integrate the processes of sorting, packaging, processing, and shipping of crops, will increase employment and improve profits in the area.

③ “Sixth industrialization” and branding the products made from new cultivars

Even in regions with small flat plains, such as the Sanriku coast, and hilly and mountainous areas, profitable farming will be possible by taking into consideration regional conditions and selecting cultivars and techniques of cultivation and processing that take full advantage of the characteristics of each region. For example, a combination of the introduction of new cultivars, such as the easily processed “Porotan” (a Japanese chestnut cultivar with easy peeling pellicle), and processing and distribution techniques leads to intraregional processing of agricultural products and the sixth industrialization (creating new business through the fusion of primary, secondary, and tertiary industries), resulting in revitalization of the region. Use of an ordering system that allows delivery of packed fresh-cut vegetables to a farmers’ market contributes to the added value of agricultural products in the region. A new regional brand is expected to be formed by creating a new business model involving introduction of distinctive cultivars containing functional ingredients, such as “Yuyakemochi” (a rice cultivar with high polyphenol content), “Koiazusa” (a rice cultivar with high GABA content), and “Beau Fiber” (a barley cultivar with high β -glucan content), and the formation of an industrial consortium in collaboration with other industries.

④ Energy-producing agriculture (biofuels etc.)

The construction of an independent and diffuse energy system utilizing local resources present in rural communities enables creation of employment and income, secures energy supply in disaster situations, and enhances response capacity to disasters. Technology for producing biofuels from rice straw and cellulosic biomass crops and small-hydro technologies at agricultural water-use facilities will be introduced to realize such an energy system and, finally, the development of energy-producing agriculture and rural community.

In addition, environmentally benign agriculture can be achieved by exploitation of surplus or unused energy; this could include, for example, introduction of cogeneration technology and air-inflated double-layer greenhouses, an air conditioning system in greenhouses using unused heat sources such as ground heat under farmland, and energy production by methane fermentation of animal manure and food wastes.

⑤ Regional integrated agriculture incorporating livestock farming

Intraregional or interregional cooperation enables a stable supply of feedstuff and sustainable livestock farming. Rice straw has been used as feedstuff and livestock wastes have been used as manure, so far. In addition, new feed preparation techniques such as fermented total mixed ration and fermented liquid feed allow effective use of substandard agricultural products and food wastes. In particular, by-products such as pomace from juice processing contain functional ingredients and are expected to be used effectively. Production techniques involving high-nitrogen compost and nutrient-adjusted, pelletized compost enable effective use of livestock wastes. Incorporating these techniques into regional agriculture makes possible the realization of sustainable livestock farming and more advanced regional integrated agriculture.

3. Reconstruction process and NARO's efforts

Relevant organizations have to devote all their energies to the speedy realization of resumption of farming and the subsequent reconstruction of agriculture. This section describes problems in the reconstruction process and efforts NARO can make in collaboration with farmers and other relevant organizations in order to realize the reconstruction.

① Consensus building and planning for land-use

Consensus formation, taking intentions of farmers into consideration, is important for consolidation of cultivated lands into larger blocks, gathering of scattered farmlands, and construction of agricultural infrastructure for more effective land use. NARO supports it by providing a management simulation, available to help design a management plan for farming after consolidation of cultivated lands into larger blocks and increase in scale. Moreover, thorough discussions among farmers and local residents are important to formulate a reconstruction plan. NARO supports scientific and technical evidence-based formulation of reconstruction plans in the disaster-affected regions by providing a system that visualizes land-use plans, evacuation routes, etc. and simulations of landscapes and tsunamis.

② Rehabilitation of agricultural infrastructure taking long-term reconstruction into account

Since immediately after the disaster, NARO has been providing technical support in cooperation with relevant organizations for early restoration of agricultural infrastructure destroyed by earthquake and tsunami. In addition, NARO has been promoting on-site support for risk assessment of salinization and countermeasures against it, comprehensive techniques to restore disaster-stricken farmland covered with debris and sludge, and so forth. In future, for agricultural infrastructure taking long-term reconstruction into account, NARO will present easy, low-cost farmland improvement techniques such as underground water level controlling system and ground-leveling techniques for reorganization of paddy fields, an earthquake-resistant technique involving shallow-buried pipelines, and techniques for constructing earthquake- and overflow-resistant earth structures. Furthermore, in order to minimize the damage caused by disasters, NARO offers technologies that allow the use of farmland for dissipating tsunami energy and improving earthquake

resistance, thus, introducing the concept of positive disaster mitigation.

③ Early resumption of farming and increasing sophistication of farming system

In areas where farmland cannot be used immediately because of salinization, etc., early resumption of farming with little capital is needed to establish the livelihoods of active farmers and to secure their new income. Soilless culture of strawberry or tomato in greenhouses constructed with prefabricated units, which can be built at low cost in a short time period, growing fruit with root zone restriction treatment, production of salt-tolerant crops during the process of salt removal, and pasturing cattle will contribute to early resumption of farming in tsunami-hit farmland. More sophisticated farming systems are expected to be constructed, combining these techniques that enable resumption of farming with the new techniques described in section 2 above. NARO will offer techniques and information necessary for such efforts.

④ Removal of radioactive substances from farmlands and reduction of their transfer to agricultural and livestock products

The first thing to do in rural areas contaminated by radioactive substances is removal of radioactive substances, or decontamination. In collaboration with other relevant organizations, NARO conducted preliminary experiments and verification experiments to study decontamination techniques and demonstrated several techniques taking account of land categories (paddy fields or dry fields), degree of contamination, decontamination effectiveness, safety, and workability. These techniques include those involving (1) scraping off surface soil with agricultural machines; (2) scraping off surface soil after binding the surface layer of soil to prevent dust from scattering and to ensure decontamination; (3) (available only for paddy fields) sequential treatment involving stirring surface soil-water mixture at shallow depths (shallow puddling), discharging the turbid water, separating contaminated soil particles from water, and removing the contaminated soil particles; and (4) burying contaminated topsoil by plowing. Moreover, NARO has clarified the behavior of radioactive substances in crops, and has developed a technique to reduce transfer of radioactive substances to agricultural and livestock products. It may also be necessary to consider plant factories, which can reduce the influence of radioactive substances on crops, in response to regional needs. In radioactively contaminated regions, continual long-term efforts have been required

for reconstruction of agriculture and recovery of trust in agricultural and livestock products; NARO continues to provide the necessary techniques and information.

⑤ Fostering and providing support for principal farmers and bearers leading new agricultural system

It is necessary for agricultural reconstruction to foster independent farmers with high productivity and profitability based on advanced techniques and high management capability. NARO promotes construction of business models leading to creation of new products, organization of regional farming, and development of techniques useful to newcomers to agriculture. In addition, through on-site training courses and studies in which farmers participate, NARO supports realization of highly productive agriculture and development of bearers who will lead reconstruction of agriculture.

① Participation in regional cooperative community for creation of new agriculture

It is necessary for creation of new agriculture in respective disaster-affected areas to create places, or platforms, where not only farmers, research institutes, and administration but also people engaged in commerce and industry, nonprofit organizations (NPOs), etc., work together. NARO has made preparations to rapidly respond to requests for support from the disaster-afflicted regions and has also been contributing to reconstruction of the regions and creation of new agriculture by providing information on NARO's new techniques through the following efforts: on-site verification experiments; participation in collaboration with industry, academia, and government or in platforms; holding of symposiums and events; and set-up of a technical information website and provision of technical consultation services.

II. Advanced agricultural technologies for agricultural reconstruction (description of techniques)

1. Techniques for resumption of farming and reconstruction

① Consensus building and planning for land-use

- Easy-to-operate geographic information system to allow inhabitants to select evacuation routes
- A system projecting a landscape after disaster reconstruction
- A method for examining the influence of construction of seawalls on the living environment
- Databases of technology system and income and expenditure to support formulation of farm management plans
- Support method for community-based group farming
- Support for new farmers in disaster-affected agricultural regions
- Prediction of tsunami-flooded areas by computational fluid dynamics simulation

② Rehabilitation of agricultural infrastructure taking long-term reconstruction into account

- Low-cost grading and land leveling method for restoration of disaster-devastated paddy fields
- Efficient grading and land leveling method using RTK-GPS
- Construction technique for earth structures resistant to heavy rainfall and earthquake
- Shallow burying technique to prevent pipe flotation and movement during earthquakes
- Disaster-risk-forecasting system useful for precaution and inspection
- Simple technique that farmers and local residents can adopt for repairing leaks in irrigation channels
- Low-cost, weather-resistant pipe-framed greenhouses
- Disaster prevention system automatically distributing the degree of collapse risk of irrigation ponds and forecasted flooded area
- Comprehensive restoration techniques for tsunami-stricken farmlands
- Saving communities from tsunami using agricultural hinterlands and farm roads

③ Early resumption of farming

- Rapid and nondestructive measurement of salinity distribution in farmlands
- Cultivation method for mitigating salt damage to paddy rice
- Selection and cultivation of salt- and flood-tolerant plants
- Techniques for reducing salt in farmlands using salt- and flood-tolerant pasture plants
- Maintenance of farmlands by grazing

④ Removal of radioactive substances from farmlands and reduction of their transfer to agricultural and livestock products

- Burying radioactive cesium by plowing
- Removal of radioactive cesium by scraping of topsoil
- Removal of radioactive cesium by scraping hardened topsoil
- Removal of soil containing radioactive cesium after puddling with water

1. Techniques for resumption of farming and reconstruction

① Consensus building and planning for land-use

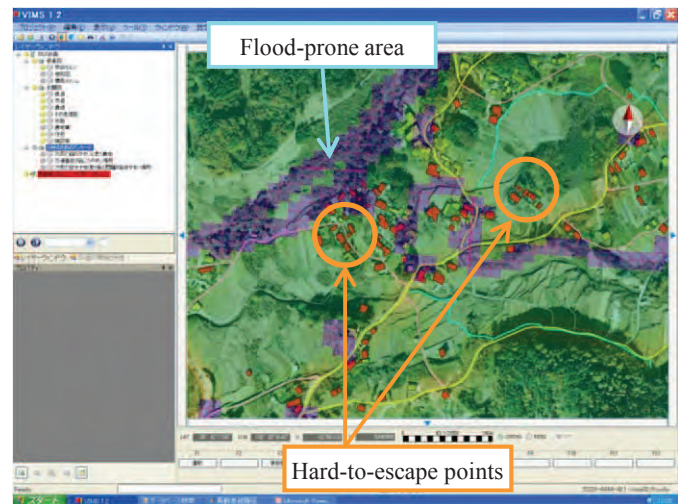
Easy-to-operate geographic information system to allow inhabitants to select evacuation routes

■ [Keywords: geographic information system, community development, evacuation routes](#)

In disaster situations, it is important to select the most appropriate evacuation routes after comprehensively evaluating ease of evacuation on the basis of road width, road type, degree of traffic jams, and road density, and also on the distance from a house where an elderly person lives alone to a nearby road.

Village Information Management System (VIMS), a geographic information system we developed, allows a community's inhabitants to consider evacuation routes for elderly people in the community by sharing information.

Because no professional skills are required to use VIMS, inhabitants can use it on their own for various kinds of community development planning and discussions.



Screenshot showing selection of the best evacuation route

A system projecting a landscape after disaster reconstruction

■ [Keywords: landscape simulation, community development, design code](#)

A community's unique disposition towards certain facilities and visual conventions regarding color and shape are known as the local design code, and a landscape design following the code serves as a source of mental support for the residents of the community.

Because infrastructural facilities of rural communities will be newly constructed in the reconstruction process, projection of post-reconstruction landscapes and advance assessment of whether or not to observe or use the design code are important in reaching consensus in the community.

We developed a landscape simulation software, Landscape Imager, to allow everyone to project landscapes easily.



Example of a landscape simulation of post-reconstruction farmland

1. Techniques for resumption of farming and reconstruction

① Consensus building and planning for land-use

A method for examining the influence of construction of seawalls on the living environment

■ Keywords: seawalls, Maertens' theory

When seawalls are reconstructed, they may exert a great influence on the living environment. For example, the height of seawalls may cause an oppressive feeling.

By using Maertens' theory, which is a basic way of thinking about the visual angle and the appearance of a visual object, the mental effects of seawalls on inhabitants can be comprehensively assessed in advance. Even if one is surrounded with buildings, it is generally believed that the sense of enclosure ceases when one is at a distance that is more than four times the height of the building away. Construction of seawalls has to be judged comprehensively and the way of thinking has to be considered.



When a seawall 15 m high is viewed from a point 15 m away, it causes an oppressive feeling.



When the seawall is viewed from a point at a distance of about four times the height, the oppressive feeling seems moderate.

Databases of technology system and income and expenditure to support formulation of farm management plans

■ Keywords: farm management plan, technology system

In disaster-affected regions, farmers are required to resume farming after purchasing new machines and facilities and must formulate an effective and rational farm management plan taking financing into account.

We offer methods of management planning and management diagnosis to support formulation of farm management plans for farmers. We also provide a regional agriculture plan in which individual farm management plans are integrated, and databases of technology systems and income and expenditure, which are needed in the planning process.

Farm Management Decision Support Systems	
☆ Contents	
Program for analyzing structural changes in regional agriculture, Ver. 1.01	
Farm management plan support system, Z-BFM Ver. 1.10 (New!)	
A farm management decision support system, Ver. 3.11 "FarmanDess"	
A management model for supporting rational selection of cropping systems in paddy	
☆ Manuals	
Organization strategies and management measures for the development of community-based group farming	
For successful farm management: process and objectives	
The organization of community-based group farming	

Figure 1 Menu of our support system

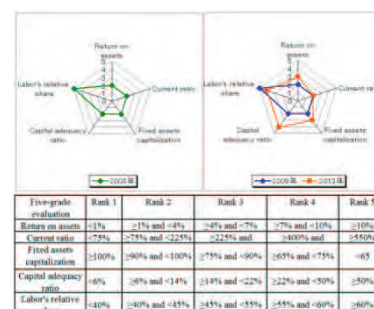


Figure 2 Ranking categories of financial condition by management diagnosis

1. Techniques for resumption of farming and reconstruction

① Consensus building and planning for land-use

Support method for community-based group farming

■ Keywords: community-based group farming, organization

It is necessary for paddy-field farming in disaster areas to establish community-based group farming organizations with co-ownership and communal use of agricultural machines as a springboard, to gather scattered farmlands into larger groups, and to concentrate the farmlands into a group farming organization.

We offer manuals describing a process of organization of community-based group farming and points to note in the process.

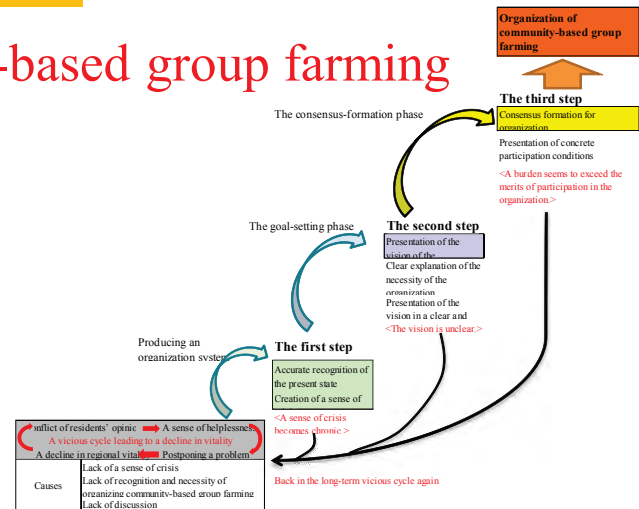


Figure 1 Organizing steps

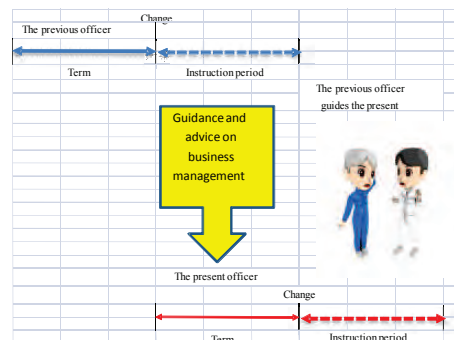


Figure 2 Implementing a system to inherit business management knowledge

Support for new farmers in disaster-affected agricultural regions

■ Keywords: newcomers to agriculture, route to farming

Because there are farmers who decide against farming because of the disasters in the region, it is necessary to receive those from outside the region who want to engage in order to restore agriculture. We offer manuals describing methods and processes to help receive prospective farmers in the region, to help establish them as farmers, and points to consider when encouraging them to engage in agriculture.

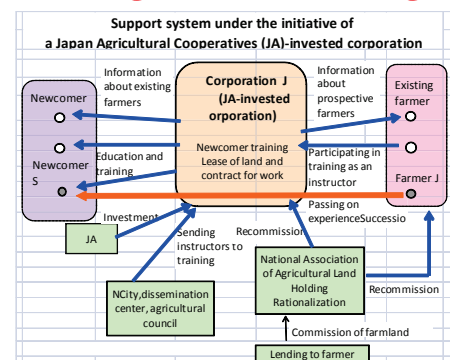


Figure 1 Scheme of succession of rice farming to a third party

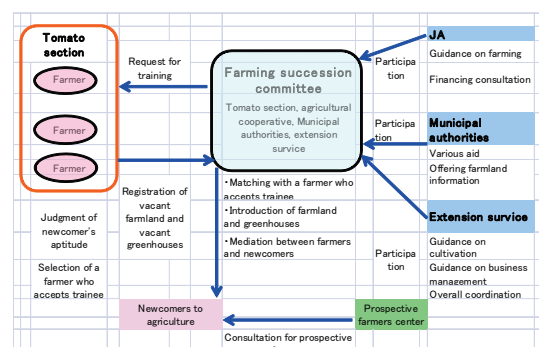


Figure 2 Support system for newcomers to vegetable farming

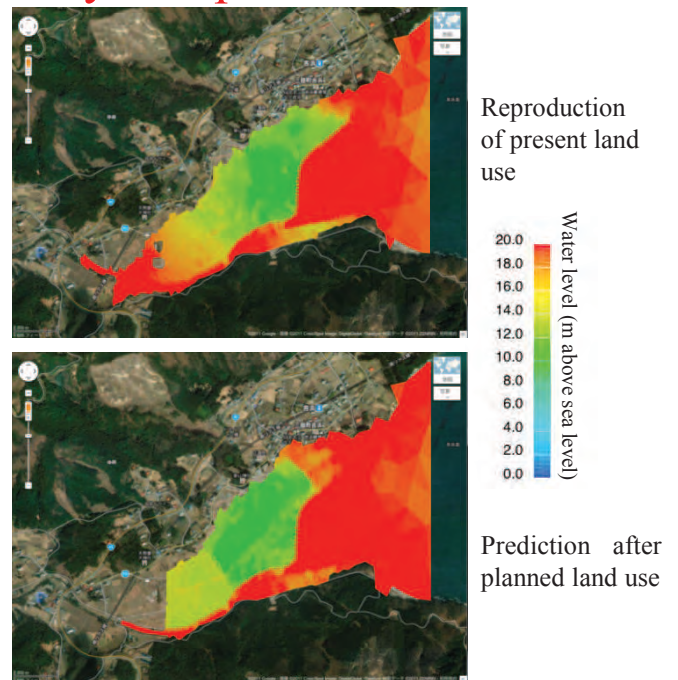
Prediction of tsunami-flooded areas by computational fluid dynamics simulation

■ [Keywords: computational fluid dynamics \(CFD\), disaster prevention plan, land use](#)

A tsunami runs up to inlands and the resulting floods are influenced by various factors, such as irrigation and drainage channels through which the tsunami propagates or roads and inland seawalls that block the path of the tsunami.

Our model can not only reproduce such phenomena but also predict the effects of various disaster prevention plans, in which the position and height of coastal seawalls are varied, inland roads are constructed so that they can serve as second seawalls, and so on.

Since the model can predict tsunami-flooded areas, it can be used to formulate land-use plans in coastal areas.



1. Techniques for resumption of farming and reconstruction

② Rehabilitation of agricultural infrastructure taking long-term reconstruction into account

Low-cost grading and land leveling method for restoration of disaster-devastated paddy fields

■ Keywords: grading and land leveling methods, laser leveler, restoration of cultivated lands

Because of accumulation of earth and sand, subsidence, and disturbance of the land surface by heavy machinery used to remove debris, some low and flat paddy fields struck by tsunami require restoration work including land leveling.

Our method, using a laser leveler controlled by a laser beam, allows high-precision, low-cost grading and leveling of harrowed lands. If there is a large level difference in an area of cultivated land, a technique of turning over and leveling of land using a laser plow allows flat grading while keeping the thickness of the surface soil uniform.



Laser leveler



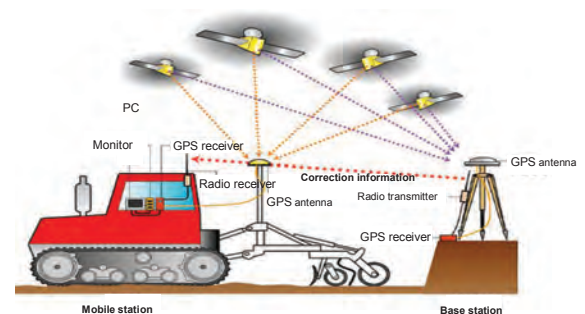
Laser plow

Efficient grading and land leveling method using RTK-GPS

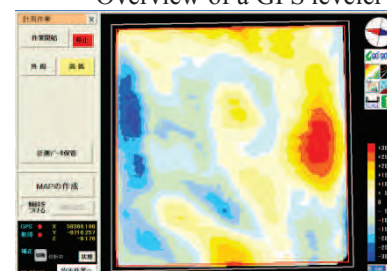
■ Keywords: GPS leveler, grading of paddy fields, cultivated land map

We introduce a technique in which a more developed laser system is used. A GPS leveler controlled by real-time kinematic global positioning system (RTK-GPS) with high precision allows real-time monitoring of level differences and efficient transfer of soil and grading of fields.

Compared to a conventional laser leveler, the GPS leveler can reduce working hours by about 40%. It can also produce a map depicting uneven spots or spots where sand boils caused by liquefaction occurred. The map will also be useful for fertilization management after restoration.



Overview of a GPS leveler



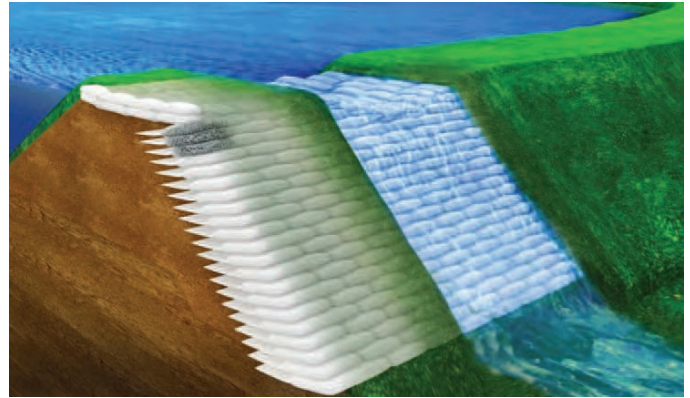
Measurement results for a disaster-affected paddy field (Inashiki City, Ibaraki Prefecture)

Construction technique for earth structures resistant to heavy rainfall and earthquake

■ [Keywords: earthquake, flood, tsunami](#)

We developed a construction technique that allows reinforcement of embankments, making them more resistant to erosion by overflow compared to those constructed by conventional techniques.

This construction technique features inclined stacks of sophisticated soil bags, which exhibit high durability and are hard to erode by overflow. The high erosion resistance can prevent embankments from breaking or can delay breaking. The high earthquake resistance resulting from the technique allows application not only to revetments of irrigation ponds or water channels and banks of farm roads, but also to seawalls.



Reinforced embankments highly resistant to erosion

Shallow burying technique to prevent pipe flotation and movement during earthquakes

■ [Keywords: earthquake resistant, shallow burying, geotextile](#)

Pipelines buried underground often float up or move during earthquakes owing to buoyancy caused by the liquefaction of the ground or backfill sand.

Using this shallow burying technique, which is highly earthquake resistant, pipelines are incorporated into the surrounding ground using geotextiles (stable fabrics for civil engineering applications) to restrain deformation of pipes and the ground and to prevent pipe flotation and movement during earthquakes. In addition, because pipelines are buried at shallow depth in the technique, the technique needs less excavation compared to conventional techniques and leads to reduction of the construction period and the construction cost.



Laying of large-diameter pipelines using the shallow burying technique with geogrid

1. Techniques for resumption of farming and reconstruction

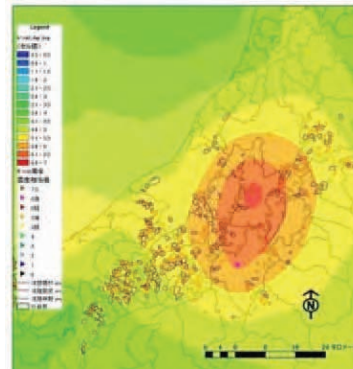
② Rehabilitation of agricultural infrastructure taking long-term reconstruction into account

Disaster-risk-forecasting system useful for precaution and inspection

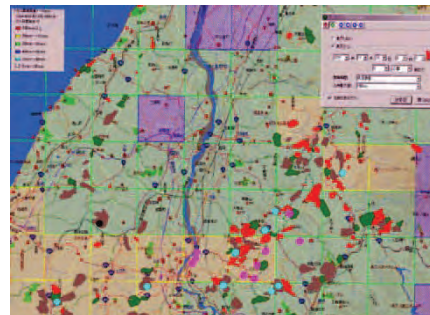
■ [Keywords: caution and inspection support system, disaster risk forecasting](#)

In order to minimize damage by disaster in landslide prevention areas, it is important to notice early signs of landslide and to monitor and inspect the area in the event of heavy rainfall or earthquake.

We superimpose estimated seismic intensity distribution, which is obtained in real time, and radar-AMeDAS data on a base map in which landslide prevention areas have been drawn in advance. This system, which we developed, identifies and classifies spots to be inspected on the basis of conditions including seismic intensity and rainfall index and outputs location information and totaled results to support caution and inspection in disaster situation.



Estimated seismic intensity distribution for the main shock of the 2004 Mid Niigata Earthquake and distribution of landslide prevention area



Distribution of total rainfall over the last 4-day period just before the 2004 Mid Niigata Earthquake, landslide prevention areas, and distribution of major landslides caused by the earthquake.

Simple technique that farmers and local residents can adopt for repairing leaks in irrigation channels

■ [Keywords: water channel diagnosis, leak, simple repair](#)

Emergency restoration of water leaks from joints or cracks in concrete irrigation channels leads to early resumption of farming.

We offer a technique for temporarily repairing leaks in small-scale irrigation channels using commercially available materials and repairing tapes that we have recently developed. Farmers and local residents can easily carry out highly durable repairs. In addition, we have published a manual describing practical methods of repair and procedures and points to note, in response to problems related to irrigation channels.



Manual and videos published by the Rural Culture Association (above) and repairs being carried out (below)

1. Techniques for resumption of farming and reconstruction

② Rehabilitation of agricultural infrastructure taking long-term reconstruction into account

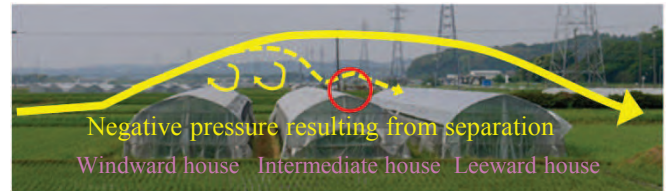
Low-cost, weather-resistant pipe-framed greenhouses

■ Keywords: pipe-framed greenhouse, strength against wind, strength against snow

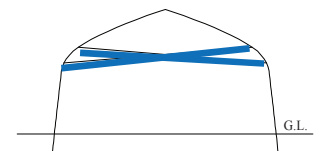
It is important to understand features of air flow and wind pressure and to consider the disposition of pipe-framed greenhouses. Because pipe-framed greenhouses may be lashed by strong winds in open spaces like the disaster areas.

In the case of pipe-framed greenhouses of the same type constructed side-by-side, wind pressure on the greenhouses varies with distance between the greenhouses. A wind pressure coefficient, obtained in the case of two pipe-framed greenhouses adjacent to each other, will be used for construction of pipe-framed greenhouses to resist breaking by strong winds.

Moreover, in order to improve strength against snow, it is effective to reinforce a roof by installing braces at a height 67–70% that of the ridge.



Separation and reattachment of air flow results in variation in wind pressure with the distance between pipe-framed greenhouses.



Installation of braces reinforces a pipe-framed greenhouse even if the ground is not firm.

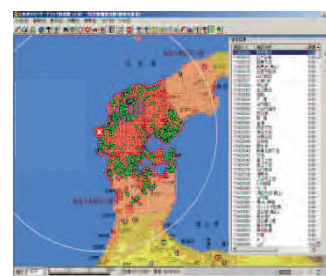
Disaster prevention system automatically distributing the degree of collapse risk of irrigation ponds and forecasted flooded area

■ Keywords: caution and inspection support system, disaster risk forecasting

This is a comprehensive disaster prevention system for irrigation ponds under conditions of heavy rainfall or earthquake.

The system automatically inputs weather and earthquake information into a database of 120,000 irrigation ponds and forecasts the degree of collapse risk under conditions of heavy rainfall or earthquake. It then distributes the result automatically by e-mail, enabling people to reach safety in a timely manner and to mitigate human casualties and socio-economic loss.

It also offers information useful for construction of a crisis management system for disaster situations.



Forecast of the degree of collapse risk



Forecast of area flooded when a pond collapses



Pond A	risk
At present	●
After 1h	●
After 2h	●
After 3h	●
After 4h	●
After 5h	●
After 6h	●

From XXX@XXX
To △△△@△△△
An earthquake occurs
(JMA Seismic
Intensity 4).

Check the irrigation
pond B.

In an earthquake situation

In a heavy rainfall situation

Send an e-mail to the registered address automatically

1. Techniques for resumption of farming and reconstruction

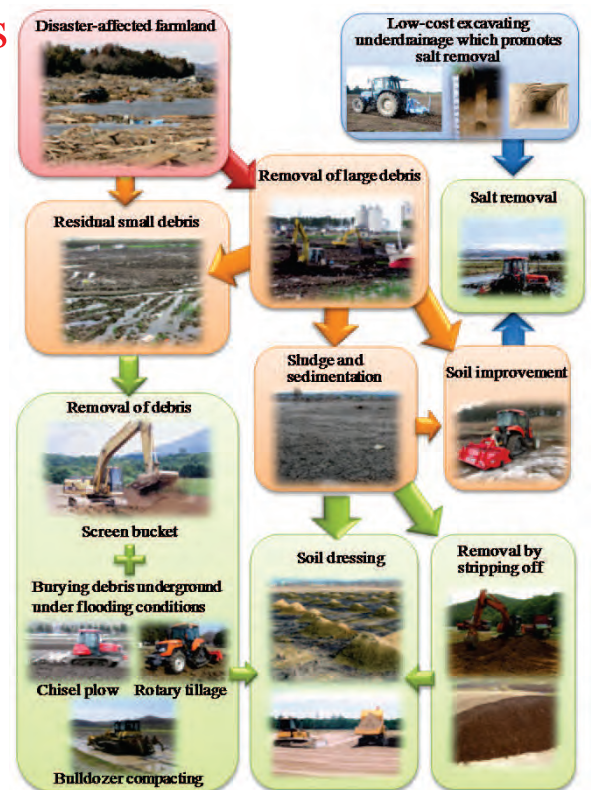
② Rehabilitation of agricultural infrastructure taking long-term reconstruction into account

Comprehensive restoration techniques for tsunami-stricken farmlands

■ Keywords: small debris, low-cost construction, soil improvement

When tsunami floods farmland, the plowed layer is greatly disturbed and debris and sludge accumulate on the farmland. Restoration of the disaster-stricken farmland involves stepwise countermeasures, including removal of large debris, removal of small debris, treatment of sludge containing acid sulfate, and measures to make fertile soil.

We offer low-cost restoration techniques, such as removal of small debris by burying them underground under flooding conditions and excavating underdrainage, in which case underdrain pipes are not used, to continue contributing to farmland restoration.

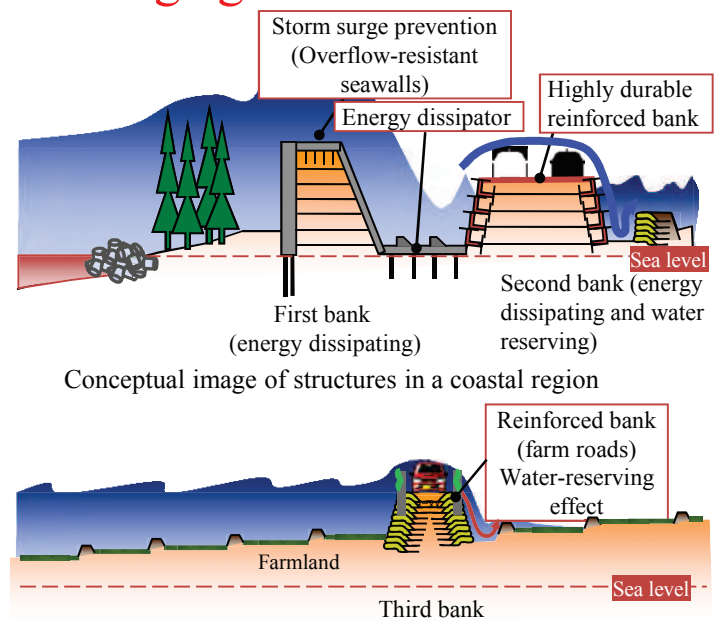


Saving communities from tsunami using agricultural hinterlands and farm roads

■ Keywords: wide-area disaster prevention plan, overflow-resistant embankments

The prevention of destruction caused by a giant tsunami using only seawalls is not practical because of enormous construction costs.

For this reason, wide-area, multiple disaster prevention measures are believed to be effective, such as construction of overflow-resistant seawalls, reinforcement of farm roads to be used as second banks, and use of farmland to dissipate tsunami energy. Such disaster prevention measures are considered to save rural communities and shorten the period of restoring farmland, etc., if an enormous tsunami strikes.



A conceptual image of structures in an inland region

Rapid and nondestructive measurement of salinity distribution in farmlands

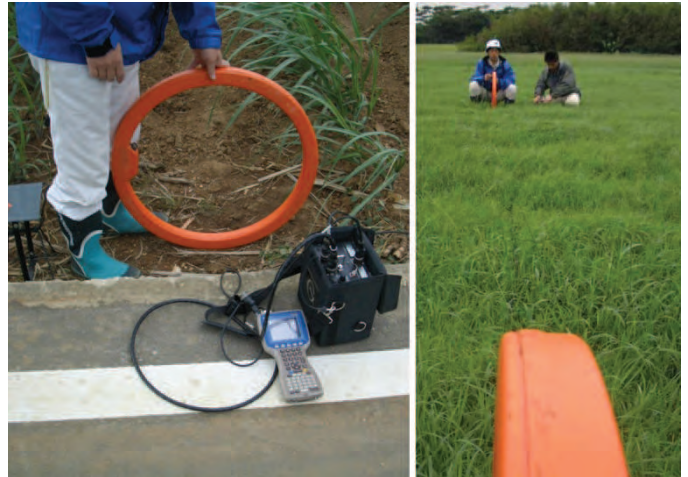
■ [Keywords: salinity, electromagnetic survey](#)

The salt water remaining in tsunami-stricken farmlands could cause problems for cultivation of crops.

We offer a technique for measuring the salinity distribution in such farmlands.

The technique is based on the principle that apparent electrical conductivity of the ground measured by an electromagnetic survey method is affected by the salinity of the topsoil. By conducting the electromagnetic survey over a large area of the farmland, the relative distribution of salinity would be obtained.

The technique does not require sampling of soil and allows rapid and nondestructive measurements.



Measuring equipment (left) and the measurement being made (right)

Cultivation method for mitigating salt damage to paddy rice

■ [Keywords: paddy rice, salt damage, water management, cultivars, cultivation management](#)

When the irrigation water used for raising seedlings contains salts, excessive transpiration has to be prevented. Because seedlings are highly sensitive after transplantation, vigorous seedlings with more leaves have to be transplanted while avoiding wind and low temperatures.

In a rice paddy, appropriate nitrogen fertilization is needed and heavy use of organic matter should be avoided. With regard to water management, if salts have accumulated in the soil, midseason drainage should be avoided to prevent these salts from moving to and accumulating in the surface of the soil. If the irrigation water contains large amount of salts, in order to reduce introduction of salts into soil, the amount of irrigation water has to be limited to a level such that the soil does not become excessively dry.

Because adaptability to salts varies depending on cultivars, cultivation of cultivars with higher salt tolerance is recommended.



Symptoms of salt damage to the seedlings in the seedling-raising period (above) and difference between cultivars in adult plants (below)

1. Techniques for resumption of farming and reconstruction

③ Early resumption of farming

Selection and cultivation of salt- and flood-tolerant plants

■ [Keywords: salt tolerance, flood tolerance, forage crops](#)

To produce livestock feed in tsunami-flooded farmlands, forage crops resistant to salt and flood damage have to be selected. We offer information about salt tolerance and flood tolerance of forage crops and about a ridge-making seeding method that mitigates flood damage.

Forage crops with relatively higher salt and flood tolerance include pasture plants such as Italian ryegrass, perennial ryegrass, tall fescue, and reed canarygrass. In the case of crops with low flood tolerance, such as corn, flood damage can be mitigated by ridge-making seeding.

Salt tolerance and flood tolerance of major forage crops

Crops	Salt tolerance	Flood tolerance
Barley	Strong	Weak
Reed canarygrass	Somewhat strong	Strong
Italian ryegrass, perennial ryegrass, tall fescue	Somewhat strong	Somewhat strong–Medium
Orchard grass, clover	Somewhat weak	Medium
Corn	Somewhat weak	Weak



Ridge-making seeding of corn

Techniques for reducing salt in farmlands using salt- and flood-tolerant pasture plants

■ [Keywords: salt removal, farmland, pasture plant](#)

Because of the high salt concentration in tsunami-affected farmlands, including paddy fields, efforts to reduce salt concentration are required.

Pasture plants such as ryegrass (including festulolium), which have a good flood and salt tolerance, are expected to be used as salt-removal plants. However, the characteristics of pasture plants vary according to the types of plants and cultivars and appropriate types of plants and cultivars vary according to usage conditions and weather conditions.

We offer information on the selection of cultivars and methods of use of pasture plants suited to the respective environments of the tsunami-affected farmlands.



Photographs: Festulolium cultivars
Left: Barfest. Right: Tohoku 1

1. Techniques for resumption of farming and reconstruction

③ Early resumption of farming

Maintenance of farmlands by grazing

■ [Keywords: grazing, labor-saving maintenance, farmland conservation](#)

Farmlands that were abandoned after the disaster can be conserved and maintained by using them as grazing lands for livestock.

In an integrated grazing system for scattered small pastures, beef cows for breeding are grazed and raised on abandoned agricultural lands fenced in by simple electric fences suitable for the terrain, resulting in low-cost farmland maintenance. In addition, the cost of recovery of the farmland can be reduced by preventing weeds and bushes from becoming overgrown, and income can be earned by selling calves when farming is suspended.



Grazing in abandoned agricultural land



A paddy field restored after being used as pastureland (right) for about 6 years

1. Techniques for resumption of farming and reconstruction

④ Removal of radioactive substances from farmlands and reduction of their transfer to agricultural and livestock products

Burying radioactive cesium by plowing

■ Keywords: plow, jointer, double plowing

Topsoil contaminated by radioactive cesium is buried by plowing. As a result, the radiation dose at the surface will be reduced and transfer of radioactive cesium to crops will be also reduced.

While another technique involving scraping of topsoil produces contaminated soil as radioactive waste, this technique does not result in the production of radioactive waste. However, because radioactive cesium continues to remain in the soil, this technique can be applied in fields with relatively low radioactivity.

Applying the technique in paddy fields at 30-cm tillage depth takes about 30 min per 10 a when using a three-furrow plow with jointers that scrape off the surface of soil.



Soil turning in a paddy field by a plow with jointers



Double plowing is effective in upland fields

Removal of radioactive cesium by scraping of topsoil

■ Keywords: radioactivity, soil decontamination, topsoil removal, agricultural machines

In order to remove topsoil containing radioactive substances and restore farmland, we developed a technique involving physical removal of topsoil of contaminated farmland using agricultural machines.

After harrowing using a tractor equipped with a vertical harrow, topsoil is scraped off by a tractor equipped with a rear blade. The soil is collected by a front loader on the tractor and loaded onto a dump truck to be carried off the farmland. When scraping topsoil 4-cm deep, the volume of waste soil is 40 m³/10 a. The work takes 55–70 min per 10 a.



Surface soil crushing by a tractor equipped with a power harrow



Scraping of topsoil by a tractor equipped with a rear blade

1. Techniques for resumption of farming and reconstruction

④ Removal of radioactive substances from farmlands and reduction of their transfer to agricultural and livestock products

Removal of radioactive cesium by scraping hardened topsoil

■ [Keywords: decontamination, topsoil scraping, hardener](#)

The surface of cultivated land is sprayed with a magnesium hardener. After the topsoil hardens, it is scraped off. Hardening of the topsoil enables effective removal of soil containing radioactive cesium, which prevents the soil from scattering (i.e., recontamination), and improves safety in the working environment.

Concentration of radioactive cesium in the soil decreased from 9,090 Bq/kg to 1,671 Bq/kg (by 82%) due to the removal of about 3-cm-thick topsoil. Because topsoil is colored white by the hardener, the progress of scraping can be checked visually.



Spraying of the hardener



Scraping of the hardened topsoil

Removal of soil containing radioactive cesium after puddling with water

■ [Keywords: decontamination, shallow puddling, solid-liquid separation](#)

In paddy fields, surface soil is stirred at shallow depths (shallow puddling) and turbid water containing soil particles is discharged into a temporary settling basin by pump. Addition of a flocculant to the discharged turbid water in the basin separates the contaminated soil particles from water and removes the contaminated soil.

Because the concentration of radioactive cesium in the separated supernatant fluid is smaller than or equal to the detection limit (4–8 Bq/L), the fluid can be discharged to the environment. Although radioactive cesium was only reduced by 36%, this technique is expected to reduce the volume of waste soil by eliminating only particles from the topsoil.



Stirring soil (shallow puddling)



Solid-liquid separation

2. Technologies for realization of new agriculture

① Advanced uses of paddy fields toward the second Green Revolution

Advanced use of paddy fields with an underground-water control system
Labor-saving, low-cost paddy rice cultivation by direct sowing of iron-coated rice seeds in flooded paddy fields
Direct sowing on well-drained paddy fields by plowing and sowing with a grain drill
Technique for mitigating flood damage using tilling and ridge-making seeders
Labor-saving techniques using seeder machines for wheat, barley, soybean, etc.
Simultaneous mulch laying and sowing for vegetable cultivation by using a tilling and ridge-making machine
High speed disk-type cultivator-ridger well adapted for wet soil
Fertilizer reduction by in-ridge partial fertilizer application

② Highly productive and highly profitable greenhouse horticulture

Low-cost production system using an air-inflated double-layer greenhouse and soilless culture
Next-generation large-scale greenhouse horticulture of a sunlight-type plant factory
Low-cost and weather-resistant greenhouses built using unitized roofs
Hybrid heating using a heat pump and warm air heater
An ICT-oriented agricultural production system for greenhouse horticulture
Automation of strawberry harvesting by using a robot
Morphogenesis control technique for garden crops using LED light sources
Technique for culture of summer and autumn strawberry in cool summer climate
A low-cost technique for inhibiting a rise in medium temperature of strawberry high-bench culture

③ “Sixth industrialization” and branding the products made from new cultivars

Single-cultivar planting and a training system of low-height trees using the JM rootstock series in apple production
Labor-saving, high-quality fruit production technique with root restriction and automatic fertigation
Labor-saving growing of grapevine using tools for flower thinning and flower-cap removal
Fifty percent reduction of agrochemicals in apple cultivation using multiple mating disruption
Preservation of the quality of fruit with a new freshness preservative
Techniques for production and quality preservation of fresh-cut apples
Revitalization of regional agriculture by contract farming and development of new products in farmers' market
Effective use and processing techniques for substandard and unused products
Processing and distribution techniques for adding high value to crops
An evaluation technique for functional components contained in vegetables and fruits

④ Energy-producing agriculture (biofuels etc.)

Techniques to use crop residues from large-scale farming
Local production for a local consumption system of energy and materials
Various biomass-derived gasification power generation and liquid-fuel production techniques
A method for converting stream energy to electric power in low-gradient agricultural water channels
Technologies for the air-conditioning of greenhouses using a water-source heat-pump system
Construction of a livestock farming system supplying renewable energy

⑤ Regional integrated agriculture incorporating livestock farming

No-tillage cultivation of corn, a key technology for forage production organization
Use of food wastes and agricultural byproducts as feed
Wide-area distribution technology for forage rice and fermented total mixed ration (TMR) produced in paddy fields
Preparation and distribution of fermented TMR through a TMR center
Whole crop rice silage feeding of the beef cattle, and its effect on the vitamin E content in the meat.
A composting system using vacuum-type aeration

2. Technologies for realization of new agriculture

① Advanced uses of paddy fields toward the second Green Revolution

Advanced use of paddy fields with an underground-water control system

■ [Keywords: an underground-water control system, FOEAS, advanced use of paddy fields](#)

Consolidation of paddy fields into larger blocks, restoration of irrigation and drainage facilities such as pipelines, and introduction of an underground-water control system, the Farm-Oriented Enhancing Aquatic-System (FOEAS), enables effective, productive, large-scale rice farming.

Combination of FOEAS and subirrigation in rice farming allows direct sowing of rice on well-drained paddy fields without puddling, resulting in a large reduction of labor. When the fields are used as dry fields, stable high yields of barley, wheat, soybean, etc. are expected, leading to more effective farm management.

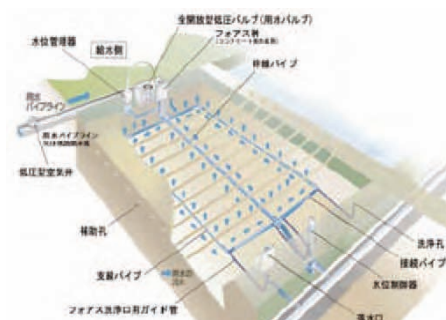


Figure 1 Overview of an underground-water control system, FOEAS.



Figure 2 Soybean cultivation in Nishikanbara, Niigata Pref.

Labor-saving, low-cost paddy rice cultivation by direct sowing of iron-coated rice seeds in flooded paddy fields

■ [Keywords: direct sowing of iron-coated seeds, unmanned helicopter, power applicator](#)

The farmlands of disaster-affected farmers, who have difficulty in continuing rice farming, are gathering around core farmers in the region in order to promote labor-saving, low-cost, large-scale rice production.

Direct sowing of rice seeds coated with iron powder reduces floating seedlings and bird damage. A combination of iron-coated “Moeminori,” which is a lodging-resistant cultivar suitable for direct sowing, and a direct sowing technique with labor-saving seeders such as industrial unmanned helicopters and knapsack power applicators reduces working hours to 60 hours per hectare and production cost to 120 yen per kilogram of brown rice (54% of the average in the Tohoku region in 2009).



An industrial unmanned helicopter



A knapsack power applicator

Figure 1 broadcasting iron-coated rice seeds in flooded paddy fields

2. Technologies for realization of new agriculture

① Advanced uses of paddy fields toward the second Green Revolution

Direct sowing on well-drained paddy fields by plowing and sowing with a grain drill

■ Keywords: direct sowing on well-drained paddy fields, plowing, grain drill

The Sendai plain is fertile with low percolation rates and is suitable for direct sowing on well-drained paddy fields. If an efficient technique of direct sowing on dry fields is introduced to farming in consolidated farmlands, the farmland will be a large-scale food supply base.

The technique involves application of a grain drill seeder and a cultipacker land roller, both of which are used in large-scale dry-field farming, to rice farming and features deep tillage by a plow and high-speed work at about 10 km per hour using a grain drill. In a demonstration test, working time per 10 a was estimated at 4.8–6.4 h and total expenditure per 60 kg in the case of “Moeminori,” which is a suitable cultivar for direct sowing, was estimated to be about 6,700–8,400 yen, which is 55% of the average in the Tohoku region in 2009.



Technique for mitigating flood damage using tilling and ridge-making seeders

■ Keywords: tilling and ridge-making, flood damage, up-cut rotary, harrowing, one-step work, soybean, barley, wheat, buckwheat

If rotation crops are cultivated in fields that have reduced drainage capability due to the earthquake, they may suffer flood damage.

Therefore, if ridge-making and seeding are performed simultaneously with tilling, ridge-making can mitigate flood damage and one-step work from tilling to seeding can improve working efficiency and decrease risk of rainfall in the middle of work. In addition, an up-cut rotary, which crushes soil well, is used and clods in seedbeds will be broken up and made finer. Because the shape of the ridge can be changed by changing the direction of the blades, this technique is applicable to ridge-making cultivation of soybean, barley, wheat, buckwheat, etc. Five models with different tilling widths are commercially available.



Figure 1 Structure of an operating machine (75-cm ridge × 3)

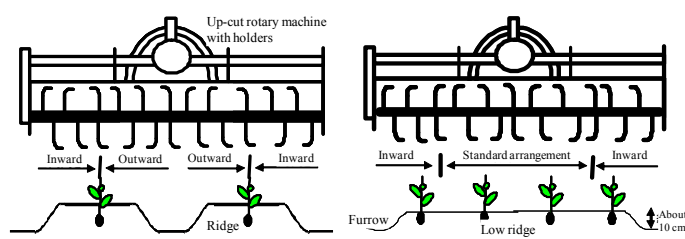


Figure 2 Arrangement of blades and shape of ridges (Left: soybean, etc. Right: barley, wheat, buckwheat, etc.)

Labor-saving techniques using seeder machines for wheat, barley, soybean, etc.

■ Keywords: crop rotation in paddy fields, seeder equipped with chisel a chisel plow, inter-row strip tillage

Consolidation of paddy fields into larger blocks, restoration of irrigation and drainage facilities such as pipelines, and promotion of low-cost, high-productivity, and large-scale crop rotation in paddy fields is required.

However, because farmers in the Tohoku region do not have enough time to switch crops, they need labor-saving techniques involving machines. A seeder equipped with a chisel plow enables minimum tillage, fertilizer application, and sowing simultaneously, leading to efficient crop switching such as wheat, barley, and soybean (Figure 1).

In addition, in order to reduce flood damage and drought damage in soybean cultivation, we developed a sowing method involving inter-row strip tillage with a chisel applied. This method allows us to till and sow at a higher speed than that possible by conventional methods (Figure 2).

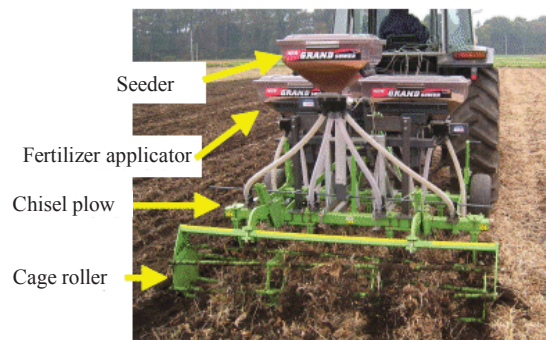


Figure 1 Seeder equipped with a chisel plow

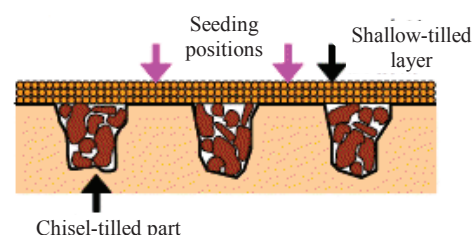


Figure 2 A sectional view of soil showing the application of the sowing method involving inter-row strip tillage with a chisel

Simultaneous mulch laying and sowing for vegetable cultivation by using a tilling and ridge-making machine

■ Keywords: tilling and ridge-making, mulch, vegetable, green soybean (edamame), direct sowing cultivation

When vegetables are grown in upland fields converted from paddy fields, clods cannot be broken down sufficiently and working efficiency may decrease due to lower drainage capability.

We developed a machine that is equipped with an up-cut rotary, which crushes soil well, and can simultaneously carry out tilling, ridge-making, and mulch-laying operations for vegetables. This machine can break down clods and makes labor-saving operation possible.

Moreover, if farmers use mulch film with holes and a machine that can directly sow green soybean seeds at the position of the holes after performing simultaneous tilling, ridge-making, and mulch laying, they can omit the step of seedling culture, compared to transplant cultivation.

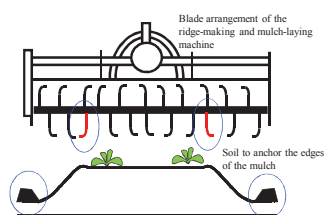


Figure 1 Simultaneous tilling, ridge-making, and mulch-laying machine and the arrangement of its blades

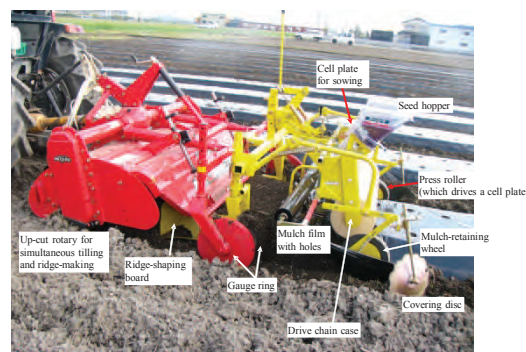


Figure 2 Simultaneous tilling, ridge-making, mulch-laying, and direct-sowing machine for green soybean cultivation

2. Technologies for realization of new agriculture

① Advanced uses of paddy fields toward the second Green Revolution

High speed disk-type cultivator-ridger well adapted for wet soil

■ Keywords: soybean, inter-row cultivation, disk, earthing up

The problems of inter-row cultivation and earthing up by conventional rotary cultivator are soil kneading on wet soil condition and low travel speed.

We developed disk-type cultivator-ridger with two sets of disks that turn over inter-row soil laterally (Figure 1).

This machine enables high-speed (4–6 km/h) operation and prevents wet soil from sticking together (Figure 2); it is effective for weed control because it turns soil upside down and available in the field with large stones.



Figure 1 A disk-type cultivator for intertillage



Figure 2 Soil state after work in wet soil conditions

Fertilizer reduction by in-ridge partial fertilizer application

■ Keywords: outdoor-grown vegetables, ridge making, fertilizer reduction, partial fertilization

In contrast to a conventional broadcast application technique, in which fertilizers and agrochemicals are spread over the field and then mixed into the soil, fertilizers and agrochemicals are mixed into soil only at the center of the ridge during the ridge-making process using the in-ridge partial application technique.

In the cultivation of outdoor-grown vegetables such as cabbage, Chinese cabbage, and broccoli, basal dressing is mixed into soil only at the center of the ridge in a band during the transplanting and ridge-making process. This method reduces the amount of fertilizer per unit area by 30–50%, leading to reduction of material cost and environmental load.

An in-ridge partial fertilizer application machine



An in-low-ridge partial fertilizer application machine

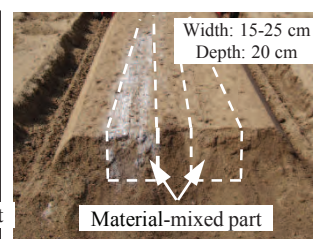
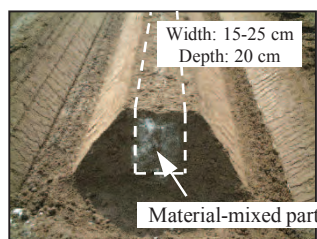


Figure 1 In-ridge partial fertilizer application machine (commercially available)

2. Technologies for realization of new agriculture

② Highly productive and highly profitable greenhouse horticulture

Low-cost production system using an air-inflated double-layer greenhouse and soilless culture

■ Keywords: air-inflated double-layer structure, high-bench culture, soilless culture

Removal of salts and sludge in paddy/dry fields takes a long time. In order to get income early, farmers who have produced paddy rice or open field crops can start vegetable production using pipe-framed greenhouses and soilless culture. A combination of high-eave, multi-span, and pipe-framed greenhouses with an air-inflated double-layer structure (air-inflated double-layer greenhouse) and soilless culture enables production of vegetables and fruits such as tomato, strawberry, and cucumber.

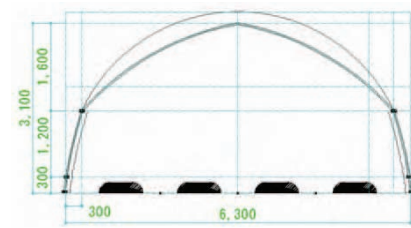


Figure 1 The basic structure of a pipe-framed greenhouse with an air-inflated double-layer roof



Figure 2 Elevated bed culture of strawberry

Next-generation large-scale greenhouse horticulture of a sunlight-type plant factory

■ Keywords: plant factory, large scale, soilless culture, ubiquitous environmental control system

For the revitalization of regional agriculture using new technologies, sunlight-type plant factories are constructed on the hectare scale to demonstrate the effectiveness of a next-generation large-scale facility equipped with new technologies (such as environmental control, information and communications, resource-saving, energy-saving, harvesting robots, moving benches, carrying robots, an ubiquitous environmental control system, and a renewable natural energy-using system).

A plant factory is a culture facility that allows year-round production of plants such as vegetables in a systematic way involving sophisticated environmental control based on monitoring of the environment and growth of plants.



Figure 1 An example of sunlight-type plant factory (Tsukuba plant factory center)

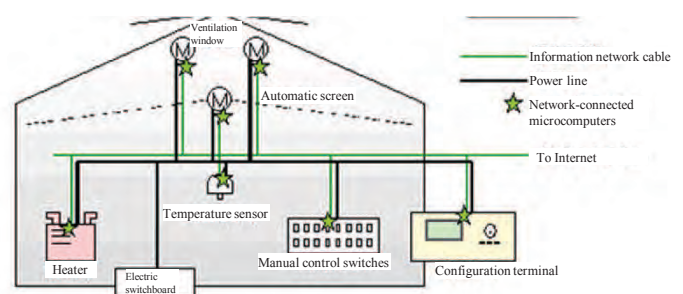


Figure 2 A schematic illustration of a ubiquitous environmental control system

2. Technologies for realization of new agriculture

② Highly productive and highly profitable greenhouse horticulture

Low-cost and weather-resistant greenhouses built using unitized roofs

■ [Keywords: low-cost and weather-resistant greenhouse, method using unitized roofs](#)

Commercially available low-cost greenhouses include weather-resistant greenhouses (resistant to wind up to 50 m/s) and greenhouses that have lower construction costs but lower strength. A high-eave, large-sized, steel-frame greenhouse, was developed at very low cost, and is constructed by a technique involving a pipe batter pile-driven foundation without excavation and a method using unitized roofs built with thin-walled light-gauge steel. This construction technique reduces the construction period to about 1/3 and the construction cost by 40% (as of 2006).

The construction technique is available for a large-sized greenhouse (maximum eave height: 3.5 m, maximum area: about 4,000 m²), in which long-term tomato cultivation with a high-wire system is possible.



Figure 1 A very-low-cost and weather-resistant greenhouse built using unitized roofs

Hybrid heating using a heat pump and warm air heater

■ [Keywords: heat pump, energy-saving, hybrid heating, greenhouse](#)

We developed a new hybrid heating system that controls heating by switching between heat pump only mode and hybrid heater mode automatically in response to the room temperature. The hybrid heating system provides heat to a greenhouse by automatically controlling a heat pump, which is a main heater, and a warm air heater, which is an auxiliary heater. It is expected that the system will reduce input energy, operating cost, and carbon dioxide emission compared to conventional systems.



Figure 1 An example of an agricultural heat pump

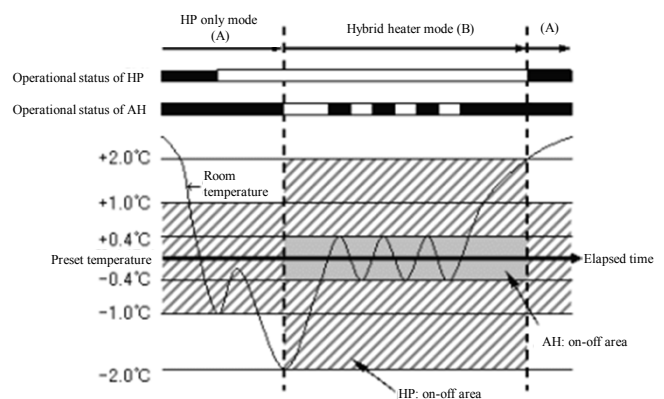


Figure 2 Operational status of the heat pump (HP) and the oil-fired air heater (AH) of the hybrid heating system and preset temperatures. □: On, ■: Off.

2. Technologies for realization of new agriculture

② Highly productive and highly profitable greenhouse horticulture

An ICT-oriented agricultural production system for greenhouse horticulture

■ Keywords: ubiquitous environmental control system (UECS), information and communications technology (ICT)

Some environmental control systems that were installed in glass or plastic greenhouses destroyed by the earthquake are not commercially available. If an ubiquitous environmental control system (UECS) is introduced as a substitute, it can automatically collect information about environmental control and instantly transmit data on agricultural production and labor management through the UECS LAN. UECS is expected to interface with the FieldServer, an outdoor observation system, and has been operating in a plant factory built in Tsukuba demonstration station.



Figure 1 Wet-bulb globe temperature (WBGT) sensor , which is compliant to UECS and can be used for labor management.



Figure 2 Plant factory in Tsukuba demonstration station installed with UECS

Automation of strawberry harvesting by using a robot

■ Keywords: strawberry, harvesting robot, high-bench culture

Because an elevated substrate culture for strawberries does not require soil, farmers can begin the cultivation of strawberries at an early date regardless of whether the farmland was affected by disaster. In addition, the use of robots is a trump card for the automation of tedious work, labor-saving, and productivity improvement, leading to large-scale production in greenhouses.

A strawberry-harvesting robot detects a ripened fruit from the aisle, reaches out the robot-hand to the stem, cuts and grasps in one motion without touching the pericarp, and places it gently in a shipping tray. To achieve an efficient strawberry production, we offer the automated harvesting system with the harvesting robot and a hanging bench system, enabling farmers to increase yield per unit area and to reduce the working hours.



Figure 1 A strawberry-harvesting robot

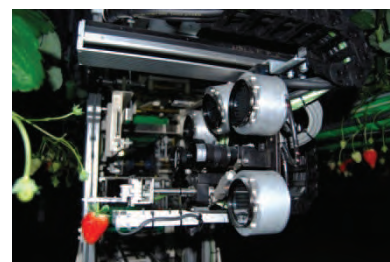


Figure 2 Harvesting action

2. Technologies for realization of new agriculture

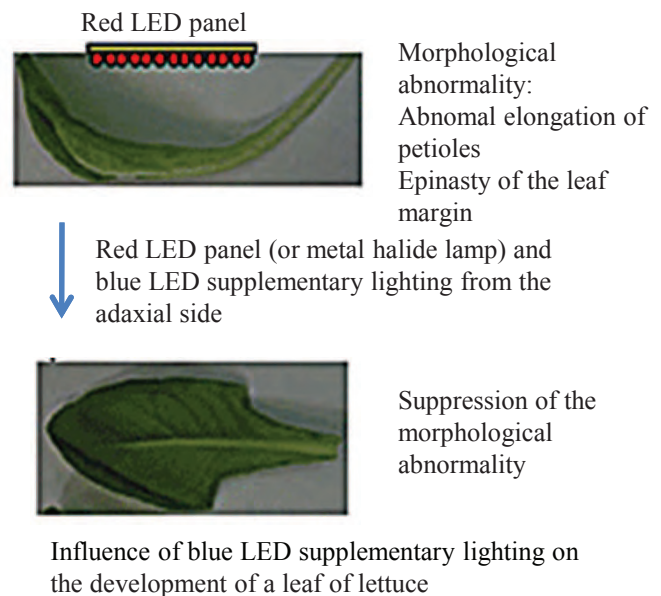
② Highly productive and highly profitable greenhouse horticulture

Morphogenesis control technique for garden crops using LED light sources

■ [Keywords: LED light source, supplementary lighting, leafy vegetables, morphology](#)

Supplementing lighting with specific light quality using light emitting diodes (LEDs) may lead to control of morphogenesis and quality improvement of crops.

Supplementary lighting on the upper region of a peduncle of geranium by red or blue LEDs resulted in suppression of peduncle elongation. Moreover, occurrence of epinasty of leaves in geranium, lettuce, spinach, qing-geng-cai, observed under red LED irradiation can be suppressed by blue LED supplementary lighting. We offer techniques involving appropriate use of LEDs for the production of high-quality garden crops.



Technique for culture of summer and autumn strawberry in cool summer climate

■ [Keywords: summer and autumn strawberry, Natsuakari, short-day treatment](#)

Cool summers in the Sanriku region make possible culture of summer and autumn strawberry in a simple, plastic greenhouse that shelters crops from the rain and production and shipment of high-quality, domestically grown strawberries in a between-crop season.

Ever-bearing cultivars that flower continuously in summer are well suited to culture of summer and autumn strawberries, for example, “Natsuakari” (improved by the NARO Tohoku Agricultural Research Center), a flavorful large-fruited cultivar.

If farmers have facilities for short-day treatment for strawberry seedlings, they can culture conventional high-quality June-bearing cultivars in fall.



Large-fruited, flavorful, ever-bearing cultivar “Natsuakari”



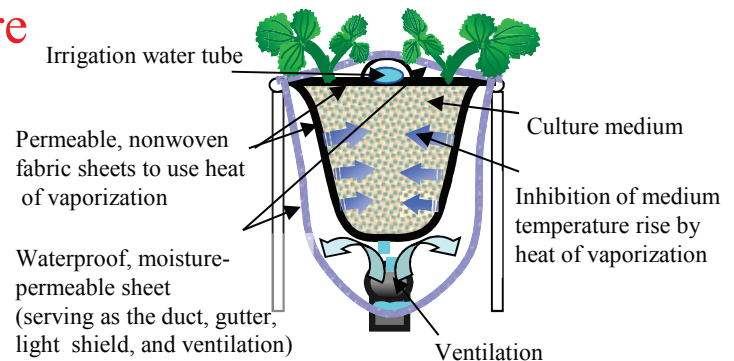
Short-day treatment facilities for strawberry seedlings

A low-cost technique for inhibiting a rise in medium temperature of strawberry high-bench culture

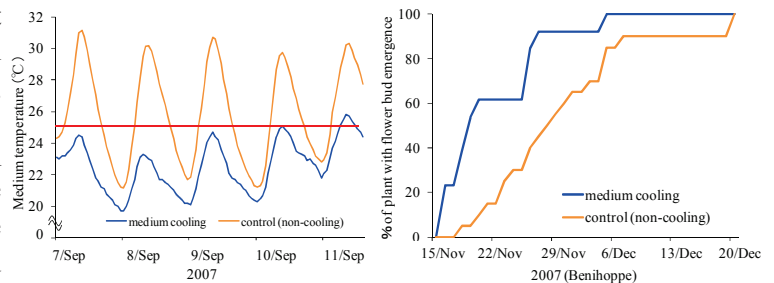
■ Keywords: strawberry, heat of vaporization, cooling of culture medium, shortening of the period between harvests, simple and low cost

It is expected in the disaster-affected strawberry-producing area that high-bench culture will be introduced with the aim of saving labor. In the strawberry culture, high temperatures in summer and fall may become a problem.

We offer a technique for inhibiting medium temperatures from rising. In this technique, a culture bed made with nonwoven fabric sheets is always wet with surplus irrigation water and air sent from underneath takes away latent heat of vaporization, resulting in cooling of the culture medium. In the case of forcing culture of June-bearing cultivars, medium temperatures can be lowered by about 5°C in late summer, and the period between harvesting of the fruits of the first inflorescence and that of the second inflorescence can be shortened by about 10 days.



Schematic illustration of cooling mechanism using heat of vaporization



Transitions of medium temperatures of high-bench culture with and without cooling mechanism (left) and advanced flower bud emergence of the second inflorescence (right)

Single-cultivar planting and a training system of low-height trees using the JM rootstock series in apple production

■ [Keywords: apple, monoculture, JM rootstock, culture of low-height trees](#)

In tsunami-stricken paddy/dry fields, farmers may start the new and profitable occupation of fruit production. We present a low-cost, labor-saving, and simple apple culture system in which newcomers can engage. Single-cultivar planting and a training system of low-height trees using JM rootstocks make possible labor-saving apple growing taking drift of pesticide into account.



Figure 1 Manual of single-cultivar planting in apple



Figure 2 A training system of low-height trees using JM7 rootstock

Labor-saving, high-quality fruit production technique with root restriction and automatic fertigation

■ [Keywords: root restriction, automation, fertigation, labor-saving, high-quality](#)

This technique allows farmers who start the new profitable fruit culture in the disaster area to shorten the non-bearing period and to manage orchards with saving labor.

Roots of fruit trees such as grapevine, peach, and cherry, are looked after by feeding optimum water and fertilization automatically. By restricting a root zone with a root barrier, central control of irrigation and fertilization (fertigation) becomes possible, leading to shortening of the non-bearing period and stable production of high-quality fruits. In addition, avoidance of contact between soil in the root zone and soil outside the root zone can prevent trees from being affected by salt damage and serious diseases including root rot diseases.



Figure 1 Root-restriction culture



Figure 2 Drip fertigation system

Labor-saving growing of grapevine using tools for flower thinning and flower-cap removal

■ [Keywords: grapevine, labor-saving, damage by wild animals](#)

In tsunami-stricken paddy/dry fields, farmers may start the new and profitable fruit culture. We present a low-cost, labor-saving, and simple grapevine growing Techniques in which such newcomers can engage.

The use of a tool for grapevine flower thinning and a tool for removing flower caps of grapevines allows farmers to greatly reduce working hours in the flowering season. A fruit-protecting net can easily be attached and removed under a grapevine trellis and is helpful in preventing damage by wild animals.



Figure 1 Tool for grapevine flower thinning



Figure 2 Tool for removing flower caps from grapevines



Figure 3 Fruit-protecting net

Fifty percent reduction of agrochemicals in apple cultivation using multiple mating disruption

■ [Keywords: apple, multiple mating disruption, agrochemical reduction](#)

In a fruit-producing area affected by earthquake or tsunami, strategic agrochemical reduction will enable cost reduction and improvement of the perception people have of the area, resulting in improvement of orchard management and revitalization of the producing area.

We offer a manual describing a pest-control technique by which agrochemicals would be reduced by 50%. This technique involves use of specified pest control materials such as multiple mating disruption agents and involves spraying of the following 21 components of agrochemicals in total: 7 components of insecticides, and miticides, 10 components of fungicides, 2 components of herbicide, and 2 components of growth regulator. Damage caused by major pests such as peach fruit moth and Alternaria blotch can be well controlled.

Table 1 Comparison of the number of applications of agrochemicals between a conventional pest control technique and the 50% reduction technique

	Conventional pest control					50% reduction technique				
	Insecticides	Fungicides	Herbicide	Growth regulator	Total	Insecticides	Fungicides	Herbicide	Growth regulator	Total
Before budding	●					—				
At budding	●					●	○			
At foliation	●	○				●	○			
7 days before flowering	●		●			—		●		
Just before flowering	●					●	○			
At petal fall	●	●				●	●			
10 days after petal fall	●					●	☆			
20 days after petal fall	●			●	●	—			●	
Mid-June						●	●			
Late June	●	●	●			—				
Early July	●	●				●	—			
Mid-July	●	●				●	●	●		
Late July	●	●				—				
Early August	●	●	●			●	●			
Mid-August	●	●		●		—			●	
Late August	●	●				●	●			
Mid-September	●					●				
Mid-and Late October	●			●	●	—				
Mid-and Late November	●					—				
Total	22	12	3	6	43	10	7	2	2	21

Open circles indicate pesticides allowed for use in the Organic JAS. Open stars indicate a mating disruption agent.

Preservation of the quality of fruit with a new freshness preservative

■ [Keywords: apple, Japanese pear, persimmon, 1-MCP, freshness preservation](#)

In disaster-affected apple- or pear-producing areas, techniques for maintaining the freshness of fruits are important to construct a sales strategy. A new freshness preservative, 1-methylcyclopropene (1-MCP), registered in the fall of 2011, inhibits the action of ethylene, which promotes ageing of fruits, and exerts a positive effect on apple, Japanese pear, and persimmon by preserving their freshness. Because the effect of 1-MCP can last at atmospheric temperatures, 1-MCP is expected to be used for export of fruits, which requires reduction of storage cost and delicate temperature management, as well as to be used in store fronts. Treatment with 1-MCP has to be carried out by specific dealers.



Figure 1 Inhibition of greasy skin for an apple cultivar “Jonagold”

Techniques for production and quality preservation of fresh-cut apples

■ [Keywords: apple, cutting, quality preservation](#)

To stabilize fruit-growing businesses in the disaster area, substandard fruits, which cannot be sold as whole fruits, have to be enhanced and value is added by processing and selling as fresh-cut or dried fruits. Although production of such processed fruits requires fruits with higher quality than fruits for juice, the processed fruits are expected to be more profitable than fruits used for juice.

These processed fruits can be produced even in small-scale workshops if they meet certain requirements concerning sanitation in production. If they can gain regular customers, they may launch on-site production of such processed fruits. NIFTS can offer technical guidance and technology transfer about techniques for production and quality preservation of fresh-cut apples.



Figure 1 Fresh-cut pieces of “Tsugaru”

2. Technologies for realization of new agriculture

③ “Sixth industrialization” and branding the products made from new cultivars

Revitalization of regional agriculture by contract farming and development of new products in farmers’ market

■ Keywords: farmers’ market, sales manual, fresh-cut vegetables

For reconstruction of the disaster-afflicted horticultural business and regions, it is necessary to enhance the added value of agricultural products of the disaster-afflicted area by contract farming and farmers’ markets.

We offer a manual describing procedures and points to note regarding contract farming of vegetables for the catering industries on the basis of precedents and a system to receive orders for and to sell packaged fresh-cut vegetables as new products in farmers’ markets.

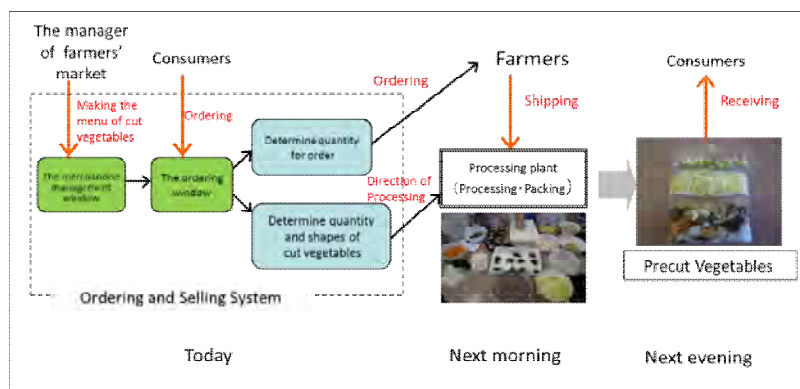


Figure The flowchart of a system of sales and processing instructions for packaged fresh-cut vegetables

Effective use and processing techniques for substandard and unused products

■ Keywords: understanding of the behavior of useful functional ingredients, efficient separation, extraction technique, high value-added materials

We investigate useful ingredients contained in unused or little-used parts of products generated at shipment and primary processing and offer techniques to use such ingredients efficiently.

We offer a system of producing a high-value-added substance (oligosaccharide) from a material not used for food by physical and enzymatic treatment (Figure 1), an efficient technique for solid-liquid separation of balm ingredients or functional ingredients from juice residue, etc. (Figure 2), and techniques for processing substandard products into paste or powder by drying.

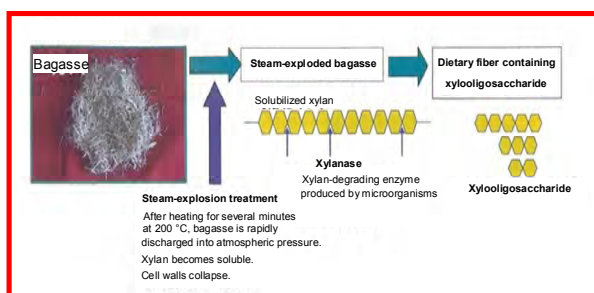


Figure 1 Production of oligosaccharide from a food-processing by-product (Bagasse)



Figure 2 Collection of useful ingredients from juice residue

Processing and distribution techniques for adding high value to crops

■ Keywords: advanced quality preservation technique, primary processing, fermentation treatment

We investigate behavior of functional ingredients contained in crops at shipment and primary processing and offer primary processing techniques applicable to respective crops and prospective food materials and processed foods in order to enhance added value. The techniques include Aqua-gas (Figure 1), ohmic heating, and high-pressure processing (Figure 2).

Such techniques can be used as preparation systems for large-scale primary processing (such as fresh-cut vegetables, blanching, and freezing), production of paste or powder materials, and processing systems using new techniques such as fermentation treatment (lactic acid bacteria in vegetables).

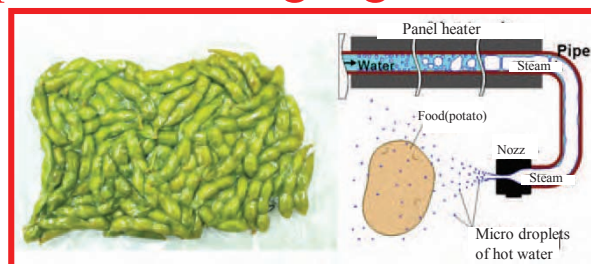


Figure 1 High-quality primary processing with Aqua-gas

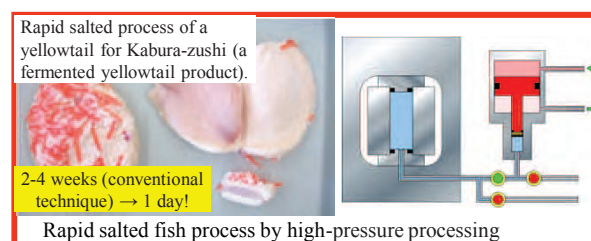


Figure 2 New food products formed by high-pressure processing or new lactic acid bacterium

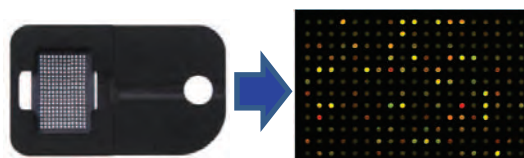
An evaluation technique for functional components contained in vegetables and fruits

■ Keywords: functionality, measures against lifestyle-related diseases, antiallergy, added-value improvement

We introduce cultivars and cultivation methods that enhance the content of functional components in crops (vegetables, fruits, potatoes, cereals, etc.). On the basis of evaluation techniques and analytical methods for functional components contained in crops developed by NARO, we also offer cultivation and evaluation techniques for cultivars with high functional ingredient content in response to needs in the disaster-affected area. We support the development of introduced crops as high value-added foods by using an evaluation technique for anti-allergic components and an evaluation technique for functionality of polyphenols such as flavonoids.



Figure 1 DNA chip for functionality evaluation



Induction and suppression of genes related to inflammation can be assessed on a single chip.

Figure 2 Assessing anti-inflammatory action of an extract of an agricultural product

Techniques to use crop residues from large-scale farming

■ Keywords: crop residues, composting, greenhouse cultivation

In earthquake- or tsunami-stricken farmlands, large-scale green house are expected to be established. A large amount of waste including inferior fruits and leaves (crop residues) is produced in the process of year-round culture of greenhouse tomatoes and comprises up to one third of gross production. Fertilizer components such as nitrogen (N) and phosphorus (P) and CO₂ gas obtained in the composting of such crop residues will contribute to productivity improvements.

By methane fermentation or a combustion method, the residue can be converted to biogas, which is used in a cogeneration system.

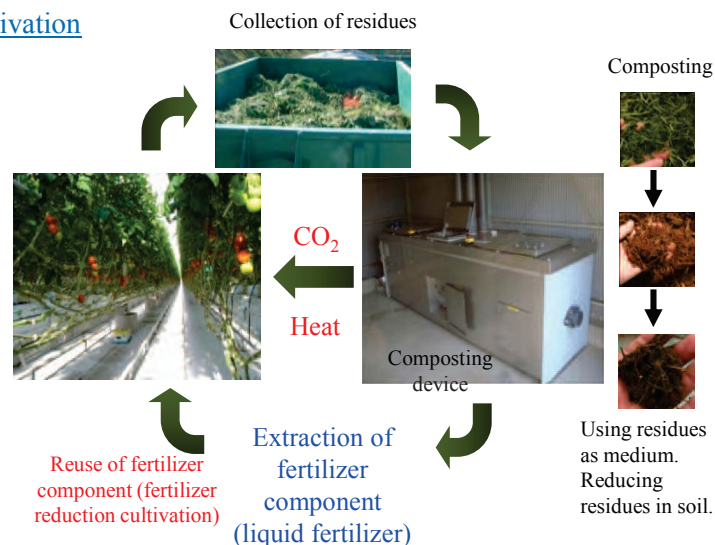


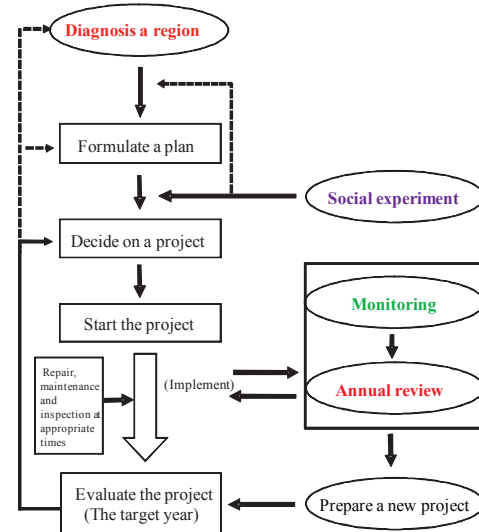
Figure 1 Overview of use of crop residues

Local production for a local consumption system of energy and materials

■ Keywords: municipal biomass utilization promotion plan, project cycle management

Introduction of renewable energy is attracting attention in disaster reconstruction. Utilization of biomass is a part of local production for local consumption of resources to which local residents contribute.

It is important for promotion of biomass utilization to introduce techniques suitable to local conditions, to grasp the effects of the efforts, and to verify the effects of the efforts objectively. To enhance the feasibility of a plan, we propose a management method, which involves gathering of regional force, diagnosis and formulation of the plan, implementation of the plan, and evaluation of the plan, and relevant information, which is expected to be helpful for a public official to make a plan suitable for the region.



Note: Dotted arrows show procedures that are taken when necessary.

Project cycle management of biomass utilization

2. Technologies for realization of new agriculture

④ Energy-producing agriculture (biofuels etc.)

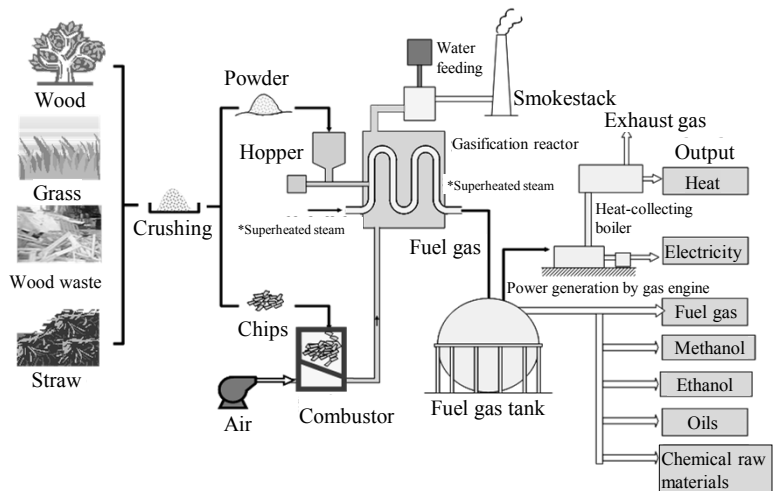
Various biomass-derived gasification power generation and liquid-fuel production techniques

■ [Keywords: gasification, debris, methanol](#)

Dealing with biomass such as wood contained in debris generated by tsunami and as driftwood has become a problem.

We offer techniques to convert cellulosic biomass such as wood and rice straw into clean, high-calorie fuel gas by crushing and gasification by a floating external heat-type gasification method and to synthesize methanol from the obtained fuel gas.

The effectiveness of these techniques were demonstrated by using Norin Biomass the Third.



A system to produce heat, electricity, and liquid fuel from biomass

A method for converting stream energy to electric power in low-gradient agricultural water channels

■ [Keywords: agricultural water channels, stream energy](#)

Use of renewable energy is helpful for reconstruction of disaster-affected rural communities. Because conventional hydroelectric power plants generate electricity from a drop in stream level, it has been difficult to generate electricity in low-gradient water channels.

The water wheel we developed can draw energy from a low-gradient water channel with about 1/1,500 channel gradient. Blades of the water wheel move and rotate transversely to the stream and convert stream energy to electricity efficiently with little influence on the stream.



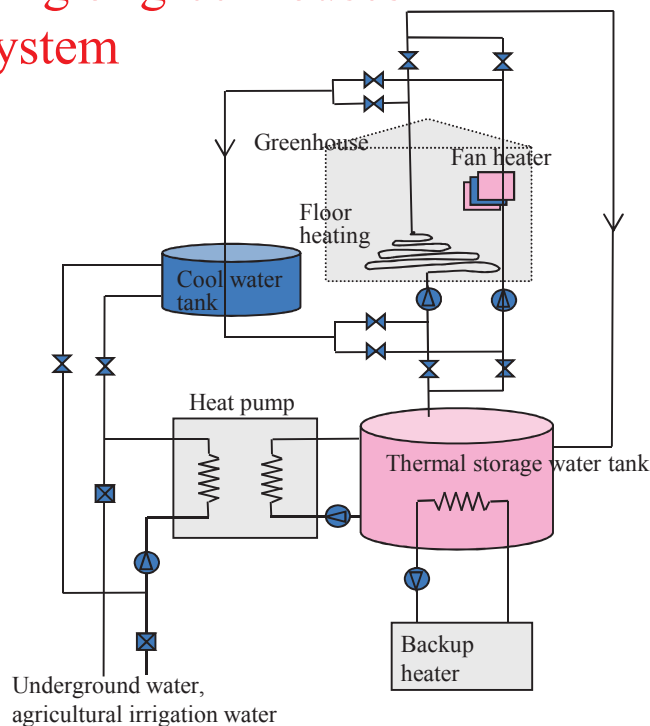
The water wheel

Technologies for the air-conditioning of greenhouses using a water-source heat-pump system

■ Keywords: water source heat pump, underground heat, agricultural irrigation water

In the Tohoku region, the inside of a greenhouse reaches high temperatures in summer while the outside is cool, while the outside is severely cold in winter. We verify that air-conditioning using a water-source heat-pump system works efficiently in such climates.

As an energy-saving technique for greenhouses, we offer a design technique for an air-conditioning system for greenhouses with a water-source heat pump utilizing unused heat sources such as underground heat of farmland and agricultural irrigation water.



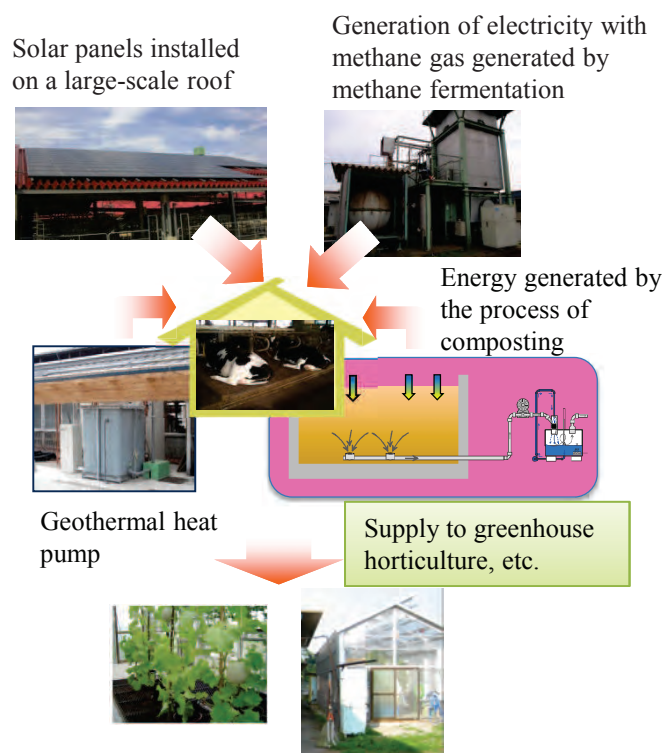
Example of an air-conditioning system for greenhouses with a water-source heat pump

Construction of a livestock farming system supplying renewable energy

■ Keywords: livestock house, renewable energy, photovoltaic power generation

Because energy such as regular electricity and heavy oil depend on imports, agricultural production will be threatened by the rise in the price of energy and by unforeseen circumstances. A renewable energy-supplying livestock farming system can contribute to energy-self-sufficient farming that does not depend on fossil energy and makes full use of renewable energy.

Energy can be obtained from the system in several ways: electricity from solar panels installed on a large-scale cattle shed roof; electricity from methane gas generated by methane fermentation of animal wastes; combustion energy from the incinerating waste; and energy generated in the process of composting. Energy can then be supplied to greenhouse horticulture, livestock farming, and local communities.



2. Technologies for realization of new agriculture

⑤ Regional integrated agriculture incorporating livestock farming

No-tillage cultivation of corn, a key technology for forage production organization

■ Keywords: corn, no-tillage cultivation

Concerns are rising that abandoned agricultural lands will expand due to the disaster. Although corn, which can be grown in inferior conditions, is the crop best suited to being introduced to such lands, large-scale cultivation by forage production organization is necessary to solve the problem of abandoned agricultural lands while making the most of the features of corn. No-tillage cultivation, which saves a lot of seeding work, is a suitable technique for forage production organization to efficiently use many scattered abandoned agricultural lands. Yield does not fall as a result of no-tillage cultivation, and pesticide-free cultivation can be made possible by introducing living mulch system.

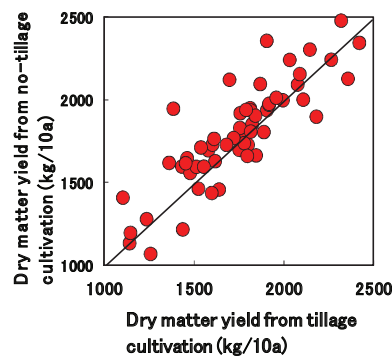


Figure 1. Comparison of yield between no-tillage and tillage cultivation (Based on data from NARO Tohoku Agricultural Research Center and Iwate Agricultural Research Center, Animal Industry Research Institute)

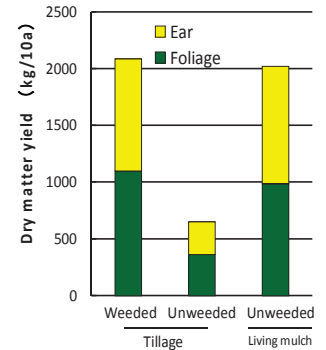


Figure 2. Corn yield from living mulch cultivation (no-tillage seeding in cover crops) with a cover crop, hairy vetch.

Use of food wastes and agricultural byproducts as feed

■ Keywords: food wastes, farm wastes, feed design program

If feed become unavailable or expensive due to the disaster, food wastes and farm wastes can be used to reduce feed cost.

Use of waste from local specialties and substandard agricultural products, which have not been used so far, leads to cost reduction and stable feed supply.

We developed a program for designing feed for pig breeding incorporating use of Ecofeed, feed produced from recycled food wastes. This program is available on the NILGS home page.



Making silage of dried sweet potato (Hitachinaka City, Ibaraki Pref.)

Feed calculation sheet

Feed No.		Feeding amount	Correction factor	DM	Amount of DM	Ratio of DM	ME	DE	TDN	CP	EE	Crude fiber	NDF	Ca	P	Lysine
	Name of feed	Original (kg)	Actual values (%)	%	kg	%DM	Mcal	Mcal	kg							
88	Rice	30.00		40.0	12.0	16.7	49.7	49.7	11.26	798	106	0	409	0.9	7.9	25.2
73	Bread crumbs (dry)	20.00		89.2	17.8	24.8	77.6	77.6	17.60	2600	860	120	1960	12.0	24.0	52.0
108	Vegetable wastes	50.00		7.4	3.7	5.1	11.0	11.0	2.50	745	146	0	692	20.1	11.2	11.8
92	Udon and soba noodles (boiled)	25.00		33.3	8.3	11.6	32.9	32.9	7.46	1130	86	0	775	6.1	10.4	24.2
61	Whole milk	70.00		12.3	8.6	12.0	48.3	48.3	10.92	2240	2590	0	0	77.0	70.0	175.0
35	Wheat bran	4.00		86.8	3.5	4.8	10.4	10.4	2.34	628	172	380	1480	4.0	39.6	26.8
52	Tofu lees (fresh)	10.00		22.5	2.3	3.1	7.0	7.0	1.59	590	260	360	760	9.0	8.0	38.0
115	Residue from barley tea (dry)	20.00	50.00	94.1	10.0	13.9	58.1	30.9	7.00	1420	270	0	2310	0.0	0.0	12.0
82	Alfalfa meal (dehydrated)	5.00		90.7	4.5	6.3	8.5	8.5	1.92	825	130	1240	2070	78.5	11.5	38.0
83	Dibasic calcium phosphate	1.00		96.0	1.0	1.3	0.0	0.0	0.00	0	0	0	0	222.6	176.6	0.0
87	Water	100.00		0.0	0.0	0.0	0.0	0.0	0.00	0	0	0	0	0.0	0.0	0.0
67	Lysine hydrochloride	0.15		98.5	0.1	0.2	0.6	0.6	0.14	140	0	0	0	0.0	0.0	118.2
	Amount of nutrients fed	335.2				71.8		304.0	276.8	62.7	11115.9	4620	2100	10456	430	359
	Content of ingredients (%DM)				21.4		4.2	385.2	87.3	15.5	6.4	2.9	14.6	0.60	0.50	0.73
	Sufficiency rate				101.4		105.2	103.0	103.0	105.0				105.7		100.4
Ca/P ratio 1.20																

A feed-calculation sheet using food wastes

Wide-area distribution technology for forage rice and fermented total mixed ration (TMR) produced in paddy fields

■ [Keywords: forage rice, fermented total mixed ration \(TMR\), wide-area distribution](#)

Some regions have a difficulty producing self-supplied feed because production bases of forage rice, etc. collapsed due to the disaster. We offer wide-area distribution technology to stably supply livestock farmers with wrapped round bales of fermented total mixed ration (TMR) using forage rice.

For wide-area distribution of round bales, forage rice and fermented TMR have to be stored temporarily and then transported by large trucks on a massive scale. It is important to prevent rolled bales from becoming deformed and degrading in quality at loading and unloading. We developed a round-bale-handling assister, which can load and unload round bales without deformation and is commercially available.



The wide-area distribution system using a round-bale-handling assister

Round bale kept in temporary storage space (above)

Loading to a large truck with a round bale handling assister (below)

Preparation and distribution of fermented TMR through a TMR center

■ [Keywords: TMR center, fermented TMR, wide-area distribution](#)

Feed supply from abroad was stopped for a while at the time of the Great East Japan Earthquake. Stable supply of feed can be achieved using regional resources such as self-supplied feed, byproducts from food processing, and substandard vegetables, as part of fermented TMR. Unlike conventional fresh TMR, fermented TMR can be stored for a certain period and is resistant to deterioration and rotting, even after opening, owing to the fermentation. In addition, fermented TMR is packed in flexible container bags or formed into a roll or box, and is therefore suited to wide-area distribution. We support the disaster regions by sending lecturers to seminars for the establishment of TMR centers.



TMR center (round fermented TMR)



Loading of round bales of fermented TMR using a round bale handling assister

2. Technologies for realization of new agriculture

⑤ Regional integrated agriculture incorporating livestock farming

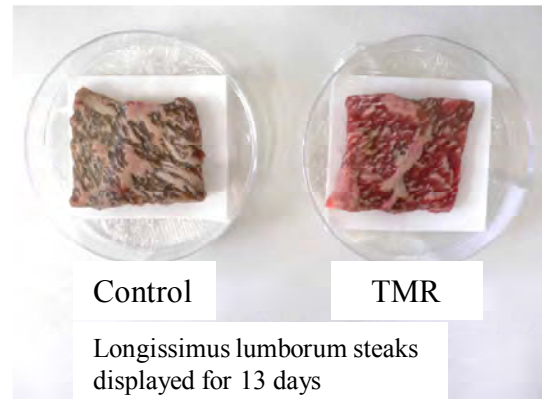
Whole crop rice silage feeding of the beef cattle, and its effect on the vitamin E content in the meat.

■ Keywords: beef, whole crop rice silage, vitamin E

Revitalization of livestock farming in the disaster-affected area is expected to be achieved by producing distinctive beef containing a lot of functional ingredients.

Whole crop rice silage features high content of vitamin E (α -tocopherol). When fattening cattle are fed with whole crop rice silage, the vitamin E content in the meat increases more than that of hay-fed cattle. The increased vitamin E concentration in the meat improves meat color and lipid stability.

Techniques for feeding whole crop rice silage to dairy and beef cattle, including the technique described here, are made available through MAFF's web site as a manual of techniques of production and feeding of whole crop rice silage.



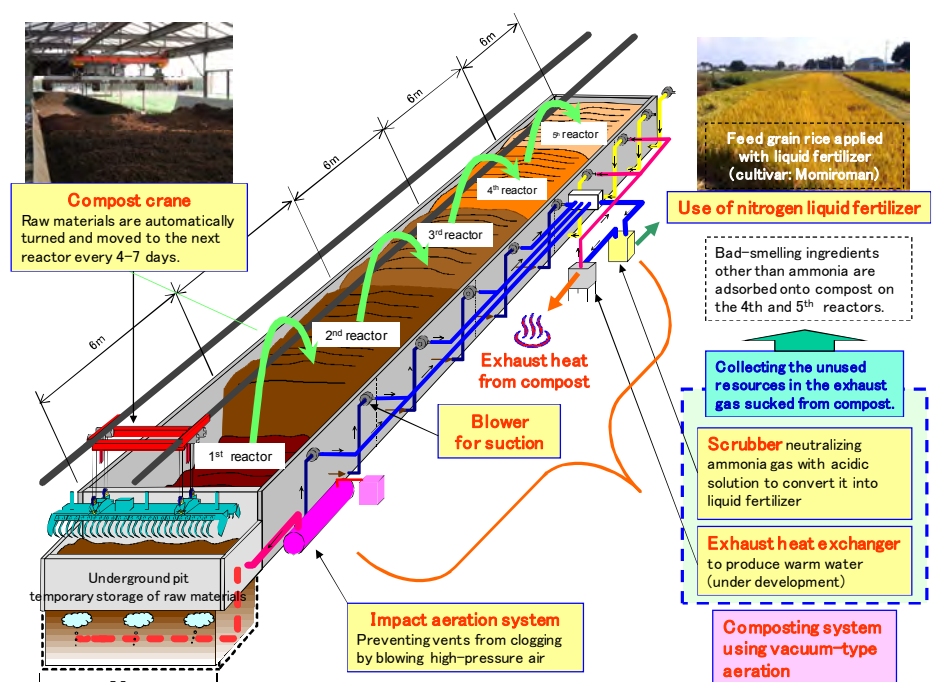
When beef cattle was fed with whole crop rice silage (right: TMR), oxidization of lipids and changes in color were suppressed.

A composting system using vacuum-type aeration

■ Keywords: livestock wastes, composting, ammonia

This system draws air from the bottom of compost with blowers and has the effect of promoting maturation of compost no less than the case of a popular blowing aeration method. In addition, the system uses a scrubber to collect ammonia gas generated during composting as nitrogen liquid fertilizer (ammonium phosphate or ammonium sulfate) and therefore contributes to environmentally conscious, resource-recycling livestock farming.

This system is applicable to compost centers in the disaster-affected regions, yields stable production of compost and effective use of nitrogen resources, and is conducive to reconstruction of livestock farming.



3. Techniques for resumption of production and reconstruction (FFPRI)

① Consensus formation and land-use planning and ② Construction of production bases taking reconstruction into account

Numerical simulation evaluation of the function of coastal forests in mitigating tsunami inundation flow

③ Removal of radioactive substances from forests

Lowering of air dose rate by removal of the litter layer

3. Techniques for resumption of production and reconstruction

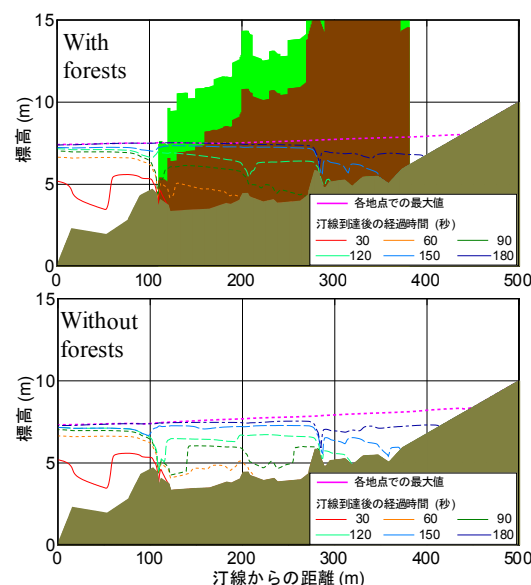
① Consensus formation and land-use planning, and ② Construction of production bases taking reconstruction into account

Numerical simulation evaluation of the function of coastal forests in mitigating tsunami inundation flow

■ Keywords: tsunami inundation flow, coastal forests, numerical simulation

The extent to which coastal forests can mitigate tsunami inundation flow is evaluated by computational numerical simulation.

The simulation model incorporates the resistance of real trees to water flow, obtained by an experiment involving large channels. In addition, conditions of coastal forests, such as the distribution of branches and leaves and forest density, can be reflected in the model, and possible effects in cases where the conditions of coastal forests change can be evaluated. The model can be used to consider different kinds of coastal forest and to study effective arrangement of coastal forests.



Change in the water level of tsunami inundation flow with time

3. Techniques for resumption of production and reconstruction

③ Removal of radioactive substances from forests

Lowering of air dose rate by removal of the litter layer

■ Keywords: forest decontamination, radiation dose, litter layer

Because most radioactive materials that have fallen on forest are deposited on leaves and fallen leaves, removal of such leaves and fallen leaves is considered to be effective for forest decontamination. In two experimental plots with dimensions of 20 m × 20 m in a coniferous forest and a deciduous broad-leaved forest in a suburb of Koriyama City, Fukushima Prefecture, we investigated the change in air dose rate with gradual expansion of the area from which undergrowth and fallen leaves were removed.

As the litter-free area was expanded, the rate of decrease of the air dose rate at the center of the experimental plot became less. Air dose rates of the plot in the deciduous broad-leaved forest decreased to about 60% after complete removal of the litter layer and those of the plot in the coniferous forest decreased to about 70%.

That the extent of decrease in the deciduous broad-leaved forest plot was larger than that in the coniferous forest plot is considered to be a result of the fact that the ratio of radioactive materials deposited on undergrowth and fallen leaves in the deciduous broad-leaved forest was higher because leaves had fallen when a large amount of radioactive materials fell.



Before (right) and after (left) the removal of undergrowth and fallen leaves



Air dose rate measurement after removal of the litter layer

Proposals for post-disaster reconstruction of agriculture

NARO's new technologies supporting reconstruction

-Revitalization of agriculture by post-disaster reconstruction-

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