

# **ASSESSING RADIOACTIVELY CONTAMINATED FARMLAND AND REGENERATION OF SAFE AGRICULTURAL PRODUCE**

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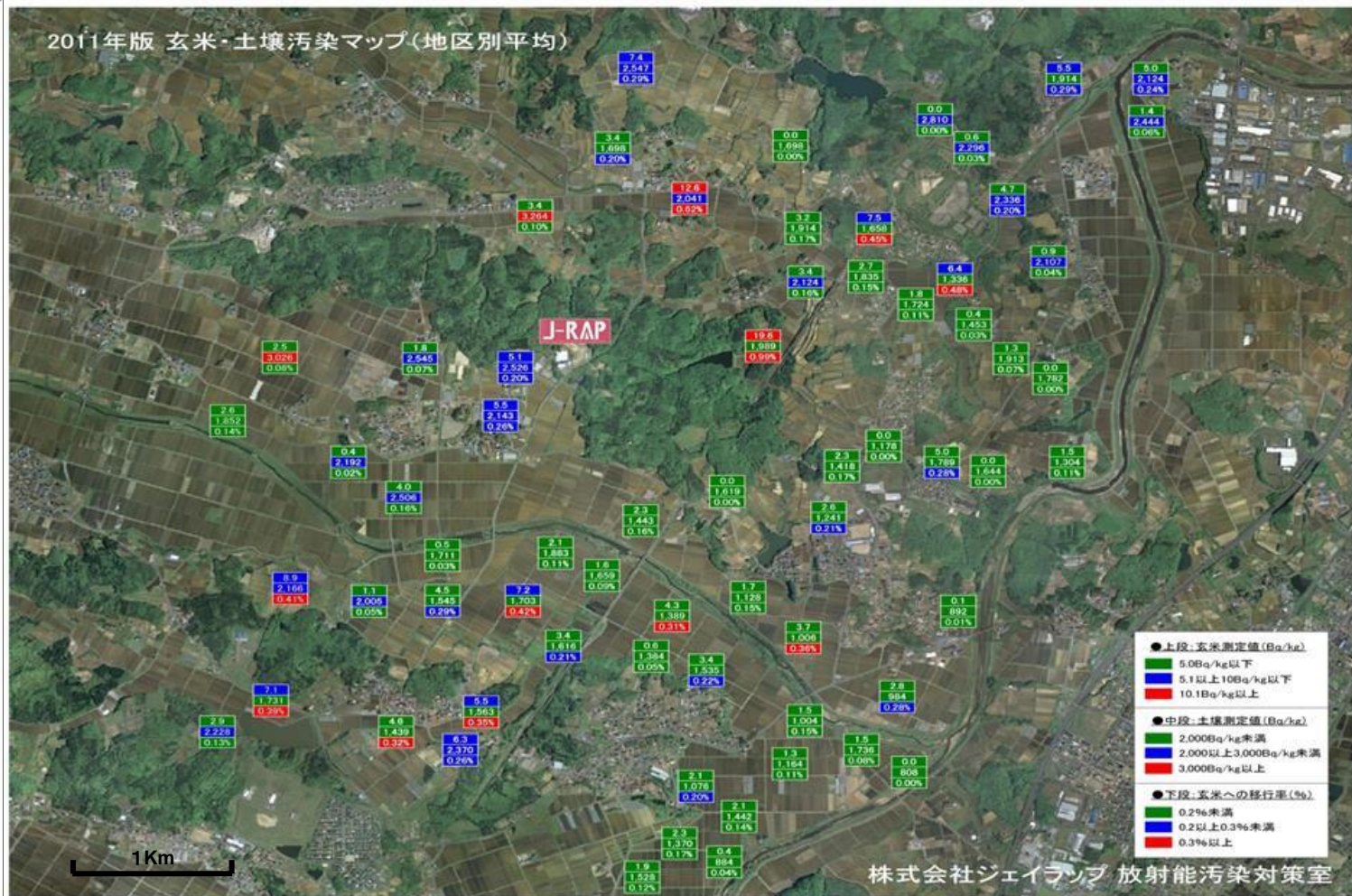
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# MAPPING RADIOACTIVE CONTAMINATION

## ■ 2011

In mapping brown rice growth rate, the Sukagawa Inada district averaged 341 sheets.

Inada District  
2011 rice crop  
341 field sheets

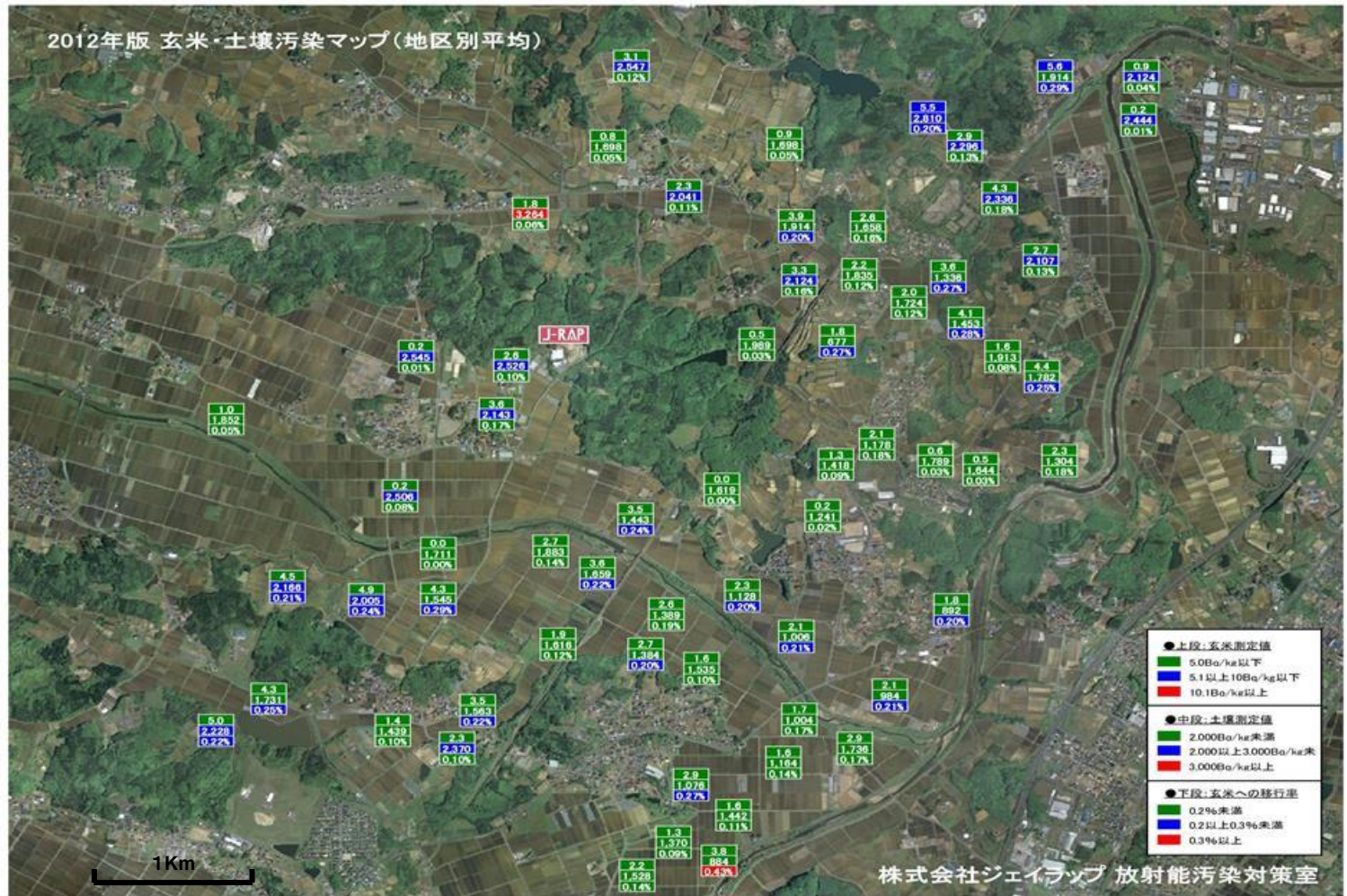


■ 2012

In mapping brown rice growth rate, the Sukagawa Inada district averaged 339 sheets.

Inada District

2012 rice crop  
339 field sheets



# RADIOACTIVITY ABSORPTION CONTROL MEASURES

- Immediately after the nuclear accident, all possible measures were taken based on diverse knowledge, and repeatedly verified.

FY	Soil improvement material	Area	Spray volume/10a Potassium component (kg)
FY2011	Silicic acid potassium	97ha	6kg
FY2012	Silicic acid potassium	85ha	6kg
FY2013	Chloride potash	130ha	12kg

Radioactive material absorption control measures



Tractors (manned manure spreaders) were used to apply potassium fertilizer

# THE STUDY

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- ✘ Impressions of actual contamination for current fiscal year

## (1) Radioactivity absorption control measures in current fiscal year

In one of the few findings from this period, it was found that large quantities of cesium 134 and cesium 137 have characteristics similar to potassium that enhance plant absorption in potassium-deficient environments. We therefore aimed to apply 6kg of potassium per 10a to 341 fields, about 97ha, of rice on June 24 -July 5, the period of highest K-absorption in the nutrient cycle.

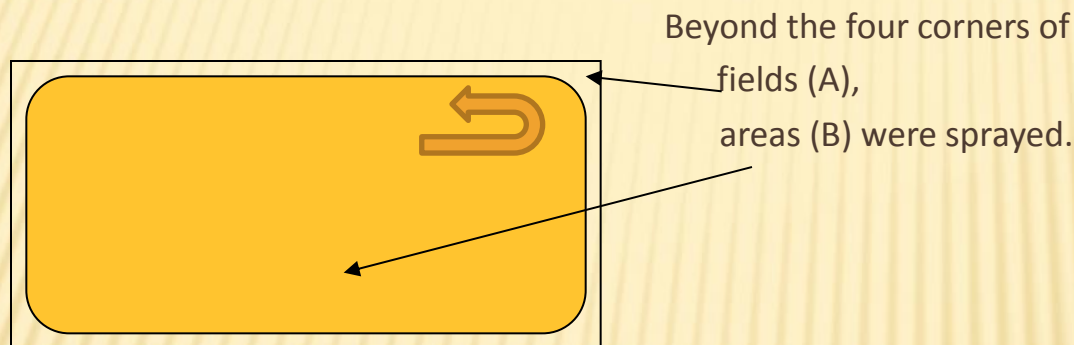
The solution used was  $\text{SiO}_2 + \text{K}$  .

Sufficient quantities of potassium in the soil were found to effectively suppress cesium absorption.



# APPLYING POTASSIUM FOR EFFECT VERIFICATION

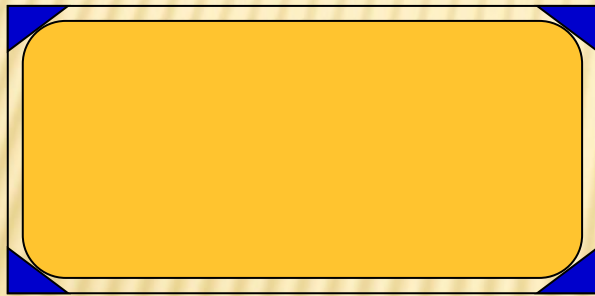
- Although unable to clearly validate with a comparison of a non-application field, the cesium absorption inhibitory effect of potassium application is predicted by observing the following results.



- As tractors (manned manure spreaders) were used to apply potassium spray to 97ha in a timely fashion, areas (A) were not sprayed when turning.
- Brown rice test samples reaped from a total of six areas (pre-harvest areas (A) four and (B) two) were measured. (A total of 341 samples)
- Although measured differences were not constant, when Reaping Samples and Harvest Samples were compared at several points, clear differences were observed.
- Compared to Harvest Samples, Reaping Samples showed statistically higher measured values.

○ Based on the above results, measurements taken in the same field areas (A) and (B) did not reveal a large differential in soil contamination rates. However, brown rice growth was clearly higher in (A) compared to (B).

◆ The above results reveal the potassium application effect. However, as it was easier to collect rice hay in the four corners, environments prone to producing ammonia and hydrogen sulfide are also considered to be related to high growth rates.



Rice hay, etc. easily collected

# ESTABLISHING RADIOACTIVITY INSPECTION SYSTEM

- Aiming to introduce radioactivity measuring instruments in concert with a radioactivity response office, to establish radioactivity inspection system before 2011 rice crop harvest.

## Radioactivity Measuring Instruments



NaI scintillation gamma-ray measuring instrument (produced by EMF Japan)

## Radioactivity Measuring Chamber



Measuring chamber to maintain constant temperature and humidity

# MEASURING BROWN RICE BY REAPING

- Measured radioactivity by reaping 341 contract fields with sheets covering all paddies. Confirmed effectiveness of potassium spraying and verified safety of harvest.

2011 and 2012 same field brown rice crop comparison: NaI scintillation measuring instrument, voluntary inspection reference values

## Radioactivity Measurement Results

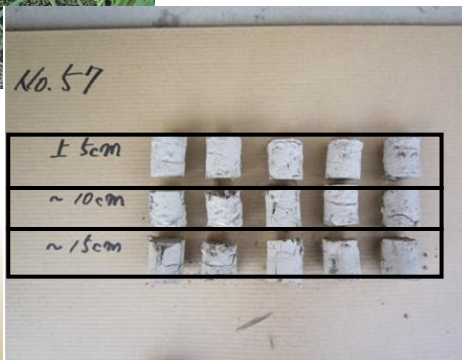
J-RAP Radioactivity measurement room

	2011 crop	2012 crop	2013 crop
Less than 1 Bq/kg	136 samples (39.9%)	93 samples (27.4%)	105 samples (32.0%)
1 Bq/kg - less than 3 Bq/kg	66 samples (19.3%)	127 samples (37.5%)	87 samples (26.5%)
3 Bq/kg - less than 5 Bq/kg	38 samples (11.2%)	79 samples (23.3%)	82 samples (25.0%)
5 Bq/kg - less than 10 Bq/kg	85 samples (24.9%)	37 samples (10.9%)	52 samples (15.9%)
10 Bq/kg - less than 15 Bq/kg	13 samples (3.8%)	3 samples (0.9%)	2 samples (0.6%)
15 Bq/kg - less than 20 Bq/kg	3 samples (0.9%)	0 specimens (0.0%)	0 specimens (0.0%)
<b>Number of fields</b>	<b>341 fields</b>	<b>339 fields</b>	<b>328 fields</b>
<b>Average value</b>	<b>3.11Bq/kg</b>	<b>2.61Bq/kg</b>	<b>2.62Bq/kg</b>

# ASSESSING PADDY SOIL POLLUTION

- Various experiments were conducted to verify nuclear accident paddy field pollution, and information collected for effective decontamination methods and activities. Based on this data, reverse tillage decontamination activities were performed for three years.

## Soil Pollution



## Reverse Tillage Decontamination Effect Verification

### Surface

25cm	0-5cm	A	54.8%	A+B (54.8+34.0) 0-10cm/88.8%
	5-10cm	B	34.0%	
	10-15cm	C	11.2%	
		B'	<b>B in this position</b>	
		A'	<b>A in this position</b>	

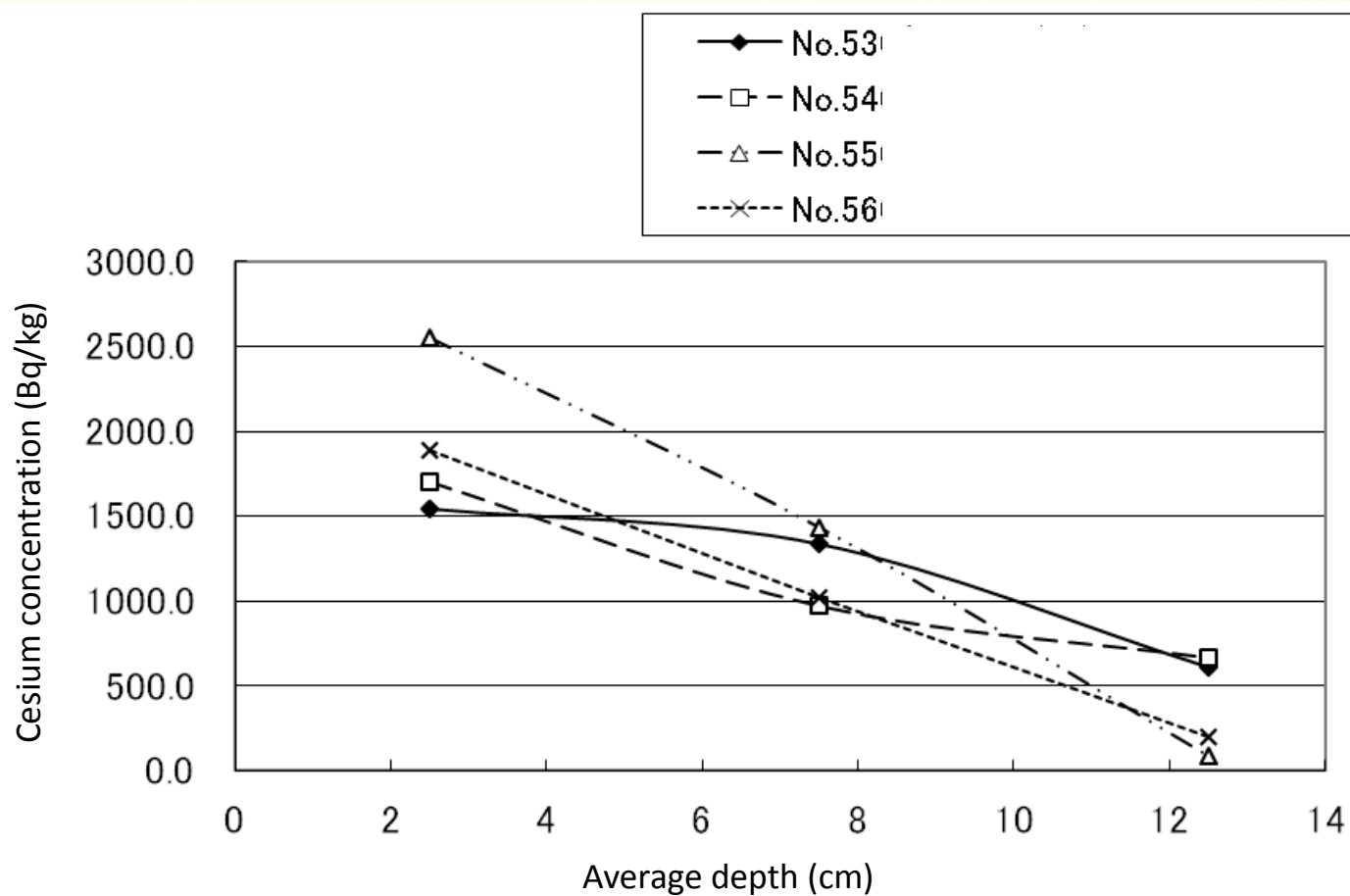
# DISTRIBUTION OF RADIOACTIVE SUBSTANCES IN RICE PADDIES

Field No.	Sample date	5cm (Bq/kg)			5-10cm (Bq/kg)			10-15cm (Bq/kg)			Avg.
		Cs137	Cs134	Cs Total	Cs137	Cs134	Cs Total	Cs137	Cs134	Cs Total	Cs Total
53	8/16	866.0	681.8	1,547.8	851.6	488.5	1,340.1	344.1	269.9	614.0	1,167.3
54	8/23	919.2	780.3	1,699.5	525.0	448.4	973.4	370.7	300.1	670.8	1,114.6
55	8/26	1467.8	1083.6	2,551.4	804.0	629.8	1,433.8	43.7	40.7	84.4	1,356.5
56	8/26	1070.2	820.6	1,890.8	566.5	454.7	1,021.2	116.0	85.9	201.9	1,038.0
Avg.				1,922.4			1,192.1			392.8	1,212.8
Ratio				100%			62.0%			20.4%	
Comp.				54.8%			34.0%			11.2%	

## Consideration 1.

Analysis results show that in rice paddies planted during the measurement period, 54,8% of radioactive cesium was retained within the first 5 cm of soil, and 88,8% within the first 10 cm. The distribution of particles in each layer, in order from large, low density particles, was replicated by filtering soil particles by specific weight during the plowing and irrigation of rice paddies. The analysis also showed that particles with a large surface area adsorbed more radioactive cesium. It is unlikely that regular work on rice fields will cause major alterations to this distribution.

# CORRELATION OF PADDY SOIL DEPTH AND CESIUM CONCENTRATION



# OUTLINE OF PADDY SOIL PROCESSING AND REPLICATION AFTER PLOUGHING AND IRRIGATION

- The following documentation shows that fine soil particles with large surface area and low density have adsorbed large amounts of radioactive cesium. This information may be a key to developing efficient ways of decontaminating soil.
- It is likely that radioactive substances adhering to soil particles will move around with water after rain.
- There may be a risk of wind spreading radioactive substances adsorbed into fine soil particles.

**A** Original soil 77,000 Bq/kg

**B** Suspended solids 59,000 Bq/kg  
Recovery rate 10.9%

**C** Suspended load 993,000 Bq/kg  
Recovery rate 4.2%

**D** Deposits 29,000 Bq/kg  
Recovery rate 84.3%

1. Filtration with 60 mesh net after stirring

2. Stirring and coagulation of suspended load

3. Separation of water and deposits

Experiment: J-Rap Inc.  
Radioactive Contamination Countermeasure Dept.

# REVERSE TILLAGE DECONTAMINATION PROCESS

120 ha tilled in 2012    350 ha tilled in 2013

## ① Radiation measurement



Two measurements per 10a

## ② Soil analysis



5 samples from each spot are combined

## ③ Spraying



100kg of zeolite per 10a

## ④ Reverse tillage



Tilling with a five-furrow plow

## ⑤ Harrowing



Soil is evened out with a harrow once dry

## ⑥ Second soil analysis



13 factors including CEC are analyzed

## ⑦ Leveling



Soil is leveled with a leveller

## ⑧ Second spraying



200kg of zeolite per 10a

## ⑨ Rotary tillage



Rotary tillage finishing

## ⑩ Radiation measurement



Final radiation measurement completes the process

# RADIOACTIVITY INSPECTION PROCESS FOR RICE

- The safety of Inada rice produced in 2011 was ensured with a four-stage radiation inspection process prior to shipping, while all rice produced in 2012 underwent a five-stage process.

## ① On every field

- Pre-harvest measurement by reaping



## ② All produced rice

- The Fukushima Association for Securing Safety of Agricultural Products inspects all rice in 30kg bags



## ③ Every pallet

- One bag out of 49 is picked at random and inspected from every pallet



## ④ Brown rice

- A sample is measured from every Batch of rice as it is polished.



## ⑤ Every shipped item

- Samples are taken and measured From the polished white rice products.



Shipped together with a measurement report



# INSPECTION OF ALL PRODUCED RICE

All rice is inspected in 30 kg packages using a radioactivity measurement device equipped with a conveyor belt.



## Radioactive contamination of rice produced in 2011-2013 and results of comprehensive inspection of rice

Regional comparison	Inasaku Kenkyujo Details (Reference values from voluntary inspections/Nal scintillation/1L)							Radiation measurements of all rice produced in Fukushima Prefecture (as of Jan. 28 2014)				
Measured radioactive cesium (Bq/kg)		Under 1 Bq/kg	1-3 Bq/kg	3-5 Bq/kg	5-10 Bq/kg	10-15 Bq/kg	15-20 Bq/kg	Under 25 Bq/kg	25-50 Bq/kg	50-75 Bq/kg	75-100 Bq/kg	Over 100 Bq/kg
3,615,584 bags Aizu	2013							99.999%	0.001%			
	2012							99.994%	0.006%			
6,399,523 bags Nakadori	2013							99.939%	0.060%	0.001%	0.001%>	0.001%>
	2012							99.669%	0.295%	0.027%	0.007%	0.001%>
803,020 bags Hamadori	2013							99.612%	0.292%	0.053%	0.040%	0.003%
	2012							99.679%	0.308%	0.005%	0.001%	0.001%>
(844,413 bags) (Sukagawa)	2013							(99.990%)	0.010%			
	2012							(99.711%)	(0.246%)	(0.034%)	(0.009%)	0.001%>
2013 Fukushima Prefecture Total								99.934%	0.058%	0.005%	0.003%	0.001%>
10,818,127 bags x 30kg								10,811,027	6,259	490	323	28
2012 Fukushima Prefecture Total								99.763%	0.214%	0.017%	0.004%	0.0004%
10,116,588 bags x 30kg								10,094,355	4,082	1,676	404	71
Production volume 300,000t – 330,000t												
Fields planted by Inasaku Kenkyujo	2014 328 fields	32.0%	26.5%	25.0%	15.9%	0.6%		(100%)				
		(105)	(87)	(82)	(52)	(2)		2.62Bq/kg				
	2013 340 fields	27.4%	37.6%	23.2%	10.9%	0.9%		(100%)				
		(93)	(128)	(79)	(37)	(3)		3.11Bq/kg				
2012 341 fields	39.9%	19.3%	11.2%	24.9%	3.8%	3.8%	(100%)					
	(136)	(66)	(38)	(85)	(13)	(3)	3.11Bq/kg					
50 reverse tilled fields	2013 rice	42.0%	30.0%	22.0%	6.0%			(100%)				
		(21)	(15)	(11)	(3)							

\* Cross-checked 2-3 times monthly, starting from rice shipped in October 2013, by the Riken Analysis Center using accurate germanium measurements.

# Changes in amount of radioactive cesium in rice

Brown rice  $\longrightarrow$  White rice  $\longrightarrow$  Cooked rice Simulation of residual radioactive substance ratio

Contamination in brown rice (Bq/kg)	After washing (Bq/kg)	Contamination in cooked rice (Bq/kg)	Annual internal exposure dosage (based on brown rice)		Annual internal exposure (ratio based on 1 mSv)
			mSv	Brown rice comparative avg. below 38%	
20	15.00	7.50	0.014	$7.5 \times 1.6 \times 10^{-5} \times 120$	100/1.4mSv
10	7.50	3.75	0.0072	$3.75 \times 1.6 \times 10^{-5} \times 120$	1,000/7.2mSv
5	3.75	1.88	0.0036	$1.88 \times 1.6 \times 10^{-5} \times 120$	1,000/3.6mSv
3	2.25	1.13	0.0022	$1.13 \times 1.6 \times 10^{-5} \times 120$	1,000/2.2mSv
1	0.75	0.38	0.0007	$0.38 \times 1.6 \times 10^{-5} \times 120$	10,000/7.0mSv
Contamination in brown rice (Bq/kg)	Contamination in white rice (Bq/kg)	Contamination in cooked rice (Bq/kg)	Annual internal exposure dosage (based on cooked rice)		Annual internal exposure (ratio based on 1 mSv)
			mSv	Brown rice comparative avg. below 12%	
20	6.0	2.25	0.00576	$3.0 \times 1.6 \times 10^{-5} \times 120$	1,000/5.8mSv
10	3.0	1.13	0.00288	$1.5 \times 1.6 \times 10^{-5} \times 120$	1,000/2.9mSv
5	1.5	0.56	0.00144	$0.75 \times 1.6 \times 10^{-5} \times 120$	1,000/1.4mSv
3	0.9	0.34	0.00086	$0.45 \times 1.6 \times 10^{-5} \times 120$	10,000/8.6mSv
1	0.3	0.11	0.00021	$0.11 \times 1.6 \times 10^{-5} \times 120$	10,000/2.1mSv

● Comparison with the highest standard in the world, the “Ukraine standard” – Comparing rice and bread

The Ukraine standard means 20Bq/kg or less in bread as a staple food. The Japanese standard is 100Bq/kg in brown rice, making comparison of the two standards difficult. However, rice and bread can be compared as follows:

- Polishing 100Bq/kg rice will bring radioactivity down to 30Bq/kg.
- Washing removes bran, which contains a relatively high dose of radioactive elements, reducing the radioactivity by a further 25% to 23Bq/kg.
- Cooking white rice with a roughly equal amount of water will approximately halve radioactivity to 12Bq/kg.
- In other words, although the Ukraine standard is considered to be the highest (staple food) standard in the world, the Japanese white rice standard is higher still.

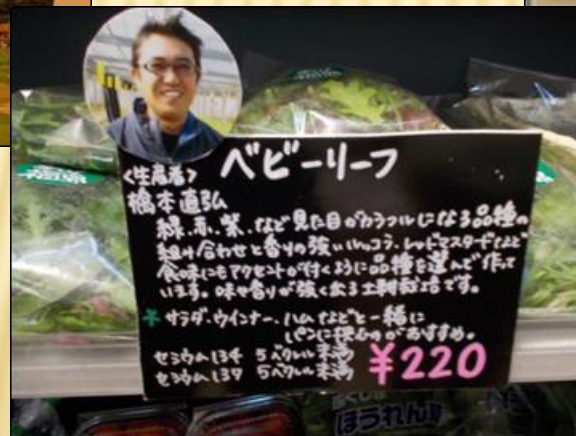
● Since 2012, rice producers in Fukushima have worked to stabilize production of low-dose brown rice with radioactivity below 1Bq/kg.

Brown rice contains several nutrients that are effective against internal exposure, such as pectin, hemicellulose and phytic acid.

# OPENING OF HONJITSU! FUKUSHIMA

CATALOG HOUSE

Honjitsu! Fukushima, a regional Fukushima store, is open in the Catalog House Tokyo building in Shinjuku. The store offers a wide range of Made in Fukushima items including processed foods, alcoholic drinks and daily commodities from 70-80 producers. Operation of the store is a way for our company as a whole to support the recovery of Fukushima Prefecture.



**THANK YOU!**

Toshihiko Ito  
Representative Director  
J-RAP Inc.  
Sukagawa, Fukushima Prefecture