temporary translation
NEA International workshop
on Post-Accident Food Safety Science

Mechanism and Measures for Contaminated Rice

Production Environment Department, Environment / Crop Nutrition Department

Fukushima Agricultural Technology Centre

Main radioactive material spread by the accident at TEPCO's Fukushima Daiichi Nuclear Power Plant.

Nuclide	Emission volume (Bq)	Half-life	Remarks
Iodine 131 (I-131)	16,000 trillion	Approx. 8 days	
Cesium 134 (Cs-134)	18,000 trillion*	Approx. 2 years	
Cesium 137 (Cs-137)	15,000 trillion	Approx. 30 years	
Strontium 89 (Sr-89)	2,000 trillion	Approx. 50.5 days	
Strontium 90 (Sr-90)	140 trillion	Approx. 29 years	

Source: Estimation of radioactive material released from TEPCO's Fukushima Daiichi Nuclear Power Plant and the nuclear bomb dropped on Hiroshima (August 26, 2011)
*Emission of Cs-134 is according to the report from Nuclear and Industrial Agency.

A large amount of radioactive Cesium 134 and 137 was released. Since these have a longer half-life they will remain in agricultural land, and the risk of absorption by agricultural crops is a problem.

"Technological Development of Measures for the Removal and Reduction of Radioactive Material"

★Research consists of seven pillars set according to the advice of experts.
A radiation countermeasures team was established, and research began.

1 Identification of the distribution status of radioactive material in farmland soil within the prefecture

2 Development of a simplified measurement method for radioactive materials (soil/animals)

3 Identification of the amount of absorption of radioactive materials in various crops

4 Development of technology for the removal/reduction of radioactive material

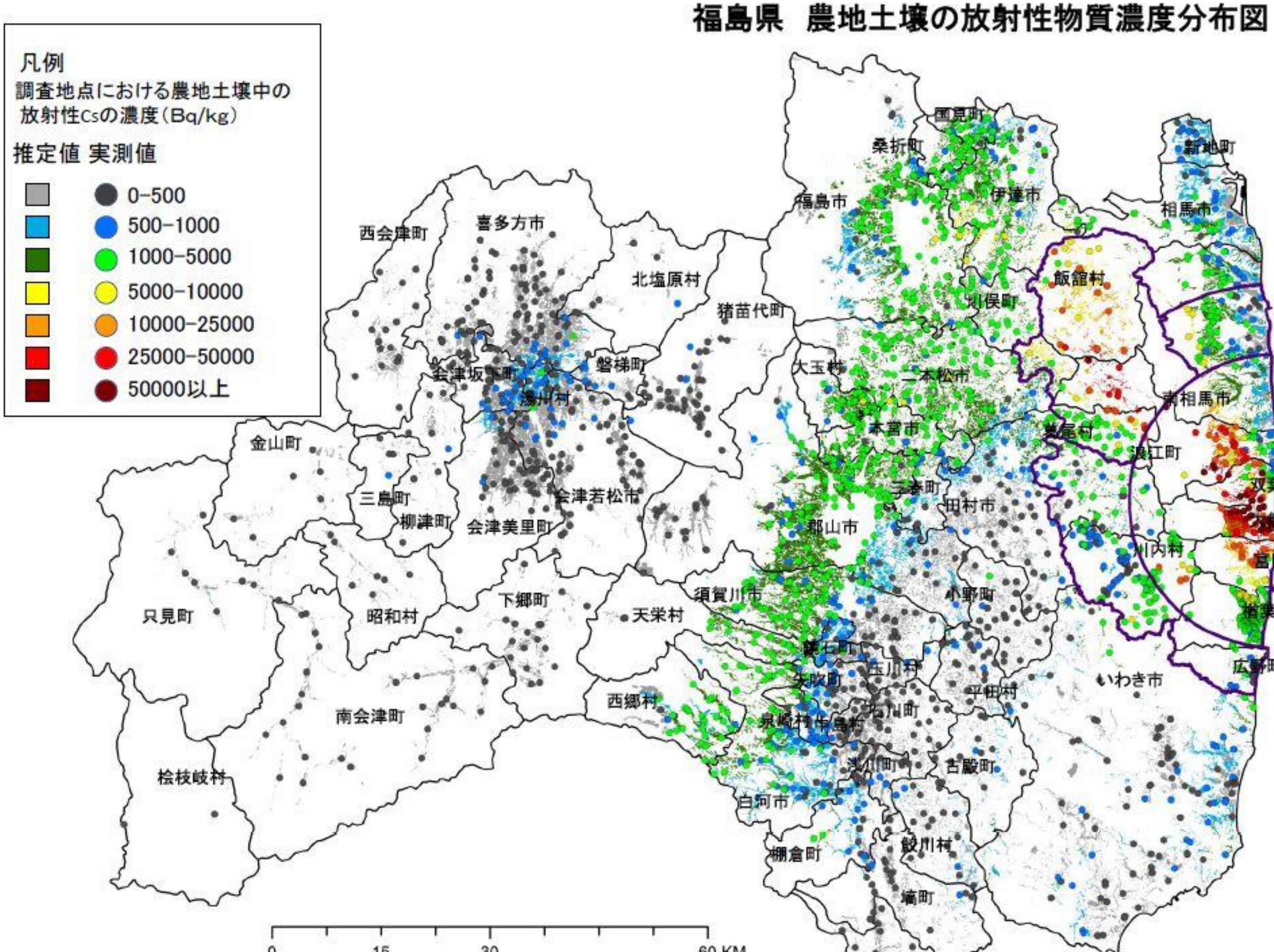
5 Development of technology for the control of absorption of radioactive material

6 Development of technology for the removal of radioactive material during processing of agricultural products

7 Development of technology for the reduction of radiation exposure in agricultural jobs

○ Distribution of radioactive cesium in Fukushima prefecture

Collected and analyzed from 2247 locations of farmland soil, published by the Ministry of Agriculture, Forestry and Fisheries



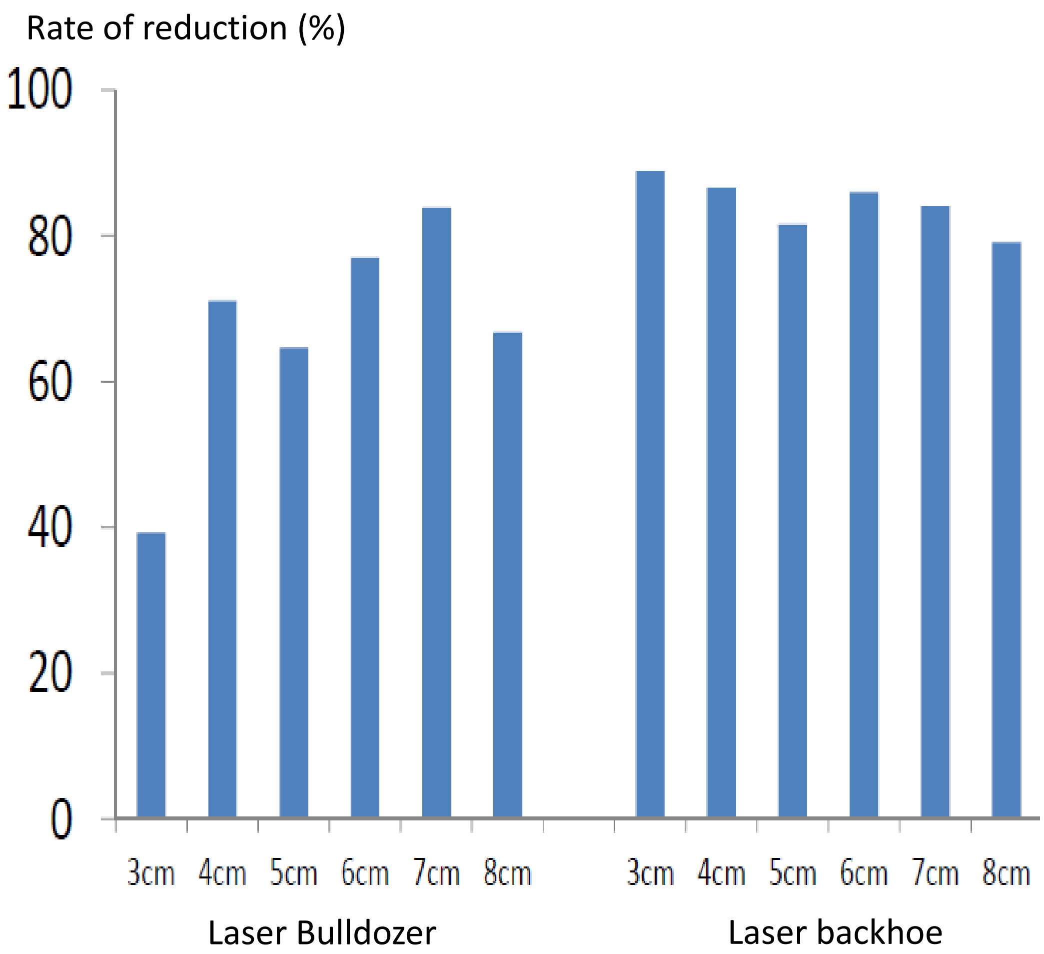
（注1）農地の分布は、独立行政法人農業環境技術研究所が2010年に作成・公開した農地土壌図（2001年の農地の分布状況を反映）から作成

（注2）推定値は、航空機による空間線量率の測定結果等を参考に試算した推計に基づくものであり、一定の誤差を含んでいます。

Decontamination of rice fields by auto laser level construction equipment

Laser bulldozer

Laser backhoe

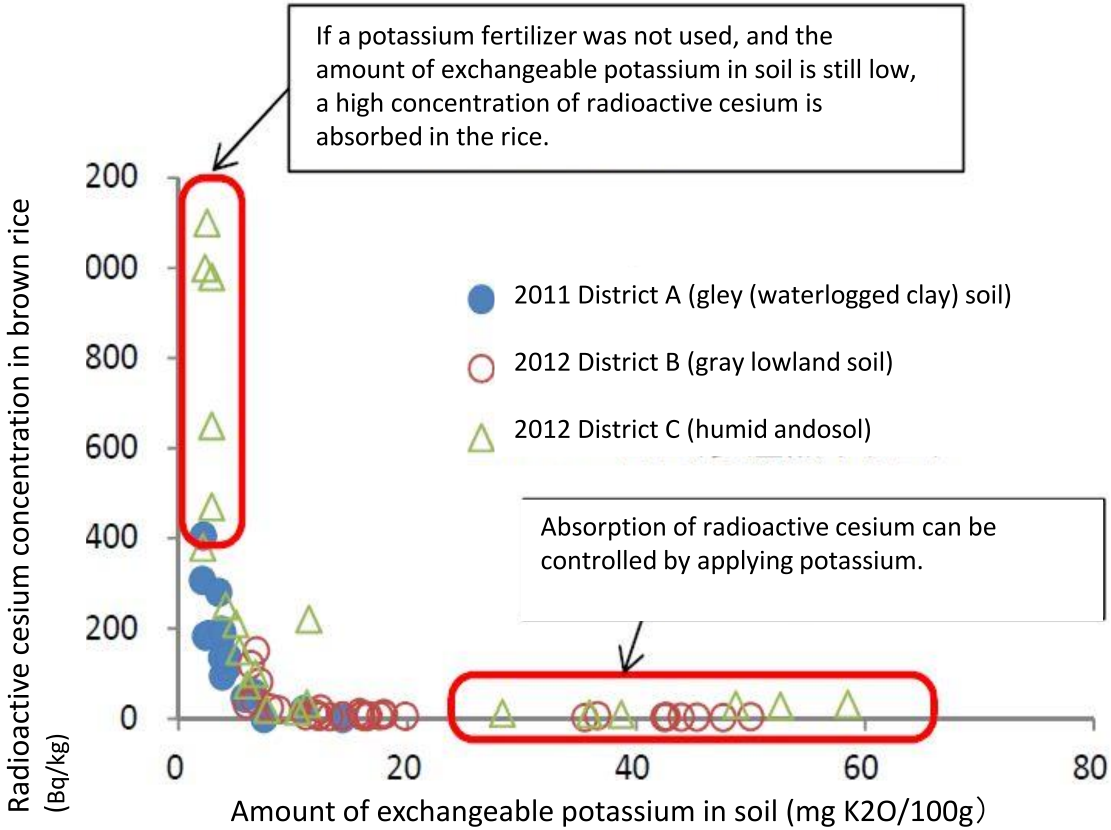


Effect of both pieces of construction equipment in the reduction of radioactive cesium in the soil was high, and the working time was short. Approx. 5cm of the surface soil was scraped off.

Scraping off decontamination work of surface soil in the “zones preparing for the lifting of the evacuation order” (Iitate village)

Processing of the soil removed during decontamination is an issue. Decontamination soil can be found throughout Fukushima prefecture

Correlation between the amount of exchangeable potassium in soil and concentration in brown rice



Description

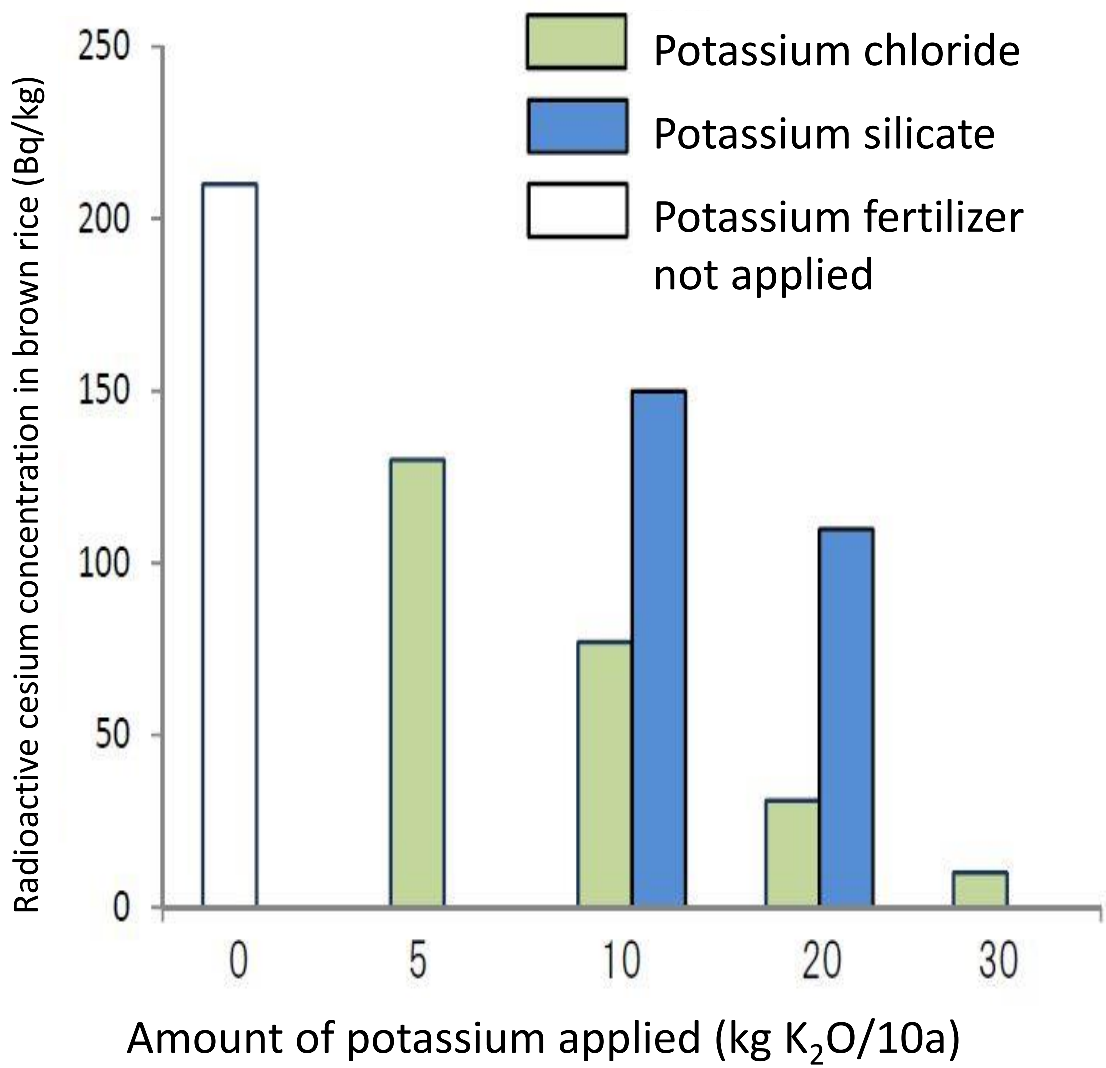
・On-site testing was carried out in 2012, in districts where high concentration of cesium exceeding 500Bq/kg was detected in brown rice produced in 2011. A correlation between the amount of exchangeable potassium in soil and radioactive cesium concentration in brown rice was considered.

・Even in districts where brown rice produced in 2011 and contained radioactive cesium exceeding 500Bq/kg, if the exchangeable potassium in the soil was greater than 25 mg K_2O/100g, the radioactive cesium concentration in the rice was shown to be below the standard value.

・Moreover, when three different districts were confirmed, a similar effect could be observed in all the districts.

There is a clear correlation between the amount of exchangeable potassium in soil and concentration in brown rice！
In cases where the exchangeable potassium in soil was greater than 25mg K2O/100g, the radioactive cesium concentration in brown rice was shown to be below the standard value.

Comparison of absorption control effect of potassium chloride and potassium silicate

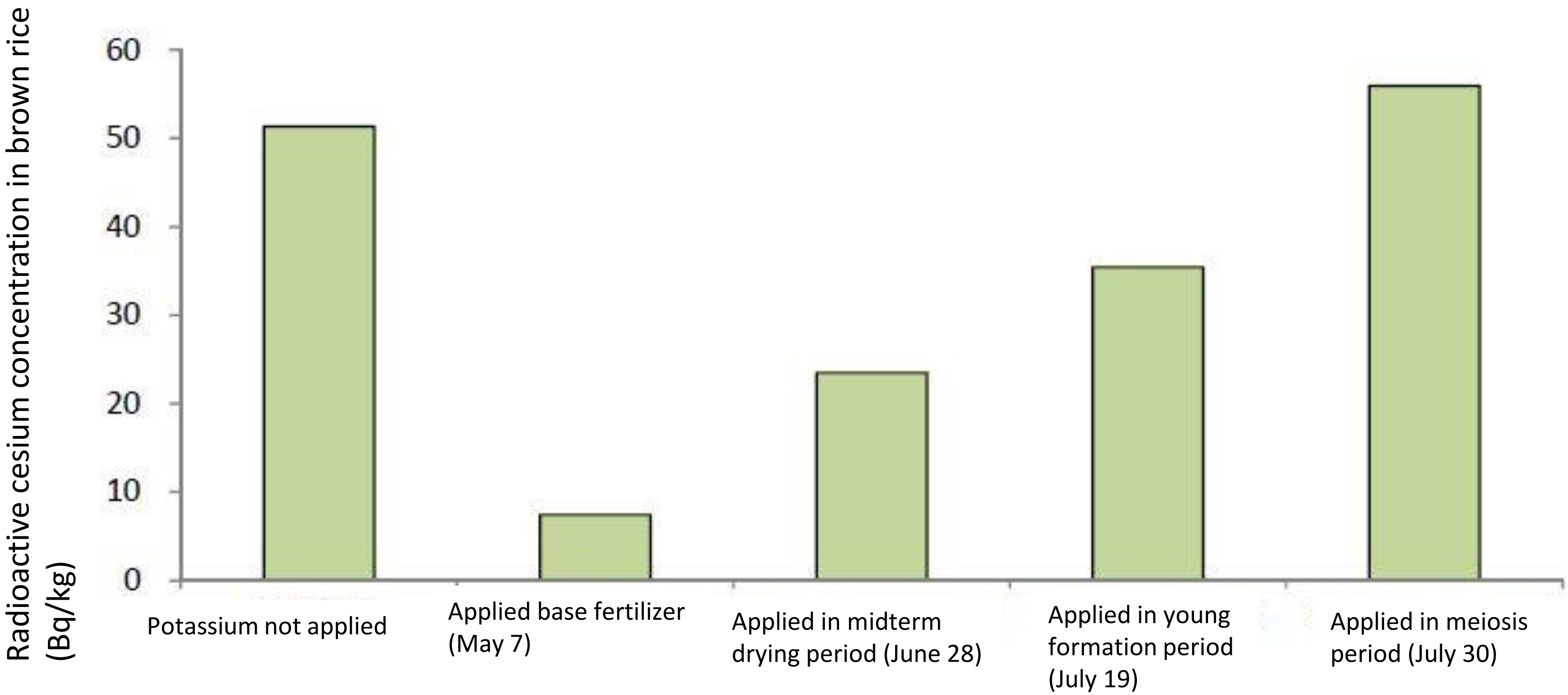


Description

・Planter test by gley soil with exchangeable potassium in the soil of 3.3mg K_2O/100g. The test results of a comparison of radioactive cesium concentration in brown rice where potassium fertilizer was not used, and where potassium fertilizer was used- in the form of potassium chloride, 8.3, 16.6, 33.3, 50.0kg (as K_2O, 5, 10, 20, 30kg), or potassium silicate 50, 100kg (as K_2O, 10, 20kg) per 10a.

・When the amount of exchangeable potassium in soil was significantly lower than the target value, fast-acting potassium chloride (which dissolves faster and has a higher reduction rate for radioactive cesium concentration in brown rice), rather than soluble potassium silicate (which dissolves potassium components in the soil more slowly), was used when applying potassium every year,

Comparison of absorption control effect of potassium chloride by fertilizing period

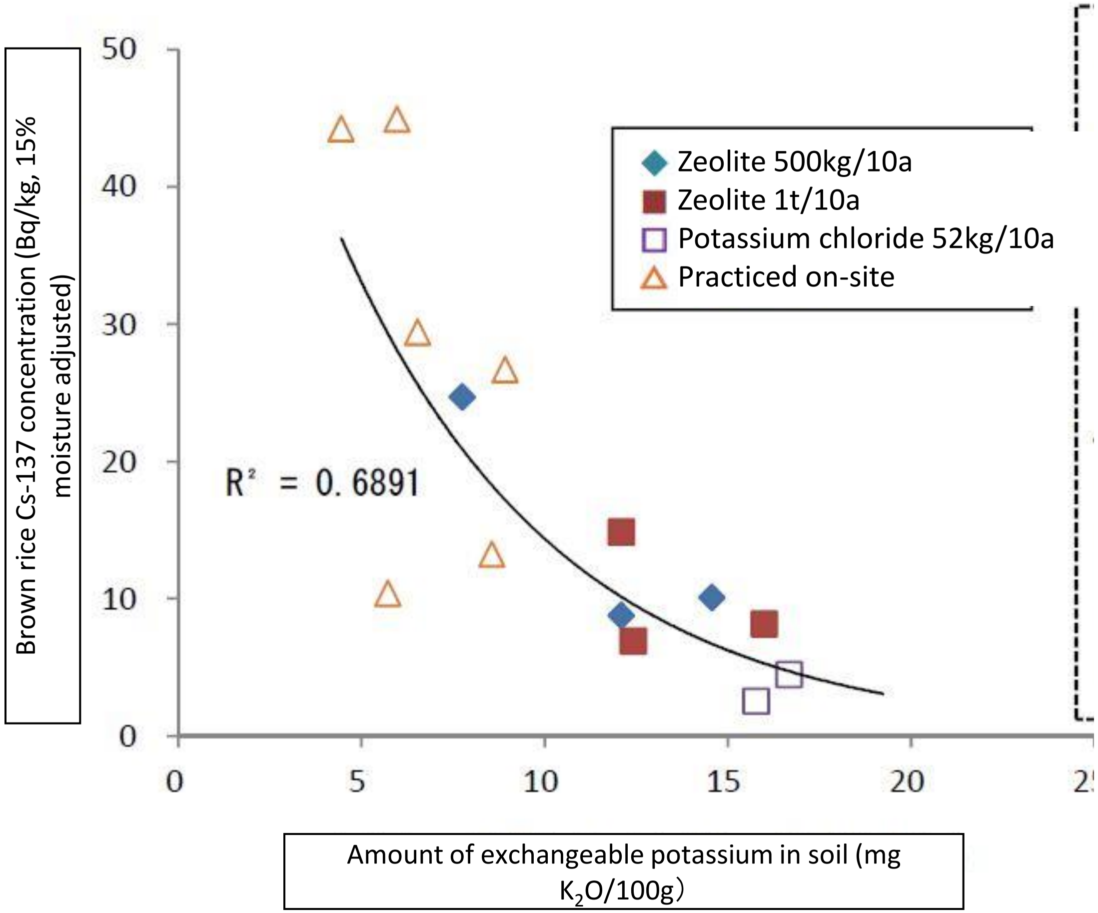


Description

・Test results of the absorption control effect of radioactive cesium concentration in brown rice, by changing the application period of potassium choloride (8kg/10a as K2O) in gley soil rice fields with14.7mg K2O/100g of exchangeable potassium.

・Assuming the quantity of fertilizer is constant, early fertilizing as a base fertilizer was more effective than additional fertilization at later times.

Effect of zeolite application on the quantity of exchangeable potassium in soil and radioactive cesium concentration in brown rice



Description

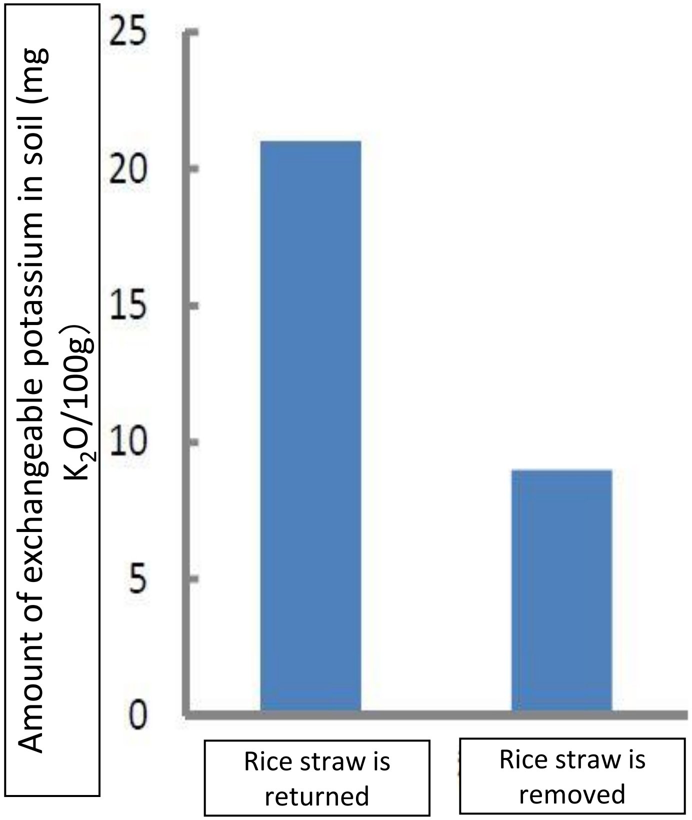
・Test results on the consideration of the absorption control effect in brown rice, by applying zeolite and potassium chloride, in rice fields which had insufficient potassium as exchangeable potassium in the soil at less than 4mg K2O /100g. Furthermore, 4kg/10a was used as the fertilizing potassium in all processing districts, and the amount of exchangeable potassium in soil at the point of May 23 was used as the measurement value.

・Since the effect of application of zeolite, etc. on radioactive cesium concentration in brown rice can be described as the amount of exchangeable potassium in the soil, use of a small amount of zeolite, etc. is considered to control the effect of potassium which contains the small amount of zeolite, etc., rather than the effect of absorption.

This confirmed the absorption control effect of zeolite.

The control effect of exchangeable potassium was shown to increase with use, according to the adsorption effect of radioactive cesium.

Effect of managing rice straw on the amount of exchangeable potassium in soil



Description

・Since a large amount of potassium is contained in rice straw, if it is returned to the field, it is easier to maintain the amount of exchangeable potassium in soil.

・In fact, when the amount of exchangeable potassium in soil was investigated for each rice field where the rice straw was returned to the soil for approx. 20 years, and for rice fields where the rice straw was removed, the amount of exchangeable potassium in soil of the rice field was approximately half of that in rice fields where such rice straw was not removed.

○ Generally, fields in which the amount of exchangeable potassium can easily decrease are listed below.

→ Field where rice straw is not returned, and application of compost has not been carried out for a long time.

→ Fields for personal consumption where potassium fertilizer has not been applied for a long time.

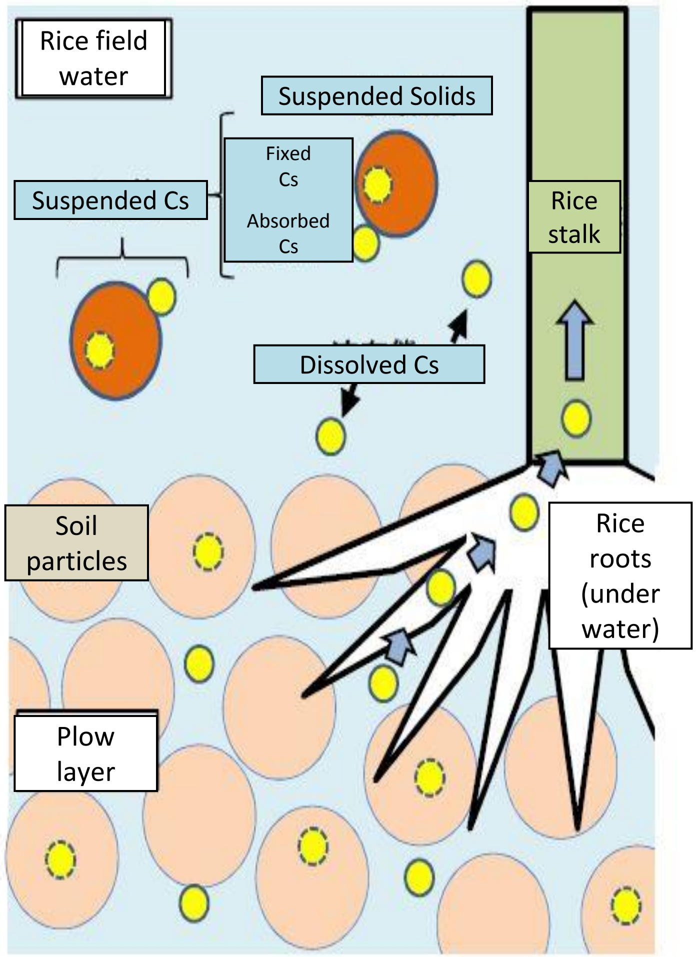
→ Fields with weaker retention such as sandy soil

According to the results of continuous testing, long-term rice straw removal reduces exchangeable potassium.

Achievement of **more than 20 years of steady research! "Endurance makes you stronger."**

Consideration of the influence of agricultural water

Formation of cesium in water (image)

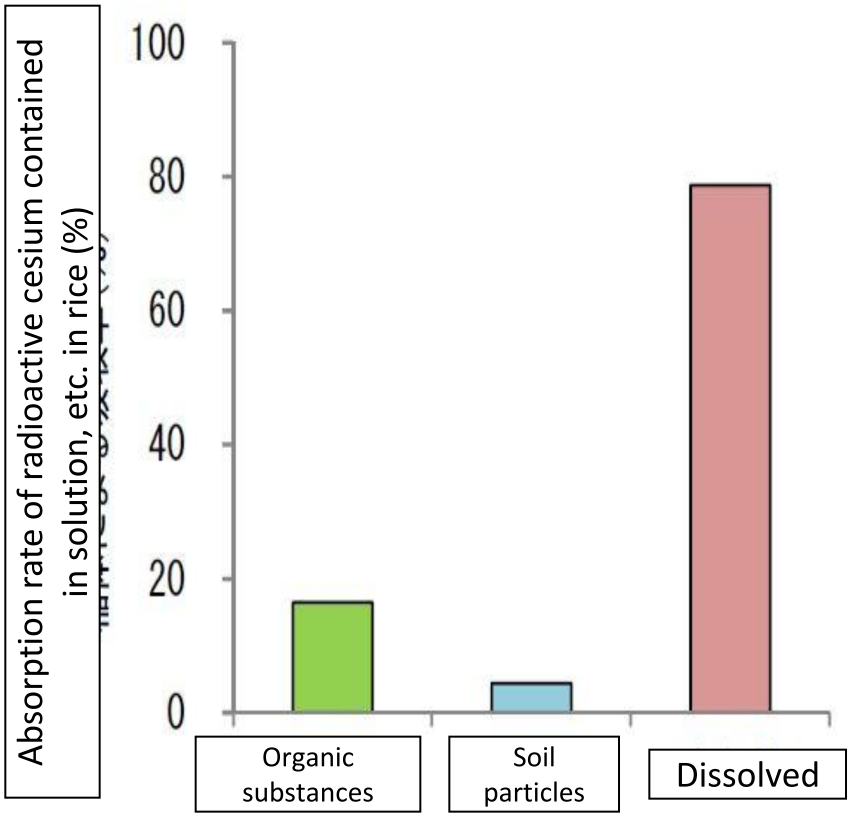


Description

・In addition to radioactive cesium contained in water as dissolved matter where cesium is dissolved in water by ions, etc., it is also present in the suspended state where it is absorbed and attached to suspended solids such as soil particles in suspension and organic matter.

・The fixed state and absorption state cesium (Cs) (suspended cesium) contained in irrigation water and suspended solids in rice field water is not directly absorbed by the rice stalk or roots, but the dissolved state of Cs in rice field water and water-soluble cesium in the plow layer migrate to through stalk and roots.

Absorption of dissolved and suspended radioactive cesium in rice field water



Description

・Using the pot test of cloth-filtered solution of ^{137}Cs extracted with water from fallen leaves collected in the prefecture:
① Filter with filter paper (No. 131), and set the residue as "organic substances"
② Soil particles are added to the residue and shaken for 20 hours, then filter with filter paper (No. 131), and set the resulting substance as "soil particles,"
③ Liquid filtered with a 0.45μm filter is set as "dissolved matter." 30 Bq is added to each in a pot (U8 container). A rice stalk with a foliar age of 3.8 is planted in it, and then collected 11 days after later. ^{137}Cs concentration is measured.

・Compared to the absorption rate of dissolved matter of the whole rice at 79%, the absorption rate for organic substances and soil particles was lower at 16% and 4%, respectively. A significant difference depending on the form ^{137}Cs was observed.

Absorption of dissolved radioactive cesium was easier in wet-land rice.

***Results from hydroponic culture in polluted water extracted from fallen leaves.**
The dissolved state contained in actual river water and storage reservoir water are minuscule, so absorption to rice plants is small, and there is almost no effect from the radioactive material concentration.

Introduction of recent research achievements

◎Radiation in the soil in rice fields and dry fields

Change of cesium concentration over time (years)

* (results of radiation material measurement survey by a consigned project)

Survey method of radioactive cesium in soil and air dose rate

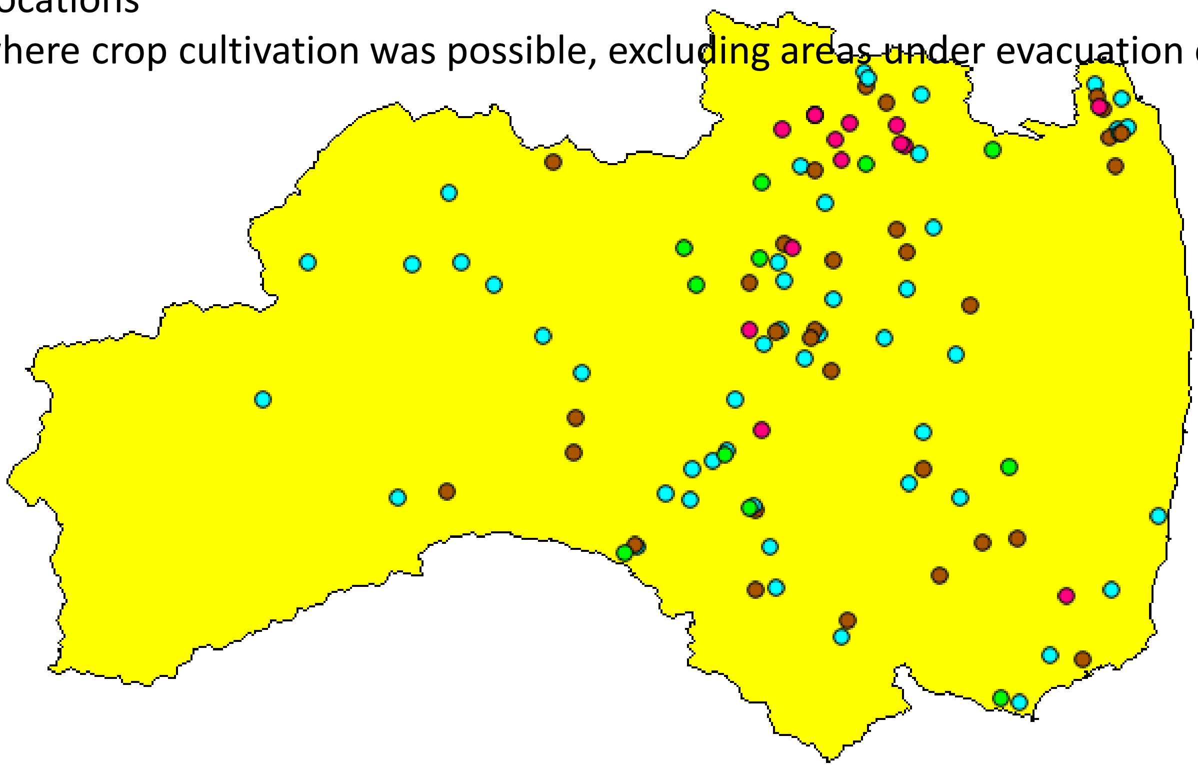
● Survey period

Three years from 2012-2014

Radioactive material measurement survey consigned project (Ministry of Agriculture, Forestry and Fisheries)

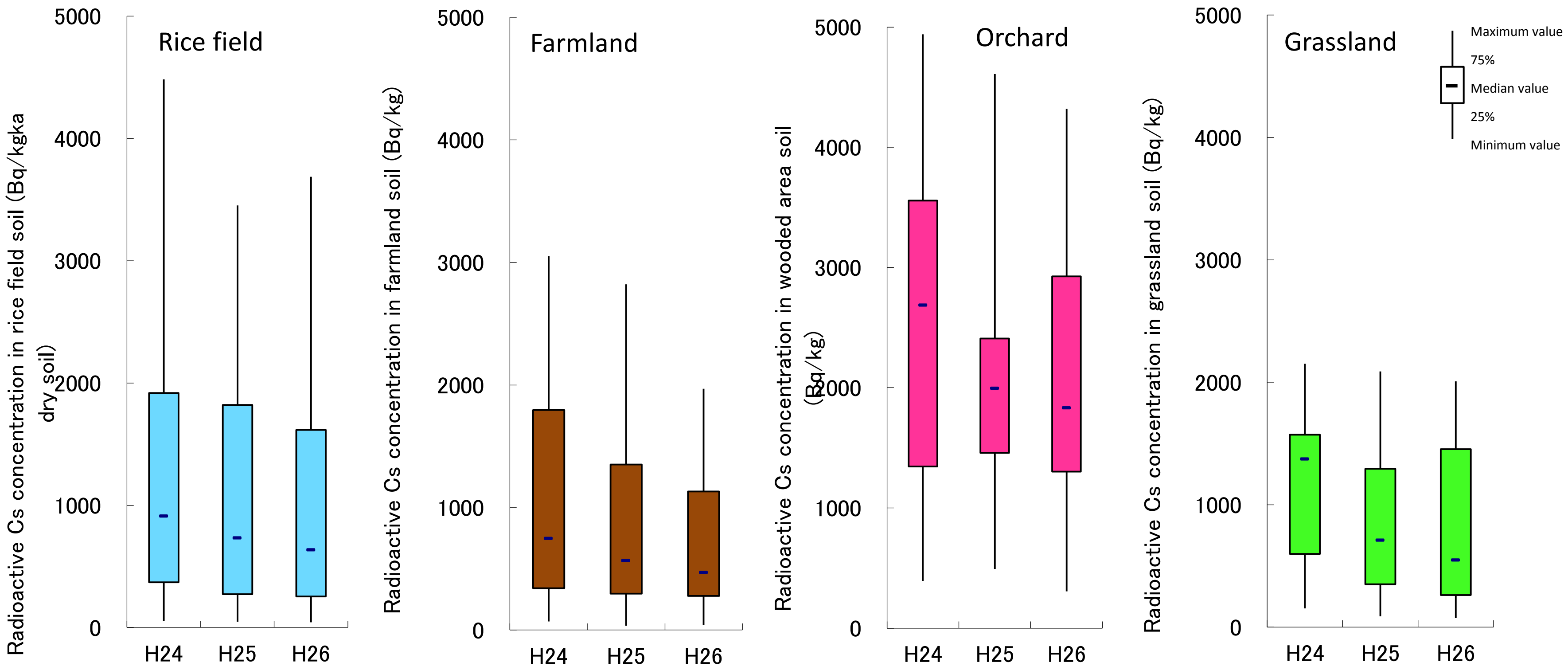
● Survey locations

Fields where crop cultivation was possible, excluding areas under evacuation orders 107 locations



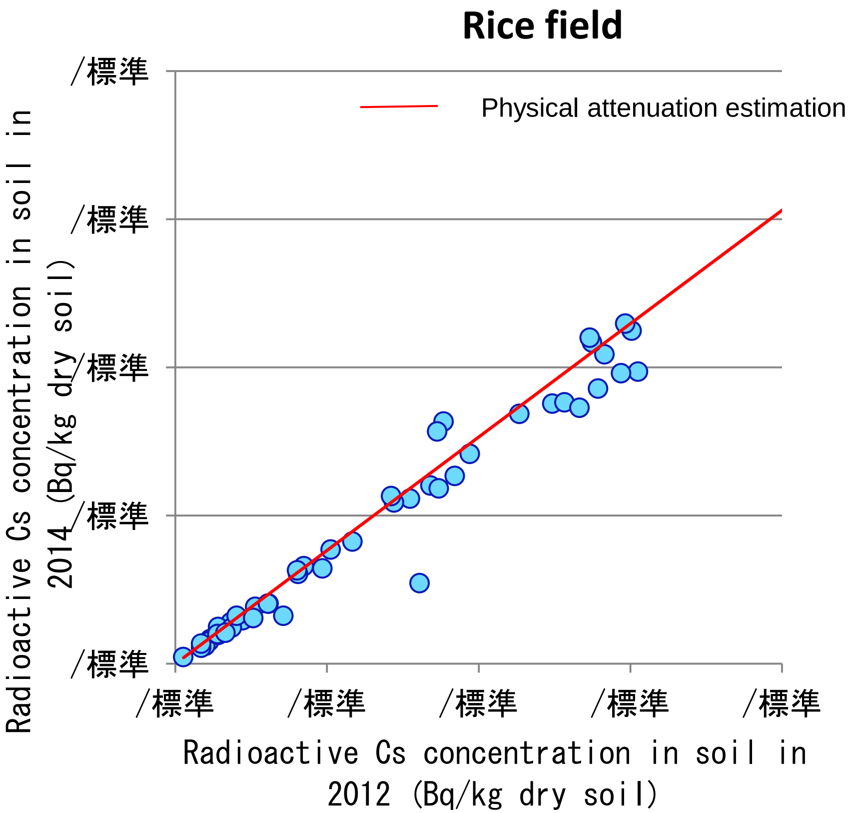
● Rice field 49 locations
● Farmland 31 locations
● Orchards 16 locations
● Grassland 11 locations

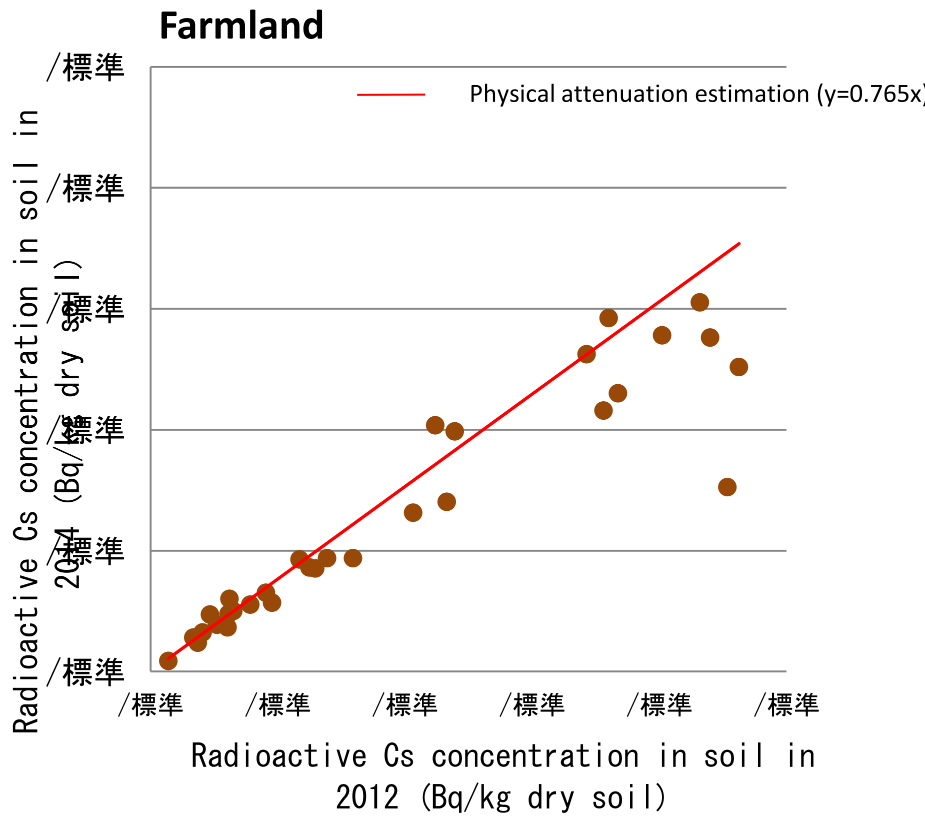
2012-2014 Change in radioactive cesium in soil over three years



Decrease in radioactive cesium in the soil could be confirmed for all land categories

Confirmation of concentration of radioactive cesium in soil in 2012, 2014





Radioactive cesium concentration in soil in rice fields and farmland
→ Physical attenuation Normal - reduced below that

Main research on current radioactive material

1 “Development of technology for countermeasures for radioactive material in order to resume farming” (2015-2017)

〇 Development of energy-saving farming technologies on decontaminated farmland

〇 Development of technologies such as technology to prevent the flow of radioactive material into farmland

〇 Clarification of the radioactive cesium absorption control mechanism

2 “Radioactive material measurement survey consigned project (2012-)

3 “Experimental study on the resumption and revitalization of farmland in under the evacuation order” (2013-)

*Handled by the Coastal Area Agricultural Recovery Research Center, Agricultural Technology Centre

Introduction and achievements of research results on the actual site

★ Main introduced technology

○ Appropriate amount of applied potassium fertilizer
○ Use of absorption control materials such as zeolite
○ Reverse tilling, deep tilling, and topsoil removal（＋soil addition)
　Farmland decontamination
○ Prevention of cross-contamination and secondary contamination of crops
○ Prevention of radioactive exposure in farming activities

Obtained achievements have been published on the website “Future From Fukushima,” providing agricultural technical information (nuclear power disaster countermeasures), and have been successfully utilized at actual sites.