Technical overview of key agricultural events since the nuclear power plant accident in 2011

Nobuhisa Koga Ph.D.

Soil Science and Plant Nutrition Group

Kyushu Okinawa Agricultural Research Center, NARO

NARO

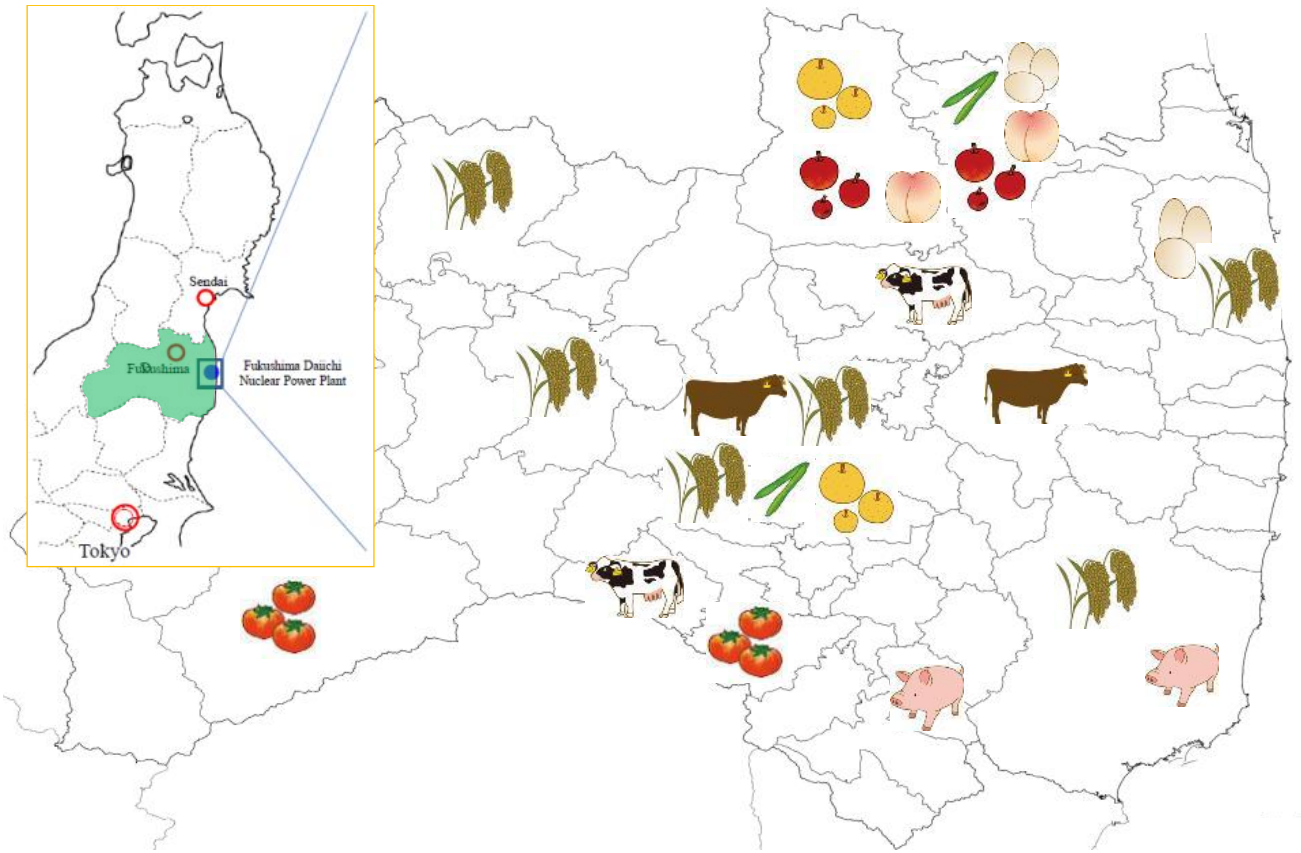
☐ The Great East Japan Earthquake and tsunami on 11 March, 2011 resulted in severe damage of three operating reactor units at the Fukushima Daiichi nuclear power plant.

☐Cooling functions for these reactors were seriously damaged, and hydrogen was released from the reactor pressure vessels, leading to explosions inside the reactor buildings in Units 1, 3 and 4.

☐Radioactive nuclides were released to the environment.....

Contamination of agricultural lands

Major agricultural products in Fukushima



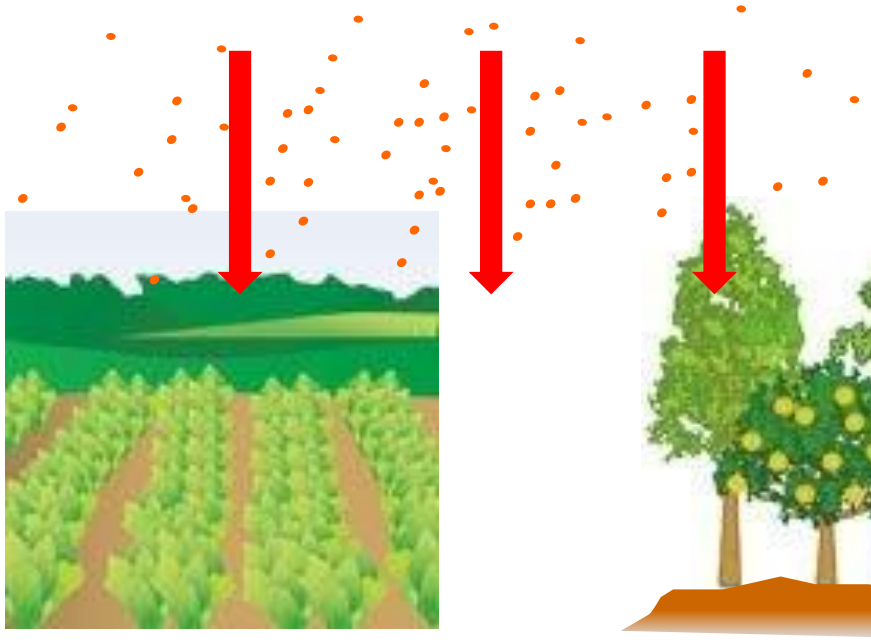
As a result of the nuclear accident, large areas of agricultural lands in eastern Japan (including Fukushima prefecture) were contaminated by radioactive nuclides (^{134}Cs and ^{137}Cs) .

Contamination pathways in Fukushima

Fallout

Uptake from soil

Radioactive nuclides

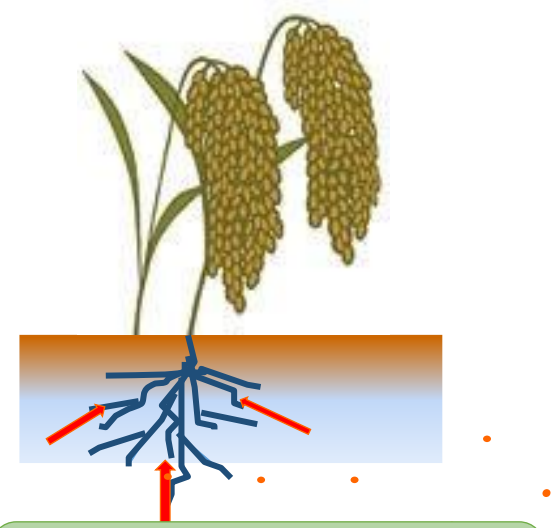


Fallout on crops that were being cultivated at the accident

e.g. winter wheat, vegetables and forage crops

Transfer of radioactive nuclides from the surface of trees to fruits or new leaves

e.g. fruits and tea

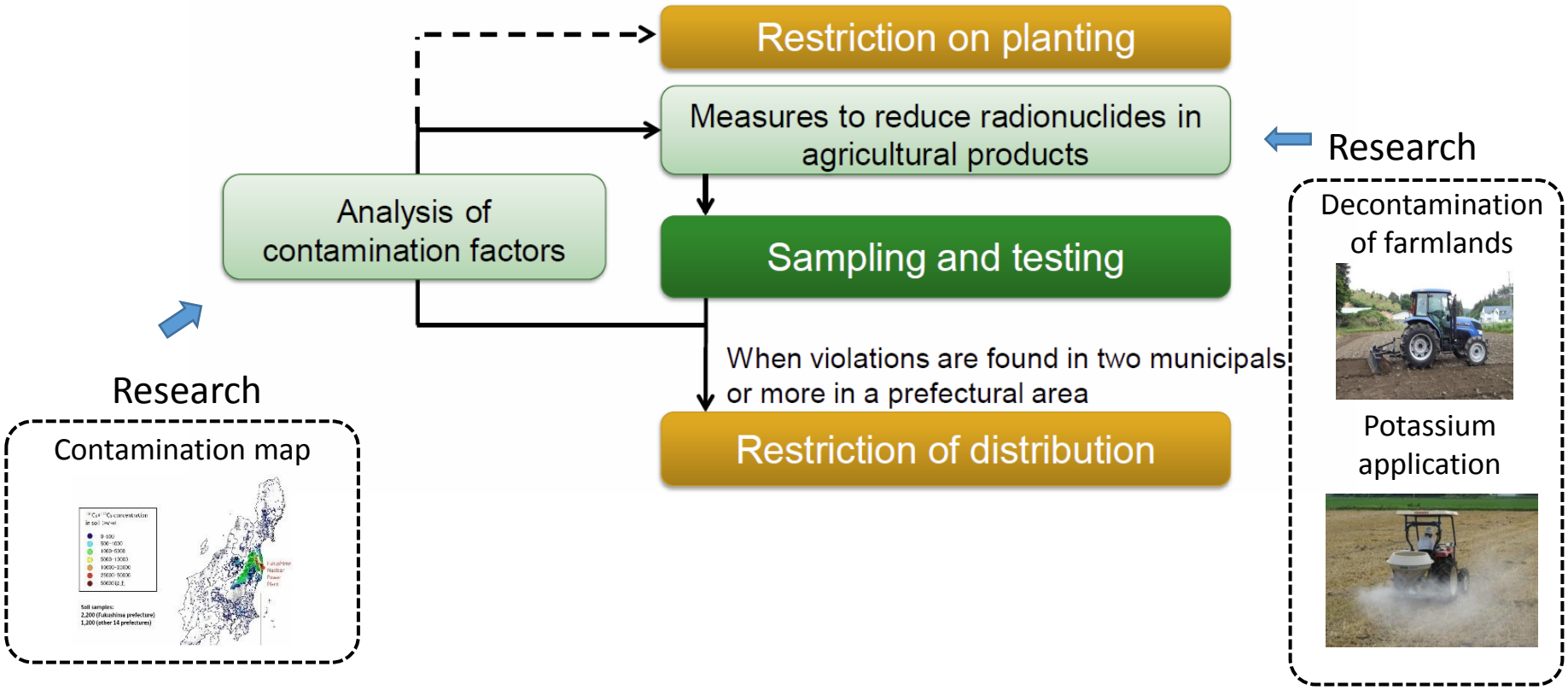


Transfer from soil to crop

e.g. rice, soybean and buckwheat

Measures taken to ensure distribution of safe foods

To ensure food safety, distribution of products with radioactive levels exceeding the limits are prevented through (1) reduction measures for radionuclides at farm lands, (2) testing of radioactive cesium before shipment, and (3) restriction of distribution according to testing results.



(Agricultural Measures for Reducing Radionuclides Contamination of Agricultural Products in Japan, MAFF, 2015)

Actions for the nuclear accident

The NARO (including former National Institute of Agro-Environmental Sciences) took the following actions in response to the accident in collaboration with the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF), local governments in affected areas including Fukushima prefecture, universities and private companies.

1. Mapping soil contamination in farmland areas
2. Developing technologies for decontamination of agricultural lands, depending on the contamination levels
3. Developing technologies for decreasing soil-to-plant transfer of radioactive cesium

Contamination of agricultural lands

Unlike the case in the Chernobyl accident, contaminated agricultural lands in the case of the Fukushima accident include the following:

1. Paddy rice fields

2. Andosol (volcanic ash-derived soil) fields
   (This soil accumulates large amounts of organic matter inherently; therefore, Andosols are considered to have low ability to fix radioactive Cs.)

Mapping soil contamination

- The first contamination map (about 580 survey points from 6 prefectures including Fukushima) was released from the MAFF on August 30, 2011.
- Thereafter, the map was updated four times.
- The most intensive survey was conducted in making the second contamination map (about 3400 survey points from 15 prefectures), and the map was released on March 23, 2012.
- The information provided by the contamination map was used for making strategies for decontamination of agricultural lands and also for deciding whether crop cultivation for that year was possible or not at a field

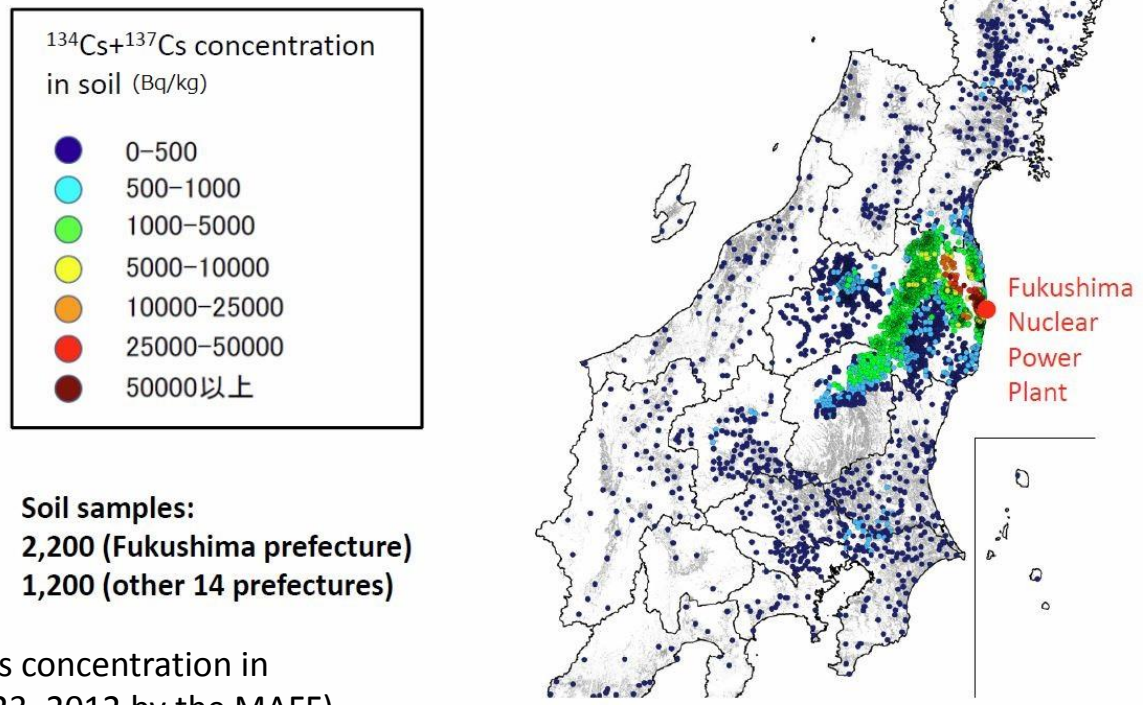


Fig.1 The distribution of radioactive Cs concentration in agricultural soils (released on March 23, 2012 by the MAFF).

Decontamination of farmlands

Technologies sorted by radioactive Cs levels in soil

Radioactive Cs level in soil	Technology
～ 5,000 (Bq / kg)	Inversion plow, reduction of radiocesium uptake(*), topsoil removal (uncultivated field)
5,000 ～ 10,000 (Bq / kg)	Topsoil removal, inversion plow, removal of soil after paddling with water
10,000 ～ 25,000 (Bq / kg)	Topsoil removal
25,000 (Bq / kg)～	Topsoil removal after solidification

Restriction of rice cultivation in 2011:
5000 Bq/kg of radioactive Cs level in soil
(500 Bq/kg of provisional limit of radioactive Cs level in rice grain x 0.1 of soil-to-transfer factor)

Inversion plow

Reduction of cesium uptake(*)

* This technology allows to reduce absorption of radioactive Cs by crops i.e. application of potassium fertilizer or adsorbent.

Topsoil removal

Removal of soil after paddling with water

Topsoil removal after solidification

Topsoil removal with grass

Decontamination of paddy rice fields

- The decontamination technology by removing floating clay after soil puddling (agitation of soil suspension before transplanting rice seedlings) was developed.
- This technology is based on the nature of cesium to bind with clay minerals in soil.

1. Introduction of water to the contaminated paddy

2. Agitation of soil suspension (soil puddling)

3. Removal of soil suspension from the paddy by pumping

4. Separation of clay from the suspension

Removed clay (high concentration of radioactive nuclides)

Decreasing soil-to-plant transfer

- The relationships between potassium concentration in soil and radioactive cesium concentration in agricultural products were examined for various crops, mainly paddy rice, soybean, buckwheat and forage crops.
- Results from field experiments served as a scientific basis for practicing potassium application in affected areas.

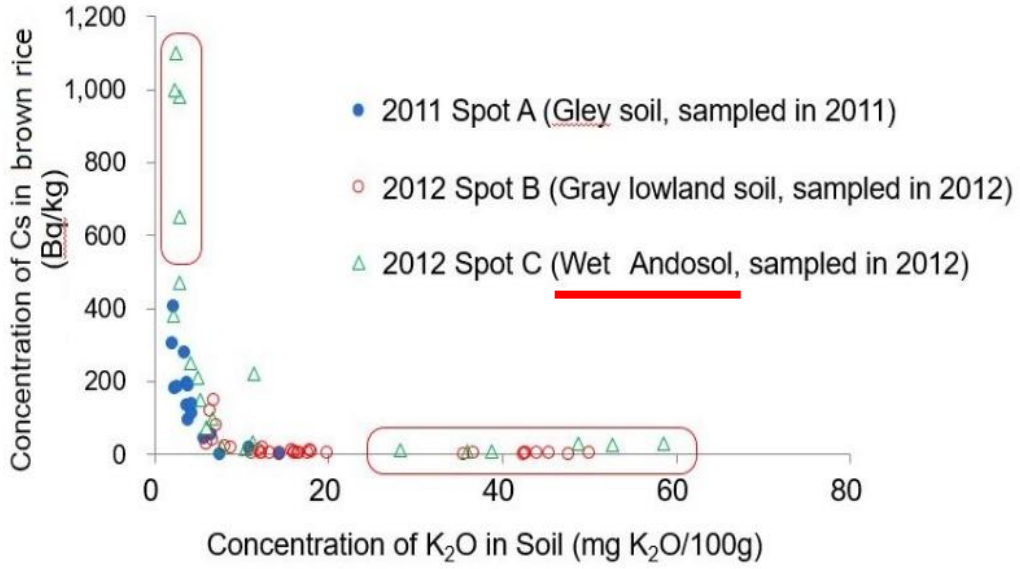


Fig. 2 The relationship between exchangeable potassium concentration in soil and radioactive Cs concentration in brown rice (available on http://www.maff.go.jp/j/kanbo/joho/saigai/s_seisan_1.html).

Screening of all rice bags in Fukushima

- Application of potassium to soil was shown to be effective to reduce the radioactive cesium concentration in brown rice below the regulation limit of general foodstuffs (100 Bq kg^{-1}).
- This potassium application was practiced in agricultural lands in and around Fukushima prefecture.
- This contributed to a drastic reduction in the number of brown rice bags exceeding the regulation limit (0.0007% of about 10 million rice bags) in 2012 (the second year of rice cultivation after the accident)

FY	No. of rice bags surveyed	No. of rice bags exceeding 100 Bq/kg	Percent ratio of rice bags exceeding 100 Bq/kg
2012	10,345,302	71	0.0007%
2013	11,005,858	28	0.0003%
2014	11,014,940	2	0.00002%
2015	10,497,428	0	0%

Data and photo from the website of Fukushima Association for Securing Safety of Agricultural Products (https://fukumegu.org/ok/contents/).

Thank you for your attention.