# Transfer of Radioactive Cesium to Plants Grown from Seeds Produced in Contaminated Soil

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## Abstract

In 2011, a major earthquake struck Japan, triggering a nuclear accident at the Fukushima Daiichi Nuclear Power Plant that released radioactive materials into the environment. We collected plant samples in Okuma Town, Fukushima Prefecture, and measured the transfer of Cs-137 from soil to plants. The results showed that Cs-137 was transferred from soil to plants, although Cs-137 concentrations in plants were lower than those in soil. Based on these findings, we became interested in seeds produced by plants grown in highly contaminated soil. In particular, we want to see how Cs-137 contained in such seeds is redistributed in plants grown in uncontaminated soil. Morning glory (Ipomoea nil) was selected because it produces abundant seeds and is widely used in Japanese elementary school education. Investigating Cs-137 transfer in this species has both educational and social significance. The study is designed as follows. Morning glories are first grown in contaminated soil, and their seeds are collected. The collected seeds are then cultivated in uncontaminated soil. Cs-137 concentrations will be compared between generations. On April 2, 2026, soil was collected from a Difficult-to-Return Zone in Okuma Town. The soil contained approximately 100,000 Bq/kg of Cs-137. Morning glory seeds were sown in this soil, and plant growth is currently being monitored.

## Background

On March 11, 2011, a massive earthquake triggered the Fukushima Daiichi Nuclear Power Plant accident, releasing a large amount of radioactive materials into the environment. Fifteen years later, some areas remain designated as Difficult-to-Return Zones despite ongoing decontamination efforts, and the environmental impacts of the accident persist.

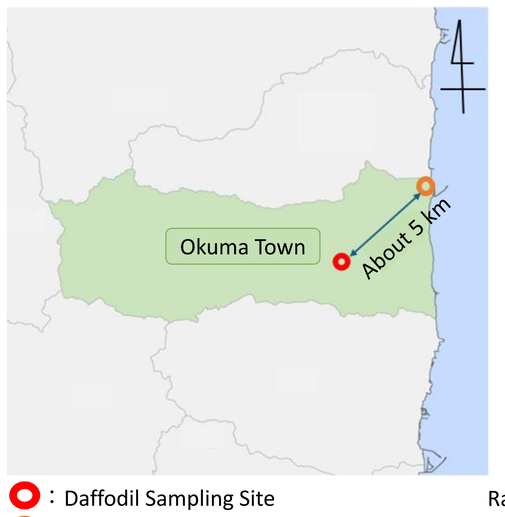
## Previous Research

We have investigated the extent to which Cs-137 is transferred to various plant species grown in highly contaminated soil. We collected wild edible plants such as butterbur sprouts, fruits, and daffodils from the Difficult-to-Return Zone in Okuma Town, Fukushima Prefecture. The Cs-137 activity concentrations in these plant samples were measured using a high-purity germanium detector, and the transfer of Cs-137 from soil to plants was evaluated. The results showed that Cs-137 was transferred from soil to plants, although the activity concentrations in plants were substantially lower than those in soil.

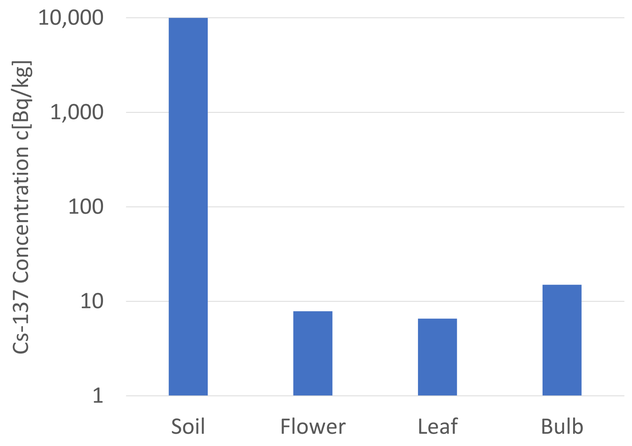
Butterbur Sprouts Growing Along a Mountain Road in Okuma Town

Daffodils Growing in the Difficult-to-Return Zone in Okuma Town

The figure below shows the Cs-137 activity concentrations, transfer factors (Cs-137 activity concentration in plant / Cs-137 activity concentration in soil), and imaging plate (IP) autoradiograph of a daffodil collected from an orchard located within the Difficult-to-Return Zone in Okuma Town, Fukushima Prefecture. The ambient dose rate at this location was 1.916 μSv/h. The results indicate that Cs-137 was transferred from the soil to the daffodil.



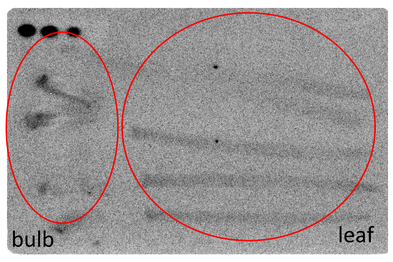

：Daffodil Sampling Site
：Fukushima Daiichi Nuclear Power Plant




Radioactivity Concentration of Cs-137 in Different Parts of Daffodil and soil

Transfer Factors in Different Parts of Daffodil

| Transfer Factor($\times 10^{-4}$) | | |
|---|---|---|
| Flower | Leaf | Bulb |
| $7.88 \pm 0.89$ | $6.57 \pm 0.62$ | $15.0 \pm 0.79$ |




IP Images of Daffodil

## Objective

The objective of this study is to investigate the extent to which Cs-137 is transferred to plants grown from seeds containing Cs-137 that were produced in highly contaminated soil.

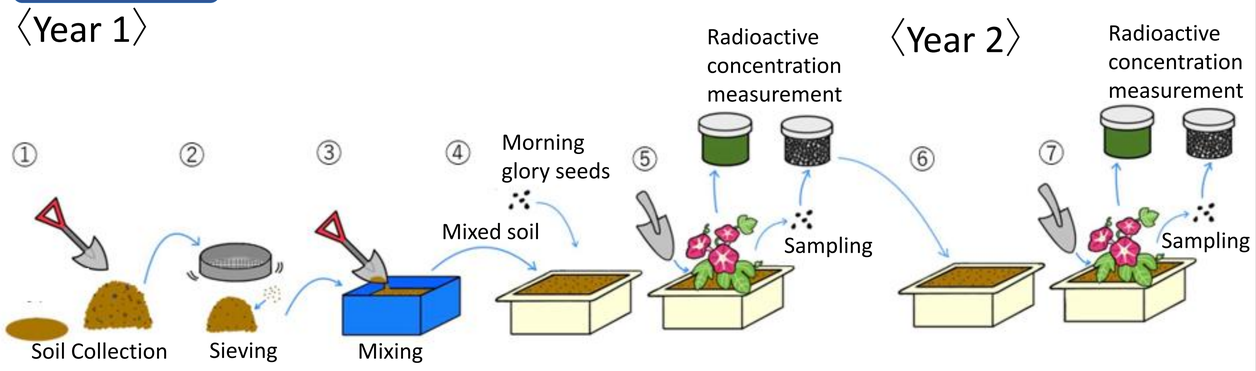
To achieve this objective, morning glory (Ipomoea nil) was selected as the target plant because it produces a large number of seeds.

In Japan, morning glory is a familiar plant that is widely cultivated by elementary school students to learn about plant growth and development. Seeds produced by the plants are often collected and passed on to students in the following year, and the flowers are sometimes preserved as pressed flowers. Thus, morning glory is one of the most familiar plants in Japan.

Therefore, investigating Cs-137 activity concentrations in a plant commonly used in educational settings has both educational and social significance. In addition, although radioactivity is a complex topic, using morning glory as the subject of this study may help attract the interest of a wider audience.

## Method

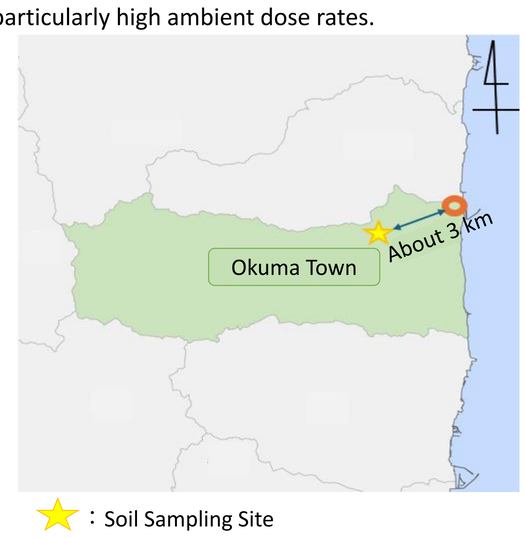
〈Year 1〉



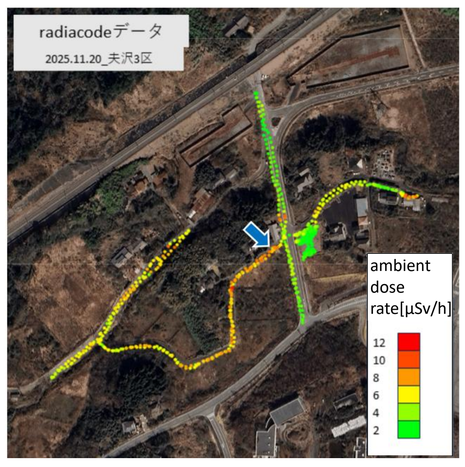

Steps ①～④ have already been completed, and steps ⑤～⑦ are planned for the future.

**① Soil collection**

Soil containing a high concentration of Cs-137 was collected. In this study, the soil was collected from the Difficult-to-Return Zone in Okuma Town, Fukushima Prefecture. The sampling site was one of the areas with particularly high ambient dose rates.




：Soil Sampling Site
：Fukushima Daiichi Nuclear Power Plant




Ambient Dose Rate Map
(The blue arrow indicates the soil sampling site)

**② Preparation of soil suitable for plant growth**

First, the soil was sieved to remove large stones and roots that could interfere with plant growth. Because the soil had become compacted and difficult to mix, large clumps that could not pass through the sieve were also broken apart by hand.

During this process, some larger soil particles necessary for plant growth were unintentionally removed, resulting in a soil structure that was less suitable for plant growth. Therefore, some of the removed sandy particles were returned to the soil to improve its suitability for plant growth.

**③ Soil mixing**

The soil was placed in a large bucket and thoroughly mixed using a shovel to make the Cs-137 activity concentration as uniform as possible. After mixing, three subsamples were collected and their Cs-137 activity concentrations were measured. The results were as follows:

| Soil① ($\times 10^5$ Bq/kg) | Soil② ($\times 10^5$ Bq/kg) | Soil③ ($\times 10^5$ Bq/kg) |
|---|---|---|
| 1.130±0.002 | 0.972±0.002 | 1.011±0.002 |

- The Cs-137 activity concentration exceeded 100,000 Bq/kg, which is far above the Japanese waste disposal criterion of 8,000 Bq/kg.
- Although the soil was mixed thoroughly, some variation in Cs-137 activity concentration remained among the planters. The standard deviation was approximately 8%. After seed collection, the Cs-137 activity concentration of each planter will be measured again in order to calculate transfer factors accurately.

**④ First sowing**

Twenty-one morning glory seeds were planted in each of five planters.

Four planters contained contaminated soil, and one planter contained commercial potting soil uncontaminated.

The planter containing commercial potting soil was prepared as a control in order to determine whether any growth problems were caused by soil conditions rather than radioactive contamination.

**⑤ First sampling**

Flowers, leaves, whole plants, and seeds produced by the morning glories will be collected.

For both the contaminated-soil group and the control group, imaging plate (IP) images of flowers and leaves will be obtained.

Each plant will be separated into seeds and non-seed tissues, and the Cs-137 activity concentration of each part will be measured.

**⑥ Second sowing**

Seeds collected from the first generation will be sown in uncontaminated soil.

**⑦ Second sampling**

The same measurements as in ⑤ will be performed.

Results from ⑤ and ⑦ will be compared to evaluate changes in Cs-137 activity concentrations and the redistribution of Cs-137 from seeds to other plant tissues.

The samples to be collected and measured in steps ⑤ and ⑦ are summarized in the table below.

| Samples | Measurement |
|---|---|
| Flower and Leaf | IP Imaging |
| Morning Glory Plant(excluding seeds) | Radioactivity Concentration, Transfer factor |
| Morning Glory Seeds | Radioactivity Concentration, Transfer factor |
| Soil | Radioactivity Concentration |

## Future Work

In our previous studies, most transfer factors measured for butterbur sprouts collected in Okuma Town during the past two years were below 15%, and some were below 1%.

Because the Cs-137 activity concentration in seeds has not yet been measured, the transfer factors for seeds are currently unknown. We expected transfer factors to be of a similar magnitude.

Seeds are reproductive organs of plants and store the nutrients required for germination. Therefore, morning glories grown from seeds containing relatively high concentrations of Cs-137 may initially exhibit elevated Cs-137 activity concentrations after germination.

However, as the plants grow and absorb nutrients from the soil, the Cs-137 activity concentration is expected to decrease and may eventually become difficult to detect.

This decrease will be evaluated by comparing the first and second generations.

In addition, germination is one of the most important stages of plant growth, and in this study it will occur in seeds containing Cs-137. Therefore, visible changes in plant growth may occur. We plan to observe the morning glories not only from the perspective of radioactivity measurements but also from other biological viewpoints.

Current Growth of Morning Glory (Photographed on 2026/5/24撮影)

## Acknowledgements

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