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POSSIBILITIES OF EFFECTIVE MICROORGANISMS™ (EM) TECHNOLOGY FOR REDUCING RADIOACTIVE CESIUM CONTAMINATION IN SOIL

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Abstract

Since the Fukushima No.1 nuclear power plant accident, the results of field experiments and farm studies we conducted suggest the possibility that Effective Microorganisms™ (EM) technology contribute to the reduction of radioactive Cs contamination in soil. Therefore, in order to assess the direct effect of EM technology on radioactive cesium (Cs), a laboratory experiment was conducted under controlled isolated condition. Various concentrations of activated EM･1® (EM) were added to soil contaminated with radioactive Cs. , then stored for 690 days. Reduction rates calculated from the measured ^{134}Cs and ^{137}Cs activities before the treatment and 690 days after, showed statistically significant differences in all EM treated groups compared with the Control group. Also, the reduction rate increased in proportion to the concentration of EM.

Introduction

Radioactive substances emitted from the Fukushima No.1 nuclear power plant accident in March 2011 contaminated a large area of eastern Japan. Consequently, the development of techniques to grow safe agricultural products and promote efficient environmental restoration is the crucial issue.

Research regarding countermeasures against radioactive contamination using Effective Microorganisms™ (EM) Technology started at The National Academy of Sciences of Belarus from the second half of 1990s and the effects on the suppression of radioactive Cs transfer due to EM application have been reported [1]. Also, there were cases in which radiation doses declined on the farmland on which EM･1® was sprayed. From these experiences, we established a research base in Fukushima Prefecture in May 2011 and have been conducting various experiments to develop a radioactive contamination countermeasure technology. It has been verified through field tests and green house tests that application of activated EM･1® and EM fermented compost has an effect on the suppression of radioactive Cs transfer and these results have been reported at academic meetings, international conferences, etc [2-4].

Soon after the nuclear plant accident, in order to verify the reduction of radioactive contamination using EM Technology, we sprayed activated EM･1® regularly and conducted an experiment at a blueberry farm in Iitate village, Fukushima Prefecture. The radioactive Cs concentration in the soil at the start of the experiment was around 20,000Bq/kg but 2 months later it declined to 5,000Bq/kg. During the experimental period, it was not recognized that radioactive Cs was percolated into the deep part of soil or washed away due to rain [5]. Moreover, Takizawa Dairy Farm in Minami-souma city, which is verifying the effect of EM fermented cow manure compost on the suppression of radioactive Cs transfer from soil to grass, also showed that the radioactive Cs concentration in the soil declined more compared with the adjoining area using chemical fertilizer. Therefore, we thought that activating the microorganisms in the soil is likely to have contributed to the reduction of radioactive Cs in some way [6].

We thought that it was necessary to evaluate the direct effect of EM on the radioactive Cs. Therefore, we conducted a laboratory experiment to examine the possibilities of reduction of radioactive Cs by EM Technology under isolated conditions, which eliminated uncontrollable factors such as weather.

Materials and Methods

In order to prepare the soil sample, contaminated soil containing Cs was air dried, screened with a 1.5mm mesh sieve and stirred well. The soil was put into U8 plastic containers so that the net weight was exactly 80.00g on the precision balance.

Six treatment groups were set up using this soil sample, a Control group with no treatment, a Water group with added water, and EM groups that added 25%, 50%, 75% and 100% concentrations of activated EM・1® (EM). Activated EM・1® was prepared by mixing the product EM・1® with molasses and water in a composition of 1:1:20 (v/v). The mixture was poured into a clean airtight plastic container and incubated at 37℃ for 7 days. Three repetitions were arranged for each treatment group. The experimental period was 690 days from the 18th of December 2013 to the 7th of November 2015. During that period, water and EM were added 6 times in total. At the same time, molasses was also added for the EM groups to increase the activation of microorganisms. After putting the lids on the U8 containers, the containers were wrapped with plastic bags and put in a foamed polystyrene container and kept at room temperature.

Before measuring the radioactive Cs activity, samples were placed inside the constant temperature drying oven to evaporate the water under 70℃ to eliminate the influence of moisture inside the soil. After that, the specific activity of ^{134}Cs and ^{137}Cs of each sample was measured with NaI(TI) scintillation spectrometer.

Results and Discussion

The activity of ^{134}Cs before and 690 days after the treatment were measured, then reduction rates were calculated (Fig.1). The physical half-life of ^{134}Cs is 2.065 years and the theoretical reduction rate 690 days after is 47.0%. The reduction rate of the Control group was 46.5%, which was very close to the theoretical reduction rate. For the other treatment groups, the reduction rate was 47.3% for Water, 52.4% for EM25%, 54.8% for EM50%, 57% for EM75% and 56.7% for EM100%. Comparing the reduction rates of these groups with the Control group, there were significant differences in all EM treated groups ($p<0.01$). Also, the reduction rate increased in proportion to the concentration of EM.

The activity of ^{137}Cs before and 690 days after the treatment were measured, then reduction rates were calculated (Fig.2). ^{137}Cs has a long physical half-life of 30.04 years and the theoretical reduction rate 690 days after is 4.3%. The reduction rate of the Control group was 3.4%, which was very close to the theoretical reduction rate. For the other treatment groups, the reduction rate was 8.4% for Water and for the EM25%, 50%, 75% and 100% were 9.1%, 12.0%, 13.4% and 14.8%, respectively. Comparing the reduction rates of these groups with the Control group, there were significant differences in all EM treated groups ($p<0.01$, except EM25%). Also, the reduction rate increased in proportion to the concentration of EM.

The factor that increased the radioactive Cs reduction rate on the EM treated groups compared with the Control group is not known at present. Physical half-life of radionuclides remains quite stable to environmental change, thus this phenomenon is not consistent with the scientific common knowledge. However, since some scientists have reported biological transmutation, we should stay open to all possibilities and must conduct more detailed studies and validate repeatedly.

Conclusion

Compared with the Control group, ^{134}Cs and ^{137}Cs activities in the soil were significantly reduced in the EM treated groups. Also, the reduction rates of ^{134}Cs and ^{137}Cs were increased in proportion to the concentration of EM. From the results of the field experiments and this test, it can be considered that by applying activated EM・1® on the soil will reduce radioactive Cs, although the mechanism is unknown.

References

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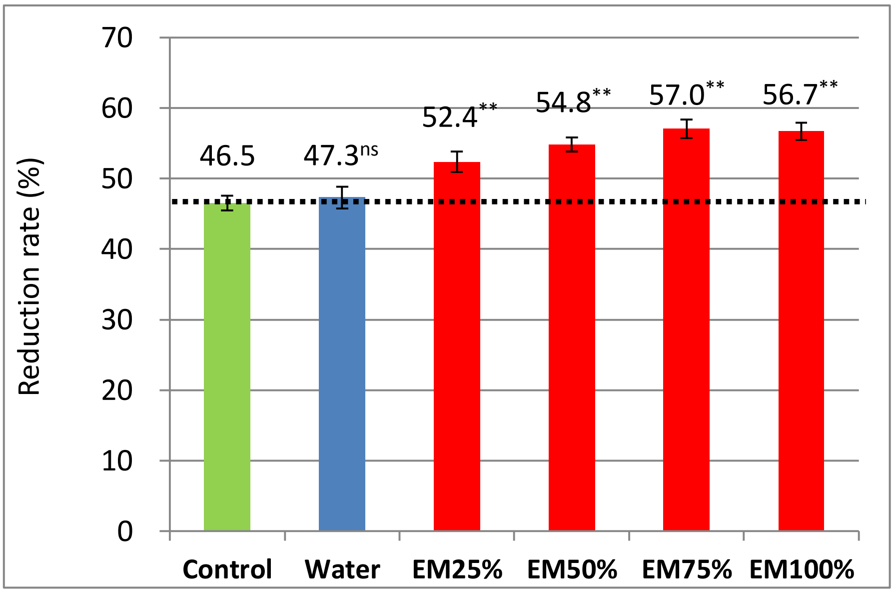

Fig.1. Effect of EM application on reduction rate of ^{134}Cs.

Values are expressed as mean ±SD (n=3)

**: significant difference at the 0.01 level in comparison to the Control (Dunnett's test)

ns: no significant difference

Dotted line: Theoretical reduction rate of ^{134}Cs after 690 days is 47.0% (half life 2.065 years)

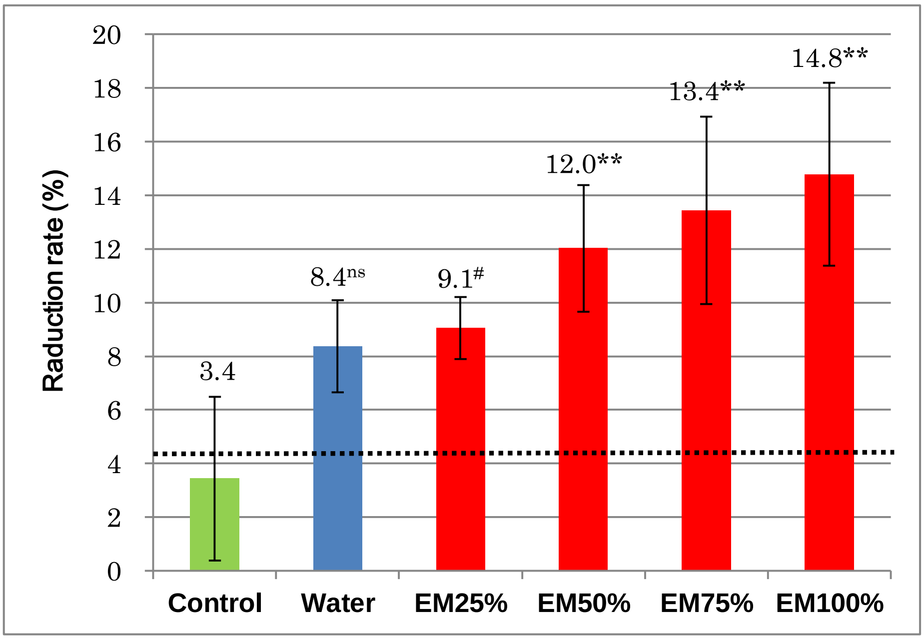

Fig.2. Effect of EM application on reduction rate of ^{137}Cs.

Values are expressed as mean ±SD (n=3)

**: significant difference at the 0.01 level in comparison to the Control (Dunnett's test)

#: significant difference at the 0.06 level in comparison to the Control (Dunnett's test, p value=0.058)

ns: no significant difference

Dotted line: Theoretical reduction rate of ^{137}Cs after 690 days is 4.3% (half life 30.04 years)