International Scientific Conference "Radiobiology: Challenges of the XXI Century", held at Institute of Radiobiology of NAS of Belarus, Gomel, Republic of Belarus. 27-29 September, 2017

ANALYSIS OF RADIOACTIVE CESIUM IN PADDY FIELDS APPLIED WITH EFFECTIVE MICROORGANSMS（EM・1®）IN FUKUSHIMA

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Abstract

For the farmland contaminated with radioactive Cs in Fukushima Prefecture, application of potassium fertilizer such as potassium chloride is recommended as a countermeasure to suppress the radioactive Cs transfer from soil to agricultural crops. On the other hand, we have reported that the application of Effective Microorganisms (EM・1®) and EM fermented compost had an effect on the suppression of radioactive Cs transfer from soil to crops and grasses. We have been monitoring the radioactive Cs concentrations in brown rice and soil of a paddy field that does not use potassium fertilizer but has been applying EM technology for several years. In this paper, we report some of the interesting findings obtained from analyzing the accumulated data. In 2011, after the Fukushima Daiichi nuclear power plant accident, even though radioactive Cs in soil of the paddy field that has been utilizing EM for a long term (long-term EM utilization paddy field) was 3,579 Bq/kg, it was not detected in brown rice. At the long-term EM utilization paddy field, radioactive Cs was not detected except in the brown rice harvested in 2012. The paddy field that started using EM in 2013 (short-term EM utilization paddy field), radioactive Cs detected from the brown rice harvested in 2013 and 2014 were 3.2 and 1.0 Bq/kg, respectively. However, it has not been detected since 2015. In addition, Fukushima Prefecture reported that the five year decay rate of radioactive Cs in the soil of 37 paddy fields was on par with or higher than the physical decay rate. However, the decay rate of the long-term EM utilization paddy field for the same period was 1.8 times greater than the physical decay rate.

Introduction

Research on countermeasures against radioactive contamination using EM started at the Institute of Radiobiology in Belarus (IRB) in the second half of the 1990s and it has been reported that application of Effective Microorganisms EM・1® (in the following referred to as EM) increases the yield of agricultural crops and suppresses the transfer of radioactive Cs and Sr from soil to agricultural crops [1-3]. Based on these findings, we are conducting research and investigation on countermeasures against radioactive contamination by using EM in Fukushima Prefecture since 2011. So far, it has been reported that the application of EM and EM fermented compost has the effect of suppressing radioactive Cs transfer to agricultural crops and grasses [4-6]. However, we have not reported on the effects of EM in rice cultivation. We have been studying the radioactive Cs concentrations in brown rice and soil of paddy fields to which EM technology has been applied for several years. In this paper, we report some of the interesting findings obtained from analyzing the accumulated data.

Materials and methods

The two paddy fields that we researched were the long-term EM utilization paddy field (in Koriyama city) that has been using EM for 20 years and the short-term EM utilization paddy field (in Miyakoji town) that started using EM in 2013. We have regularly visited and investigated the long-term EM utilization paddy field since 2011 and the short-term EM utilization paddy field since 2013 after cropping restrictions were canceled. Both paddy fields engage in organic farming using EM, EM fermented compost, EM Bokashi, etc., without using potassium fertilizer such as potassium chloride. Radioactivity concentrations of ^{134}Cs and ^{137}Cs in the soil were measured using NaI(TI) scintillation detector and its concentrations in brown rice were measured using a Germanium semiconductor detector. Exchangeable potassium content in the soil was measured only in 2016 using flame photometry.

Results and discussion

In 2011, after the nuclear power plant accident, even though it was said that the ratio of radioactive Cs easily absorbed by plants' roots in soil was high and the radioactive Cs in the soil of the long-term EM utilization paddy field was 3,579 Bq/kg, it was not detected in brown rice (detection limit<1 Bq/kg). At the long-term EM utilization paddy field, radioactive Cs was not detected except in the brown rice harvested in 2012 (Table1). At the short-term EM utilization paddy field, radioactive Cs concentrations detected in the brown rice harvested in 2013 and 2014 were 3.2 and 1.0 Bq/kg, respectively. However, it has not been detected since 2015 (Table1). Radioactive Cs transfer from soil to brown rice at the long-term EM utilization paddy field was only detected in the brown rice harvested in 2012 and the transfer factor was very low at 0.0033. At the short-term EM utilization paddy field, the transfer factors were 0.00182 and 0.00063, respectively and showed a tendency to decline every year (Table1). Several studies reported the transfer factor of brown rice harvested in 2011 in Fukushima. Kondo *et al.* reported that it was between 0.004 ~ 0.065 [7] and Endo *et al.*'s paper stated that it was between 0.013 ~ 0.017 [8]. The value of the transfer factor of EM grown brown rice was lower than these reported values.

The exchangeable potassium content in the soil immediately after the harvest was 28 mg/100g in the long-term EM utilization paddy field and 21 mg/100g in the short-term EM utilization paddy field (Table1). In Fukushima Prefecture, as a measure for absorption inhibition, application of potassium chloride is conducted with the aim of increasing the value of exchangeable potassium content to more than 25 mg/100g. The two researched paddy fields conducting organic farming with EM have not applied chemical fertilizer such as potassium chloride. However, it can be assumed that both paddy fields gained exchangeable potassium through straw residue, EM fermented compost, EM Bokashi, etc. Nikitin *et al.* reported that application of EM and EM Bokashi on the soil reduce the rate of water soluble Cs and ion exchangeable Cs, which are easily absorbed by plants [9]. It could be concluded that the transfer of radioactive Cs was suppressed on the EM utilization paddy fields due to the same mechanisms.

Table1. Radioactive Cs concentration in the soil and brown rice harvested from EM applied paddy fields.

Paddy (Location)	Year	Variety	Radioactive Cs in brown rice (Bq/kg)	Radioactive Cs in soil (Bq/kg)	Transfer factor (TF)	Exchangeable K in soil (mg/100g)
LT EM paddy	2011	Koshihikari	ND	3579	0	–
(Koriyama city)	2012	Koshihikari	1.0	2992	0.00033	–
	2013	Koshihikari	ND	2250	0	–
	2014	Koshihikari	ND	1957	0	–
	2015	Koshihikari	ND	1279	0	–
	2016	Koshihikari	ND	1025	0	28
ST EM paddy	2013	Hitomebore	3.2	1757	0.00182	–
(Miyakoji town)	2014	Tennotsubu	1.0	1588	0.00063	–
	2015	Tennotsubu	ND	1463	0	–
	2016	Tennotsubu	ND	808	0	21

LT EM paddy: Long-term EM utilizaton paddy field

ST EM Paddy: Short-term EM utilization paddy field

ND: Not detected (detection limite <1.0 Bq/kg)

Compared with physical decay values, the radioactive Cs concentrations in soil showed a tendency to decrease in the long-term EM utilization paddy field from 2013 and in 2016, it was 47% lower (Fig.1).

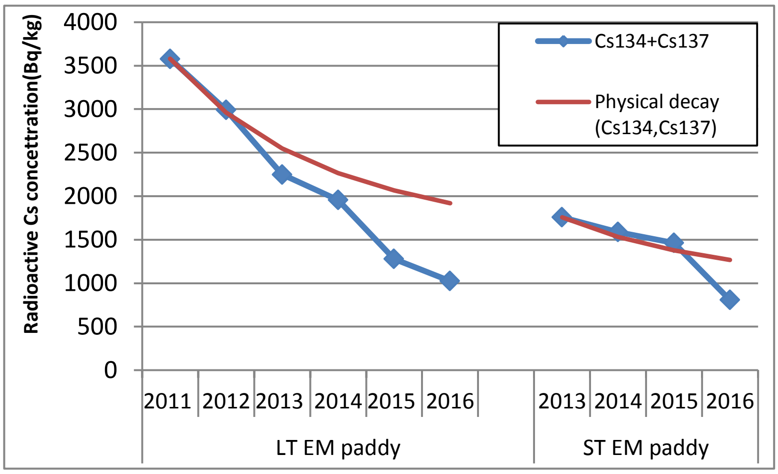

Fig.1. Radioactive Cs concentration in paddy soil using EM.

LT EM paddy: Long-term EM utilization paddy field
ST EM paddy: Short-term EM utilization paddy field

According to the Fukushima Agricultural Technology Center's survey, the reduction rate of radioactive Cs concentrations on paddy fields for the past 5 years, between 2012 to 2016, was on par with the physical decay rate (around 37%) or higher. On the other hand, at the long-term EM utilization paddy field, the reduction rate was 1.8 times greater at 66% (Table1). We observed reduction of radioactive Cs in soil on previous experiments conducted at pasture land and blueberry farm in Fukushima using EM and EM fermented compost [11, 12]. EM application study conducted at large-scale corn farm by the Institute of Radiobiology of Belarus reported that, EM application did not only increased the corn yield and suppressed the radioactive Cs transfer, but also reduced the concentration of ^{137}Cs in soil in proportion to the spray concentration of EM [13]. The reason that radioactive Cs concentrations at the two researched paddy fields reduced more than the physical decay rate is unknown. However, compared to the radioactive Cs concentrations of the adjoining conventional paddy fields, radioactive Cs concentrations in the soil of EM utilization paddy fields were more than 60% lower (Fig.2). Therefore, it can be assumed that activation of soil microorganisms due to EM application has some kind of effect on reduction of radioactive Cs.

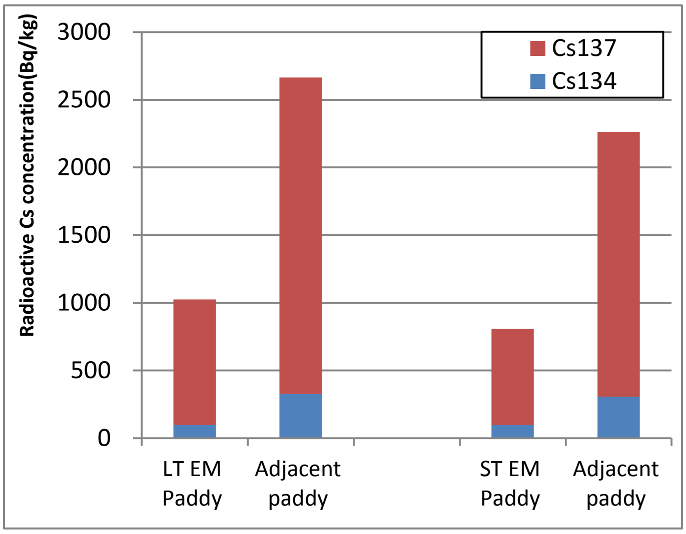

Fig.2. Comparison of radioactive Cs concentration between paddy using EM and its adjacent paddy in 2016.
LT EM Paddy: Long-term EM utilization paddy field
ST EM Paddy: Short-term EM utilization paddy field

Conclusion

Continuous application of EM on rice paddy fields suppresses the radioactive Cs transfer from soil to brown rice. Fukushima Prefecture reported that the five year decay rate of radioactive Cs in the soil of 37 paddy fields was on par with or slightly higher than the physical decay rate. However, the decay rate of the long-term EM utilization paddy field for the same period was 1.8 times greater than the physical decay rate. These results suggest that using EM for soil improvement enhance the reduction of radioactive Cs in soil.

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