（様式４）

二国間交流事業 共同研究報告書

令和 4 年 4 月 22 日

独立行政法人日本学術振興会理事長 殿

[代表者所属機関・部局]
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1. 事 業 名 相手国:ロシア (振興会対応機関:RFBR)との共同研究

2. 研究課題名

（和文） 福島第一原発事故による汚染地域におけるアカマツの放射線影響メカニズムの解明

（英文） Elucidation of mechanisms of radiobiological effects in Japanese red pine at the territories contaminated as a result of the accident at the Fukushima Dai-Ichi Nuclear Power Plant

3. 共同研究全実施期間 2019 年 4 月 1 日 ～ 2022 年 3 月 31 日 (3 年 0 ヶ月)

4. 相手国代表者(所属機関・職・氏名【全て英文】

Russian Institute of Radiology and Agroecology・Head of laboratory・Geras'kin Stanislav

5. 委託費総額(返還額を除く)

本事業により執行した委託費総額		4,392,950 円
内訳	1年度目執行経費	2,122,450 円
	2年度目執行経費	2,270,500 円
	3年度目執行経費	― 円

6. 共同研究全実施期間を通じた参加者数(代表者を含む)

日本側参加者等	5 名
相手国側参加者等	10 名

＊ 参加者リスト(様式 B1(1))に表示される合計数を転記してください(途中で不参加となった方も含め、全ての期間で参加した通算の参加者数となります)。

7. 派遣・受入実績

	派遣		受入
	相手国	第三国	
1 年度目	3	1	1(0)
2 年度目	0	0	0(0)
3 年度目	0	0	0(0)
4 年度目			()

＊ 派遣・受入実績(様式 B1(3))に表示される合計数を転記してください。

派遣:本委託費を使用した日本側参加者等の相手国及び相手国以外への渡航実績(延べ人数)。

受入:相手国側参加者等の来日実績(延べ人数)。カッコ内は本委託費で滞在費等を負担した内数。

8. 研究交流実績の概要・成果等

(1)研究交流実績概要(全期間を通じた研究交流の目的・研究交流計画の実施状況等)

The overall goals of the project were to establish an experimental network for long-term radioecological studies and to elucidate the mechanisms of the radiation-induced changes occurring in chronically irradiated young trees of Japanese red pine (*Pinus densiflora*). The study was conducted on several natural populations growing at the locations with different exposure levels in Fukushima prefecture (including the control population at the background level) and on the artificial plantation at the Fukushima University campus consisting of four groups of young trees exposed to different doses at the irradiation facility at NIRS prior to establishing the plantation. The project implementation was significantly affected by the COVID-19 situation, as required conducting the joint sampling campaigns in Fukushima and joint laboratory analyses at the partner facilities in Russia, which became impossible due to travel restrictions in FY2020-2021. We have adjusted the initial activity plans to meet the main tasks of the study. As a result, we fully implemented the field observation and sampling program, created and maintain the sample archive for the further studies, transported part of the samples to the partner and measured morphometric, cytogenetic, and molecular indices in these samples, and published a series of papers discussing the mechanisms of formation of radiation effects in the studied species.

(2)学術的価値(本研究交流により得られた新たな知見や概念の展開等、学術的成果)

Despite the aforementioned unfavorable COVID-19 situation and the associated delays and changes in research plans, the project has produced new knowledge important for understanding the mechanisms of radiation effects on plants:

- We found that in addition to the cancellation of apical dominance, chronic radiation might cause changes in some morphometric indices in the studied pine population. We observed a slight increase in fluctuating asymmetry of pine needles in evacuation areas compared to the control, trends to decrease in the weights and length of needles, and a significant increase in the proportion of needles with severe damage with increasing dose rates;

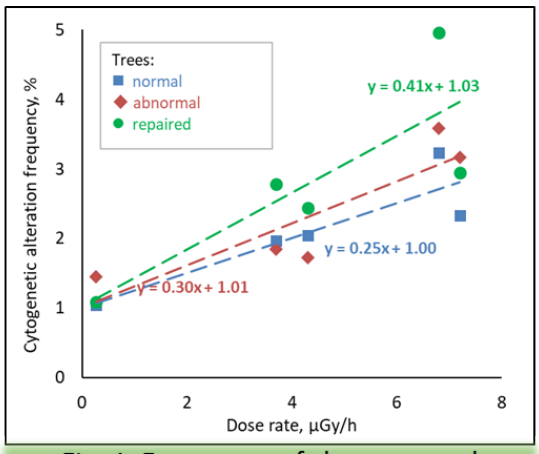

Fig. 1. Frequency of chromosomal aberrations vs dose rate

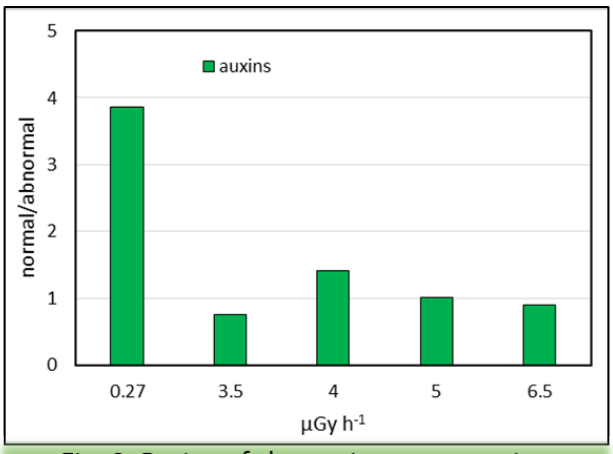

Fig. 2. Ratios of the auxin concentration normal/abnormal trees vs dose rate

- We found a strong correlation between the cytogenetic alteration frequency (chromosomal aberrations) and dose rate (Fig. 1). However, the frequencies of alteration in each studied population did not significantly differ between normal trees, trees with morphological abnormalities, and trees that recovered apical dominance after abnormal transformation. Therefore, chromosomal aberrations may serve as a marker of radiation exposure, but, on the other hand, there may be no direct link between chromosomal aberrations and abnormal morphological transformation in red pine;

- We observed changes in plant hormone balances that may be responsible for abnormal morphological transformations in chronically irradiated trees. In particular, significant changes occurred in the concentrations of auxin, a plant hormone involved in the regulation of plant growth and maintenance of apical dominance. In the control population, the mean concentration of auxin in the transformed trees was several times lower than in the normal ones (Fig. 2). The mean auxin concentrations did not differ between normal and abnormal trees at the observation sites in the evacuation areas, being close to the mean concentration in the abnormal trees at the control site;
- The mean gibberellin concentrations in the normal trees correlated with the mean auxin concentrations which confirms the regulation of gibberellin by auxins. The concentrations of zeatin and abscisic acid did not reveal the clear dependencies on the dose rate and, what is more important, the mean concentrations of these hormones at each site did not differ between the normal and transformed trees. Thus, in our opinion, abnormal transformation in young pine trees likely is caused by a decrease in the auxin concentrations. Further studies are needed to clarify the reasons for such a decrease.

(3)相手国との交流（両国の研究者が協力して学術交流することによって得られた成果）

The partner's PI visited Fukushima in May 2019 to participate in the project kick-off meeting at the IER and in a joint IER – RIRAE – NIRS sampling campaign in the evacuation areas and at the control sites (on the photo). The field observations included the assessment of the local exposure conditions, the determination of morphological parameters of the pine trees in the studied populations, selection of the control groups of trees at each site, and sampling of pine needle biomass for cytological, morphometric, and molecular analyses. The collected samples were processed at the IER facilities and transported to RIRAE (Fig. 3).

Fig. 3. Visits exchange in FY2019

The IER researchers visited the partner institutes twice during FY2019. In July-August, Prof. Yoschenko and Prof. Nanba, visited RIRAE to discuss analytical methods, participate in the sample analyses, and review the first results. In February 2020, Prof. Nanba visited RIRAE to review and analyze the results and to work on the joint publications.

For FY2020 we scheduled an exchange by visits between the project partners for the joint sampling campaign in Fukushima and joint laboratory studies at RIRAE. In the situation of the COVID-19 outbreak, the visit exchanges were postponed to the project prolongation period in FY2021. However, the situation did not improve, resulting in the cancellation of the visits and adjustments to the initial research plans: all sampling campaigns, field observations, and sample processing for the long-term storage were performed by the IER, while RIRAE focused on the sample analyses. The discussions of the results were held online and through the e-mail exchange.

(4)社会的貢献（社会の基盤となる文化の継承と発展、社会生活の質の改善、現代的諸問題の克服と解決に資する等の社会的貢献はどのようにあったか）

The Japanese project participants widely presented the project progress and findings in the special programs on NHK, as well as in other media, public dialog meetings, etc. We believe that our results may contribute to the revitalization of commercial forestry in radioactively contaminated areas of Fukushima Prefecture as they clarify the potential impacts on one of the main forest species, red pine.

(5)若手研究者養成への貢献(若手研究者養成への取り組み、成果)

The graduate school students, as well as the undergraduate students from Fukushima University, visited one of the experimental sites, Tsushima, during the 2020 and 2021 field campaigns to take part in field observation and sampling. In addition, the partner's PI Prof. Geras'kin, Dr. Watanabe (QST-NIRS), and Prof. Yoschenko (IER) gave lectures to the graduate school students in the class of Effects of radiation exposures in the 1st semesters of FY2019-2021 (in FY2020 and 2021, the whole class was supervised by Prof. Yoschenko). These lectures presented some project results to illustrate current advances and challenges in understanding the mechanisms of radiation effects in plants.

(6)将来発展可能性(本研究交流事業を実施したことにより、今後どの様な発展の可能性が認められるか)

The project partners recognize the significance of the project findings and the benefits of cooperation in studying the radiation effects on plants. We intend to continue the joint research, especially for the clarification of the roles of plant enzymes and reactive oxygen species in plant response to radiation. However, the possibilities and forms of future collaboration will depend on the development of the situation in Ukraine and international sanctions on Russia.

(7)その他(上記(2)～(6)以外に得られた成果があれば記述してください)

例:大学間協定の締結、他事業への展開、受賞、産業財産権の出願・取得など

During the visit to the partner in FY2019, we signed the Memorandum of Understanding between the IER and RIRAE, which provides the opportunity to expand the research program and exchanges between the two institutes.