様　式　Ｃ－１９、Ｆ－１９－１、Ｚ－１９　（共通）

科学研究費助成事業　　研究成果報告書

令和　２ 年　 ６ 月　 ４ 日現在

機関番号：８２４０１
研究種目：基盤研究(C)（一般）
研究期間：2017～2019
課題番号：１７Ｋ００６０８

研究課題名（和文）Developing chemical methods for removing unwanted metals from the environment using plants

研究課題名（英文）Developing chemical methods for removing unwanted metals from the environment using plants

研究代表者

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交付決定額（研究期間全体）：（直接経費）　　3,700,000円

研究成果の概要（和文）：15の化学物質（C17H19F3N2O2、C21H27N5OS2、C19H21N7S3、C27H29N3O3、C24H24N4Br2、C13H15N5、C16H11ClO4、C11H15NO5S2、C4H9NO2S、C11H14N2O2S、C20H19BrN2O、C14H22N2O、C9H13BrN2O2、C9H11N3OS2、C11H11N3OS2）が、植物の様々な重金属蓄積の能力を変えることを明らかにした。それらの中の、2つの化学物質（C17H19F3N2O2とC4H9NO2S）については、植物内での植物結合タンパク質を含む作用機序を解明した。

研究成果の学術的意義や社会的意義
In this project, we found the efficient solutions to improve phytoremediation process of heavy metals via using knowledge of chemicals and phytoremediation. The outcome of this research provided the new information of phytoremediation through combining ideas and techniques from different fields.

研究成果の概要（英文）：15 chemical compounds (C17H19F3N2O2, C21H27N5OS2, C19H21N7S3, C27H29N3O3, C24H24N4Br2, C13H15N5, C16H11ClO4, C11H15NO5S2, C4H9NO2S, C11H14N2O2S, C20H19BrN2O, C14H22N2O, C9H13BrN2O2, C9H11N3OS2 and C11H11N3OS2) were confirmed that they altered the plant abilities of various heavy metal accumulation in plants. Among them, two of chemicals (C17H19F3N2O2 and C4H9NO2S) were elucidated their mode-of-action including their plant binding proteins mechanism in plants.

研究分野：Environmental biology

キーワード：phytoremediation　lead　cesium　selenium　cadmium　CNGC　heavy metals　chemical screening

１．Scientific background for the research (研究開始当初の背景)

The radiocesium spread by the accident at the Fukushima Daiichi Nuclear Power Plant following the Great Earthquake and tsunami in 2011 still remains in soil and there is a pressing need to remove it. In addition to radiocesium, there has been a serious rise in the amount of heavy metals due to their increased industrial usage occurring many concerns to public health. The accumulations of unwanted metals cause fatal aftermath to many biological processes. Therefore, there is a compulsory need to develop efficient and effective ways for removing unwanted metals from environment. The many conventional methods of removing unwanted metals are high-costly, time consuming and the methods themselves often have bad effects to the environments. Whether to collect valuable metals or to remove unwanted metals from soil, phytoremediation, a technique to concentrate the metal of interest using ability of plants to absorb it, is recently gaining popularity for its eco-friendly and cost effective nature. However, the efficiency of phytoremediation is sometimes not sufficient for the real field. Therefore, in order to develop efficient phytoremediation system, small compounds which accelerate cesium accumulation in plants were selected through screening of commercially available chemical libraries.

Various chemicals have been intensively and widely used in agricultural fields. However, most agricultural chemicals are either fungicides or pesticides which are for overcoming the biological stresses. Although the excessive fertilizers have been used in order to avoid nutrient deficiency in plants, the efficiency of plant utilization of nutrients is not good enough and there is not much developed ways to improve the nutrient use efficiency except using arbuscular mycorrhizal fungus for increasing phosphorus utilization in plants. Since most of previously screened chemical candidates were predicted as positive charged metal binding chemicals including potassium and cesium, and few of them were proved the actual abilities to help plants to more accumulate various metals including heavy metals in plants. Therefore, the chemicals that we identified as cesium accumulators may be also useful candidates for improving positive charged nutrient utilization (potassium, zinc, iron and so on) as well as phytoremediation of heavy metals or radiocesium.

２．Purpose of the Research (研究の目的)

There are the pressing public needs for removing radiocesium and heavy metals from environments. Phytoremediation is an upcoming technique which eco-friendly, low cost and a sustainable process that can be used for removing unwanted metals. In order to improve the efficiency of phytoremediation, chemicals were previously identified as cesium accumulating enhancers and possibly function as heavy metals accumulating enhancers. Therefore, in this project, the efficient solutions via elucidating and developing the techniques using chemicals and knowledge for phytoremediation of unwanted metals from the environments were investigated.

３．Research Method (研究の方法)

To increase the efficiency of phytoremediation of radiocesium and heavy metals, 15 previously isolated chemicals from 20,000 chemicals were analyzed their abilities of various metals accumulation and the site of their actions in plants. To elucidate the mode-of-actions of selected chemicals, analysis of their binding affinity to various metals, identification of these chemical binding plant proteins, and the functional analysis of target proteins for metals accumulation were performed.

４．Research Achievements （研究成果）

Publications:

1.Journal Articles

1) Eri Adams, Takae Miyazaki, Shunsuke Watanabe, Naoko Ohkama-Ohtsu, Mitsunori Seo, **Ryoung Shin***. Glutathione and its biosynthetic intermediates alleviate cesium stress in Arabidopsis. **Front. Plant Sci.** doi: 10.3389/fpls.2019.01711.
2) Ju Yeon Moon, Celestine Belloeil, Madeline Louise Ianna, **Ryoung Shin***. *Arabidopsis* CNGC family members contribute to heavy metal ion uptake in plants. **Int. J. Mol. Sci.** 20:413 (2019).
3) Eri Adams, Takae Miyazaki, Shunya Saito, Nobuyuki Uozumi, **Ryoung Shin***. Cesium inhibits plant growth primarily through reduction of potassium influx and accumulation in Arabidopsis. **Plant Cell Physiol.** 60: 63-76 (2019).

2.Presentations

1) Development of novel phytoremediation methods to clean multiple contaminants from environment using multidisciplinary approaches. International Congress on Plant Science, Rome, Italy, October 22nd, 2019. (Invited talk)
2) Specific inhibition of potassium influx but not efflux via the AKT1-KC1 complex by cesium in Arabidopsis Plant Biology 2019, genomics and Plant Science Congress, San Jose, USA, August 3-7th, 2019. (poster)
3) Cesium is a specific inhibitor of the AKT1-KC1 complex-mediated potassium influx in Arabidopsis. 6th Global Summit on Plant Science, Valencia, Spain, Keynote speaker, October 29, 2018. (Invited talk)

4) Chemical compounds aid plants to clean multiple pollutes from the environment. The 29th International Conference on Arabidopsis Research, Turku, Finland, June 25, 2018. (Invited talk)

5) Phytoremediation by elucidating chemical compounds which alter accumulation of or response to caesium in plants. International Plant Nutrition colloquium, Copenhagen, Denmark, August 23, 2017. (Poster)

５．主な発表論文等

〔雑誌論文〕　計1件（うち査読付論文　1件／うち国際共著　1件／うちオープンアクセス　1件）

１．著者名 Ju Yeon Moon, Celestine Belloeil, Madeline Louise Ianna, Ryoung Shin	４．巻 20
２．論文標題 Arabidopsis CNGC family members contribute to heavy metal ion uptake in plants	５．発行年 2019年
３．雑誌名 International Journal of Molecular Sciences	６．最初と最後の頁 413－427
掲載論文のDOI（デジタルオブジェクト識別子） 10.3390/ijms20020413	査読の有無 有
オープンアクセス オープンアクセスとしている（また、その予定である）	国際共著 該当する

〔学会発表〕　計2件（うち招待講演　2件／うち国際学会　2件）

１．発表者名 Ryoung Shin
２．発表標題 Chemical compounds aid plants to clean multiple pollutes from the environment
３．学会等名 The 29th International Conference on Arabidopsis Research（招待講演）（国際学会）
４．発表年 2018年

１．発表者名 Ryoung SHIN
２．発表標題 A novel role for methyl cysteinate and cysteine in cesium accumulation and response in Arabidopsis
３．学会等名 28th International conference on Arabidopsis Research（招待講演）（国際学会）
４．発表年 2017年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

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６．研究組織

	氏名 （ローマ字氏名） （研究者番号）	所属研究機関・部局・職 （機関番号）	備考