氏　　名	Dandy Ahamefula Osibe
授与した学位	博　士
専攻分野の名称	農　学
学位授与番号	博甲第　　７１５３　　号
学位授与の日付	２０２４年　９月　２５日
学位授与の要件	環境生命科学研究科　　農生命科学専攻 （学位規則第４条第１項該当）
学位論文の題目	Study on the role of mineral elements in rice defense against herbivores （植食性昆虫に対するイネの防御機構におけるミネラルの役割の研究）
論文審査委員	教授　鈴木　信弘　　教授　GALIS IVAN　　准教授　新屋　友規

学位論文内容の要旨

Plants have evolved several defense systems against herbivore attack including inherent structural traits and numerous chemical compounds that collectively may be toxic and/or deter herbivorous insects from feeding on plants. In addition to these defensive structures, notably under herbivore attack, plants may recruit or re-direct mineral nutrients for use in local defense to assure survival. However, how plants recruit and/or re-direct mineral elements as resources for defense under herbivory stress is poorly understood. In this thesis, the intrinsic role(s) of minerals in rice anti-herbivore defense was investigated. First to explore the variation in the mineral profile of rice exposed to herbivory stress, different rice tissues (local attacked leaves, systemic leaves, stem and root) from herbivory-treated and untreated control plants were analyzed for elemental composition using inductively coupled plasma mass spectrometry. Generally, herbivory mediated the differential accumulation of several elements in the different tissues of herbivore exposed rice plants relative to unexposed controls. Specifically, several micro nutrients tended to significantly accumulate in both locally attacked and systemic leaves of rice plants exposed to herbivory stress when compared to the unexposed controls. Next, leveraging on the well characterized silicon (Si) mineral transport and accumulation mechanisms in previous studies in rice, a functional model of the role of Si in rice anti-herbivore defense was explored. Short-term Si uptake experiments in hydroponic system revealed that Si-supplemented rice plants exposed to herbivory stress accumulated higher levels of Si relative to unstressed control plants. Analysis of genes involved in Si uptake and distribution showed that distribution rather additional uptake of Si in rice plants may be regulated by herbivory stress. To identify the possible metabolic sinks for Si during rice anti-herbivore defense, the accumulation of several primary and secondary metabolites including volatile organic compounds (VOCs) in Si-supplied and Si-deprived plants exposed to herbivory stress were measured. Rice primary metabolism was altered in an Si-dependent manner under herbivory stress. The levels of direct defense-related secondary metabolites were higher in the leaves of Si-supplied plants subjected to herbivory stress compared to the Si-deprived plants. Furthermore, when exposed to herbivory stress, Si-supplied plants emitted higher quantities of several VOCs relative Si-deprived plants, whereas the internal production of VOCs was largely unaffected by Si supplementation. Finally, the overall importance of Si in rice resistance against herbivores was assessed using several bioassays with either insect larvae or gravid female moths. In herbivore performance assays, larvae fed on Si-deprived plants increased their mass relative to those fed on Si-supplemented plants. In oviposition preference assays with gravid female moths, Si alone did not affect oviposition choice of the moths. In contrast, gravid females showed significant preference for herbivory-treated/Si-deprived compared to Si-supplied plants. Taken together, this study provides exciting new opportunities for studying minerals as key players in plant defense systems.

論文審査結果の要旨

The student conducted an independent study on the role of mineral elements in plant defense against herbivorous insects. This research made an important contribution to understanding of multiple roles of silicon (Si) in rice defense during attack from destructive chewing insects. In particular, it has been shown that silicon increases during herbivory and works as an indispensable part of mechanical defense systems in rice. Furthermore, the role of silicon was extended to examination of metabolic changes triggered by silicon, showing that Si is an important element required for effective accumulation of various defensive metabolites in rice. The above-mentioned results have been compiled in his PhD thesis, and major part has already been published in the peer reviewed JCR journal Frontiers in Plant Science.

All PhD course work and lectures, mid-term presentation, and final defense have already been completed by the student as required by the graduate school regulations. Mr. Osibe reported his results in three conferences as the main author, one of them being an international event (The 2023 Annual Meeting of International Society of Chemical Ecology in Kuala Lumpur, Malaysia). During his PhD study, Mr. Osibe has actively contributed to another publication as a co-author.

Overall, academic and research performance of the student have been satisfactory and examination committee therefore recommends the award of PhD (Agriculture) degree according to regulations of the Okayama University Graduate School of Environmental and Life Science.