【Grant-in-Aid for Scientific Research (S)】

Dissection of plant growth and environmental response mechanisms through peptide signaling

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Project Information	Project Number : 23H05477 Project Period (FY) : 2023-2027 Keywords : peptide hormone, Arabidopsis, receptor, signal transduction

Purpose and Background of the Research

●Outline of the Research

Since the late 1990s, research on peptide hormones involved in plant morphogenesis and environmental responses has rapidly progressed as a new class of molecules. These peptide hormones have surpassed the total number of conventional hormones such as auxins and gibberellins and more than 20 types have been discovered to date. This field has evolved into a major area of plant molecular biology. We have made contributions to this field by identifying the first peptide hormone in plants, PSK, and its receptor, and by discovering four additional novel secreted peptide hormone-receptor pairs. Through these findings, we have proposed new models for understanding plant morphogenesis and environmental responses (Figure 1). We have also uncovered the existence of a unique long-distance signaling mechanism in plants mediated by non-secretory peptides that translocate through the phloem. In this study, we aim to elucidate the receptor downstream signaling pathways of the five identified secreted peptide hormone-receptor pairs using state-of-the-art analysis techniques, and explore novel non-secretory peptides involved in long-distance signaling.

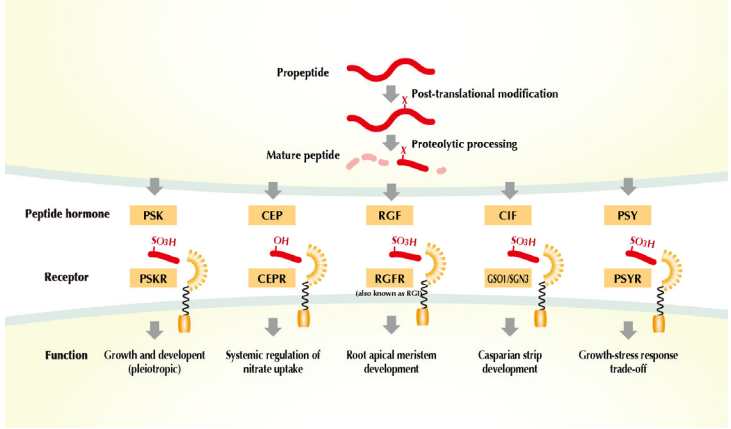

Figure 1. The five secreted peptide hormones and their receptors that have been discovered by our group.

●Elucidation of intracellular signaling pathways of secreted peptide hormone-receptor pairs

Elucidation of downstream signaling mechanisms may lead to the discovery of new functions of peptide hormones and the understanding of cross-talk with other signaling systems, thereby contributing to a deeper understanding of peptide hormone signaling. The functions of these five types of peptide hormones encompass a wide range, ranging from the regulation of stem cell properties to environmental responses. However, the intracellular domains of their receptors exhibit relatively high similarities, which raises interest in how specificity is achieved.

●Inter-organ communication mediated by non-secreted peptides translocating through the phloem

We aim to explore novel long-distance mobile peptide signals through the analysis of vascular-specific transcriptomes and inter-organ translocation studies, focusing on inter-organ communication mediated by phloem-mobile non-secretory peptides, which are unique to plants. Our interest in this field was sparked by the analysis of a non-secretory peptide family involved in nitrogen homeostasis, which demonstrated that phloem-mobile peptides can move from the shoot to the root through the phloem. The study of such phloem-mobile non-secreted peptides is still in its early stages, making it an intriguing and unexplored research field.

Expected Research Achievements

●Elucidation of intracellular signaling pathways of secreted peptide hormone-receptor pairs

We aim to analyze the intracellular signaling pathways of the five peptide hormone-receptor pairs that we have discovered in a parallel manner. We will outline our research plans for three specific pairs that we find particularly intriguing.

【PSY-PSYR System】

The peptide hormone PSY and its receptor PSYR are involved in the switch between growth and stress responses. The PSY-PSYR system operates in a unique mechanism where downstream signaling is activated when the hormone is not bound, contrasting with known receptor signaling systems. We will employ quantitative phosphoproteomics and co-immunoprecipitation/mass spectrometry techniques to unravel this mechanism.

【CEP-CEPR System】

When certain roots sense nitrogen deficiency, they produce the peptide hormone CEP, which is then transported to the leaves via the xylem and recognized by the receptor CEPR. Activation of CEPR leads to the induction of the non-secreted peptide CEPD, which translocates through the phloem to the roots, promoting nitrate uptake in the roots that still have nitrogen remaining in the rhizosphere. We aim to elucidate the pathway from CEPR activation by CEP to the transcriptional induction of downstream factors, including CEPD.

【RGF-RGFR System】

In the root apical meristem, the patterns of the stem cell region, cell division region, and cell differentiation (elongation) region are tightly controlled. The master regulator of this process is the transcription factor called PLT (PLETHORA), and it has been shown that the secretion and diffusion of the peptide hormone RGF, specifically expressed in the stem cell region, establish a concentration gradient that determines PLT expression. In this study, we aim to uncover the signaling pathway connecting RGF and PLT, as well as investigate cross-talk with other hormones.

●Inter-organ communication mediated by non-secreted peptides translocating through the phloem

Non-secreted peptides exhibiting specific expression in leaf phloem companion cells can be identified by utilizing our own vascular bundle-specific transcriptome data and publicly available databases. Their translocation can be confirmed by fusing them with GFP. For several candidate peptides that have already been narrowed down, we will proceed with functional analysis through co-immunoprecipitation/mass spectrometry in the target organs and phenotype analysis using knockout mutants.

Homepage Address, etc.	https://www.bio.nagoya-u.ac.jp/~b2/