Research area in the strategic objectives "Establishment of an Environmentally Adaptive Plant Design System to Achieve a Stable Food Supply in the Age of Climate Change" and "Construction of Models for Mathematical Notation and Elucidation of Various Phenomena whose Ruling Principles and Laws in Society are Unclear"

6.2.14 Innovational technical basis for cultivation in cooperation with information science

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Overview

The aim of this area is to achieve advanced cultivation techniques that will enable sustainable high-yield, high-quality agricultural production even under the various limitations resulting from climate change and the need for reduced environmental load and so on. To this end, collaboration between agricultural and plant science and information science (state-of-the-art measurements, data-driven science and so on) will be promoted to achieve the cultivation of plants adapted to various environments as well as control of plant growth to match production quality.

Specifically, these will include technologies for nondestructive measurement of plant biological functions, technologies to extract knowledge for ideal cultivation from diverse, large-scale data, general growth models capable of going beyond the site-specificity of plant cultivation, growth models that can consider uncertainty, complex system models that describe farm field ecosystems, technologies for precise control of growth in outdoor environments and so on.

For the pursuit of research in this area, the emphasis will be on the exchange of information, discussion and collaboration by researchers in information science and those in agricultural and plant science. Collaboration by PRESTO (Sakigake) researchers, each employing the strength of his or her specialist field, will be promoted to obtain the synergy resulting from mutual stimulation, in order to resolve food issues that will arise in the future. Furthermore, in order to maximize achievements for the achievement of the strategic objective, management of this research area will also be coordinated with the CREST "Creation of fundamental technologies contribute to the elucidation and application for the robustness in plants against environmental changes" research area and the PRESTO "Creation of Next-generation fundamental technologies for the control of biological phenomena in field-grown plants" research area.

Research Supervisor's Policy on Call for Application, Selection, and Management of the Research Area

1. Background

Even with the continued explosive growth of the world's population, economic development has made it possible for many more people to obtain a richer supply of food. For this reason, agricultural production requires not merely a simple increase in productivity but also efficiency with improved food quality. However, a variety of factors stand in the way of the achievement of this type of agricultural production, such as concerns regarding biodiversity and environmental preservation, reduction of greenhouse gas caused by agriculture, quantitative limitations on the amount of water and arable land, and consequences of climate change.

Research in this area will focus on the resolution of issues despite various restrictions, with the aim of achieving cultivation technologies to support the sustainable production of high-yield, high-quality crops, as well as the achievement of basic and foundational research to enable the control of plant growth to match the target production volume and quality even in outdoor environments, based on collaboration between information science and agricultural and plant science. Although past efforts to integrate information science and agricultural science, etc. have produced several outstanding achievements, it has yet to regulate and sufficiently draw out the capabilities of plants grown amidst the complex interactions between cultivation conditions and farm field environments. Thus, significant progress of basic and foundational research combining advanced agricultural science and plant science knowledge with measurements of plant biological functions that consider external environments, as well as state-of-the-art data-driven science and so on are needed to achieve environmental adaptation and growth control for plants in a variety of environments.

2. Approach to call for proposals

As noted earlier, there is a need to achieve sustainable agriculture that provides both high productivity and quality under a variety of restrictions that include coping with global climate change, the consideration of reducing environmental load, limited amounts of available water and arable land and so on. In Japan, this problem is compounded by issues such as inefficient production due to small-scale farming operations, an inadequate number of farm workers and the loss of exemplary farming knowledge due to the aging population, the increased number of abandoned fields that are no longer cultivated, and an extremely low rate of self-sufficiency for food production including livestock feed. In addition to these problems, production loss, leftover food, the food distribution system and so on are also intertwined in complex ways with various socioeconomic factors to make up the food problems facing humanity.

Applicants should begin by considering on their own which of the various issues should be resolved by proposed research in the future, and to what degree, in order to achieve sustainable agricultural production that ensures both high productivity and high quality, and should note a long-term scenario for their own research. Next, please note the PRESTO research topic and the means of resolving the issue, the objectives to be achieved when the research is completed, and the research exit strategy. We are really hoping for innovative basic research proposals that are based on a problem-solving approach. This research area will target primarily research that contributes to

cultivation in the outdoor environments that are expected to be still the center for crop production in the future, but proposals for research into cultivation in plant factories and other artificial environments will also be accepted. The main target scale for research is the level of individual plants and plant communities, but we also welcome proposals for research within organisms and those on a farm, regional or global scale and so on. However, it is essential that each research proposal be related to environmental adaptation of plants to farm fields and other outdoor environments and control of plant growth. When submitting proposals, please also confirm the points listed in 1) ,2), and 3) below.

1) Differences from PRESTO (Sakigake) "Creation of Next-generation fundamental technologies for the control of biological phenomena in field-grown plants" research area

JST has established this research area ("Innovational technical basis for cultivation in cooperation with information science") and the "Creation of Next-generation fundamental technologies for the control of biological phenomena in field-grown plants" research area as independent PRESTO research areas, based on the "Establishment of environmentally-adaptive-plant design systems for stable food supply in the age of climate change" Strategic Objective. Research in the "Creation of Next-generation fundamental technologies for the control of biological phenomena in field-grown plants" research area targets the control of complex plant gene functions. Specifically, a quantitative approach is used to elucidate plant environmental response mechanisms, in order to conduct informatics research that will help to develop effective methods of (molecular) design of plants with the desired traits. In contrast, research in this research area targets the research and development to design sustainable agricultural production under the limitations described above, and to derive the target yields and traits. Specifically, in addition to research into innovative technologies to measure plant biological functions in farm fields, even if the specific environmental adaptation mechanisms are unknown, such "black box" nature is recognized and research is promoted into such as robust models, simulations and predictions that can precisely describe plant adaptation to farm field environments. The objective in this area is research and development that can contribute to the design of sustainable agricultural production. As a rule, the data used for research should be data obtained from the cultivation of useful plants, whether in outdoor farm fields or plant factories or the like. However, methods that use large-volume simulation data and the like will also be accepted.

2) Collaborative proposals

PRESTO research programs are designed to bring out the ideas and capabilities of individual researchers thoroughly and free them from organizational limitations. However, in this research area, a high level of collaboration with a combination of fields including agricultural science, plant science and information science is

needed. Accordingly, in addition to the standard type of proposal (from an individual researcher), it is possible to submit collaborative proposals involving multiple PRESTO proposal researchers.

In this research area, we are actively seeking proposals from state-of-the-art agricultural science, plant science and information science researchers. However, it is possible that information science researchers will have concerns regarding their ability to establish research topics and obtain data regarding the targets for analysis in the fields of agricultural and plant science, which up to now have been outside their area of specialty. Similarly, agricultural and plant science researchers may have an interest in data-driven research based on their own measurement data but may feel that there is some distance between themselves and a knowledge of state-of-the-art information science.

Accordingly, in cases in which it is difficult for the researcher proposing the research topic to conduct the research alone, an information science researcher and an agricultural or plant science researcher may hold discussions in advance regarding the possibility of collaboration and then each submit a separate proposal in this research area, noting their individual roles and the anticipated synergistic effect in their proposals (see figure below). Even in such cases, however, the individual researchers will need to be on an equal footing and the proposals must be appropriate ones for PRESTO research. Please note that collaborative proposals with other research areas are not allowed. When submitting collaborative proposals, please note in the proposal (Form 3: Research Initiative) the status of coordination with the collaborative researcher as well as the research content that will be conducted individually by the submitting party, and differentiate it from the collaborative research content. Even in the case of a collaborative proposal, depending on the content of the collaborative research, it is possible that only one of the research proposals will be selected.

Researchers who are submitting proposals at the stage at which they are still studying the researchers for collaboration and the collaborative research topic should note in as much detail as possible the type of researcher with whom they anticipate collaborating and the types of collaborative topics they would like to study.

In addition, in the event that data will be used to pursue research toward the resolution of the target issue, please clearly note in the proposal (Form 3: Research Initiative) the type of data that will be used and the status of coordination with the data management institution in terms of data acquisition.

In order to select of collaborative proposals for this research area, we will consider the content of the collaborative research topics, evaluating the following points: 1) collaborator’s approach is required for proposed research progress, and 2) proposed research is improved through the collaborative approach. We do not expect proposals in which the collaborator’s work is nothing but data analysis, nor where the collaborator would have to do considerably more to accomplish the proposed research. We do expect the collaboration of researchers from different fields to improve each research project.

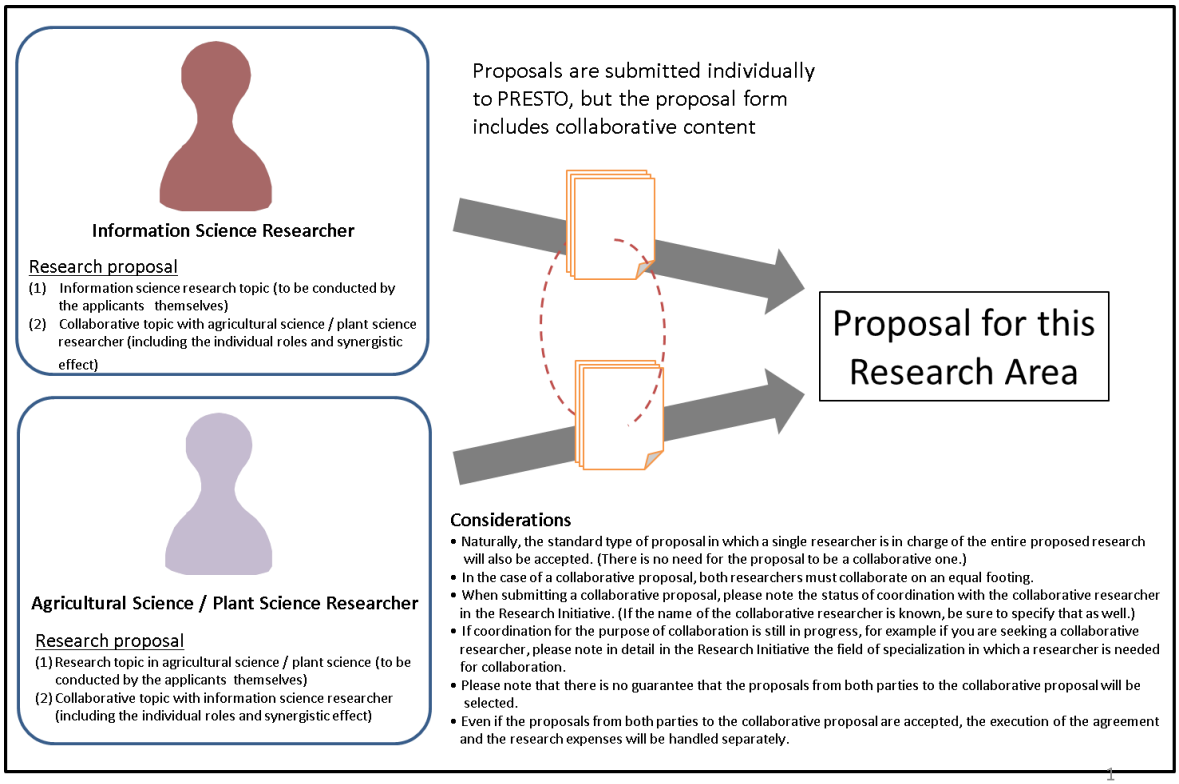

Figure: Collaborative Proposal

3) Type of Proposal

In the invitation for applications for FY2017, applicants shall select one of the following types when submitting a proposal. As shown below, even if you are not well-versed in any one of these research areas at the time of submission of your proposal, you may be able to learn any of the subjects—such as Agriculture/Plant Science or Mathematics/Informatics—through guidance from the Research Area Advisor or in coordination with other researchers outside of the area during implementation of your research project.

[Mathematics/Informatics]

If applicants entertain the idea of focusing on a research subject using agriculture-related data obtained from an external source, their own simulation data, and they pursue the research subject using approaches based on mathematical sciences and informatics sciences—and if they also wish to improve the research based on knowledge of the agricultural and plant sciences after approval—, [Mathematics/Informatics] should be selected.

For example, we look forward to the participation of those who intend to discover new knowledge about growing agricultural crops by making use of approaches based on the mathematical sciences and informatics sciences in response to time series data (or simulation data) that show complicated responses based on

interaction with the ever-changing environment.

Even if applicants are not well-versed in the knowledge of agricultural and plant sciences at the time of proposal submission, we will select applicants based on the brilliant originality and uniqueness of mathematics and informatics analysis methods that make up for current insufficient knowledge of Agriculture/Plant science, as well as clarity in the development of ideas aimed at the realization of sustainable agriculture and plant cultivation. In addition, we will consider the motivation of applicants to acquire knowledge in the agricultural and plant sciences. To allow coordination with other PRESTO researchers, we will assist those researchers who lack data to be evaluated at the time of proposal submission and after adoption of this area. Moreover, with respect to approaches in the agricultural and plant sciences, we will provide opportunities to allow you to deepen your knowledge through discussions with the Research Supervisor and Area Advisor as well as PRESTO researchers.

[Agriculture/Plant Science]

If applicants are focused on biometrics/data acquisition through approaches based on the agricultural and plant sciences —and they are also willing to acquire knowledge of mathematics and informatics after adoption—, [Agriculture/Plant Science] should be selected when submitting a proposal. For example, we look forward to the participation of those who intend to engage in the building of mathematical models that may explain the life phenomena of plants essential for agricultural applications. Even if applicants are not well versed in the knowledge of mathematics and informatics analysis methods at the time of proposal submission, we will select applicants based on the brilliant originality and uniqueness of agriculture/plant measurement techniques, which make up for current insufficient knowledge of mathematics and informatics. We will also review the appropriateness of the method for evaluating results effectively, as well as clarity in the development of ideas aimed at the realization of sustainable agriculture and plant cultivation. Moreover, the volition for acquiring proficiency in applying the mathematics and information analysis method is also an area for evaluation; accordingly, we will provide opportunities to allow you to deepen your knowledge of mathematics and informatics through discussions with the Research Supervisor and Area Advisor as well as PRESTO researchers after adoption.

[Agriculture-Informatics Interdisciplinary Science]

If your proposal does not coincide with a proposal type of [Agriculture/Plant Science] or [Mathematics/Informatics], and if you are versed in data acquisition through agriculture/plant measurement techniques as well as mathematics and informatics analysis methods at the time of proposal submission, you

should select [Agriculture-Informatics Interdisciplinary Science]. We will choose applicants based on the originality and uniqueness of both measurement and analysis methods and the appropriateness of the methods to evaluate results effectively; we will also assess for clarity in the development of ideas aimed at the realization of sustainable agriculture and plant cultivation. Moreover, we will provide opportunities to allow you to deepen your knowledge regarding subjects you should focus on through discussions with the Research Supervisor and Area Advisor as well as PRESTO researchers after adoption.

3. Examples of Specific Topics Anticipated in this Research Area

In this research area, we welcome innovative proposals that will contribute to cultivation technologies for the achievement of plant environmental adaptation and growth control.

Firstly, this research area targets the innovative research proposals, aiming at non-destructive/efficient measurement methods (phenotyping) for plants biological functions and phenotypes. We place emphasis on that the proposed methods are available in the fields. Please clarify how to make the data by measurement methods useful for modeling or simulation, as well as the measurement methods themselves.

Secondly, research proposals relating to the construction of models and simulations of plant growth or farm field ecosystems, by means of information science/ mathematical analysis of data that include the measurement data for these plant functions, the legacy data stored at agricultural testing centers and the like, meteorological observation data, publicly available data in various statistical databases and satellite images and so on, will be considered. Although this type of model and simulation research is currently underway, there are many issues that need to be resolved in order to achieve models and simulations that are highly generalized to enable use in various regions and that can accurately predict growth even when data with a high level of uncertainty are incorporated. We are seeking efforts aimed at constructing robust models and simulations. We also welcome research proposals that contribute to optimization of cultivation processes, such as seedlings raising management, fertilization, coping with plant disease or insect damage, pruning, and harvest management.

Furthermore, proposals aimed at achieving sustainable agriculture that convert implicit knowledge of cultivation into explicit knowledge and conduct total energy simulations and the like in agricultural fields and regions, etc., using data-driven science that is not bound by existing techniques to produce innovative achievements with respect to agricultural issues, will also be accepted. We consider it important for proposals that focus primarily on information science analysis to extract knowledge from data efficiently, and to include discussions of research achievements from an agricultural and plant science perspective, and researchers should keep these points in mind when submitting proposals.

Please note that the aforementioned examples of the specific research topics that are envisioned in this research area are only examples, and the topics will not be limited to these examples. We welcome innovative proposals that

are based on the applicant's own creative ideas. As for proposals in FY2017, we still put emphasis on cultivation in outdoor farm fields. We strongly welcome proposals that include research topics regarding cultivation in outdoor farm fields from the beginning of the proposed research.

Please also note that this research area considers collaborations with CREST/PRESTO research areas promoted in the fields of life innovation as described hereinbelow, through utilization of knowledge based on such research areas. Therefore, please note that the targeted plants on the research proposal for this research area are limited to practical ones since this research area aims at practical use towards plants cultivation.

4. Approach to Administration of the Research Area Following Selection

In order to increase synergy through collaboration among the selected topics in the research area, a venue should be established that will allow thorough debate on the part of PRESTO researchers, the research supervisor, the research area advisors and so on. Active assistance will be provided for necessary collaboration even after selection. Applicants should understand that they may be asked to revise the initially proposed research plan as a result of discussions.

Along with the progress of research, in order to strengthen research capabilities, the sharing of knowledge relating to control of plant growth will be promoted through the establishment of a venue for the exchange of information and views with researchers promoting research in the CREST "Creation of fundamental technologies contribute to the elucidation and application for the robustness in plants against environmental changes" research area and the PRESTO (Sakigake) "Creation of Next-generation fundamental technologies for the control of biological phenomena in field-grown plants" research area, in the field of life innovation under the aforementioned "Establishment of an Environmentally Adaptive Plant Design System to Achieve a Stable Food Supply in the Age of Climate Change" Strategic Objective.

Although we are not seeking the commercialization of systems or services using the achievements in this research area, we will value discussion that keeps these objectives in mind, and we may want to study the implementation of such objectives depending on the progress of research. Discussions encompassing the entire area will also be conducted to determine what contribution this research area can make to the shared use of data and data analysis tools and other open science initiatives. As one example, cooperation in providing the data to the JST National Bioscience Database Center (NBDC) may be requested. Moreover, as it is anticipated that information science researchers will have difficulty acquiring agricultural data for analysis, A support might be conducted within this research area for the acquisition of such data.

PRESTO researchers will also be asked to cooperate in general outreach activities. Within this research area, we plan to hold workshops, seminars and the like that bring together agricultural and plant science and information science, and we hope that researchers will actively participate in these events.

At present, the number of researchers in fields that integrate agricultural and plant science and information science is extremely limited, and we hope that participants in this research area are committed to the effort to create a new field of study. We ask that agricultural and plant science researchers actively strive on their own to learn about the field of information science during the period of research —and that information science researchers do the same for the fields of agricultural and plant science) — and that both work to bring about an evolution in their own research as they incorporate knowledge from a different field. Each of these fields is enormous, and a considerable amount of time will be needed to learn even a part of the field. We suggest that researchers begin by participating in exchanges with researchers from the different fields in order to gain clues to how to go about this. It is our fervent desire that, in the course of research activities in this PRESTO research area, researchers will learn from and improve one another, eventually becoming a bridge between the two fields and drivers of the new integrated field.

* Please note that the application forms of this research area are different from those of the other research areas.

Note: Regarding call for proposals FY2017, we don't hold the briefing sessions for the call for proposals in this research area. For more information, please visit the following site: http://senryaku.jst.go.jp/teian-en.html.
Moreover, the policy of call for proposals FY2017 in this research area is put on the following site (Japanese only): http://senryaku.jst.go.jp/teian/top/setsumeikai.html, where the movie of briefing of call for proposals FY2016 is also posted just for information.