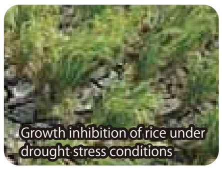
Research activities

Research on improving rice productivity in the unfavorable environments of the tropics

To feed an ever-growing global population, it is important to increase food production and secure a stable food supply even in an environment not suited for agricultural production. In particular, demand for rice, which is a staple food for over half of the world's population, is expected to keep increasing in the coming decades, which makes it imperative to increase rice production. Rice fields in the tropical regions in Asia and Africa are faced with various environmental stresses that can cause a reduction in rice yields. At our research bases in Kenya, Indonesia, and Cambodia, we are undertaking the following activities with the goal of increasing rice production in unfavorable environments: evaluation of factors inhibiting rice productivity, assessment of adaptability of local rice varieties to stress, genetic analysis, genetic improvement of rice, and development of effective cultivation techniques.

1) Genetic improvement of rice to secure stable rice production in unfavorable environments

In addition to the conventional cross breeding and mutation breeding technologies, novel breeding techniques, such as quantitative trait locus (QTL) analysis (which identifies QTLs associated with stress tolerance) and marker-assisted selection (MAS) (which can quickly and accurately identify the presence of a specific quantitative trait locus) are now available to breed improved rice varieties with a greater efficiency, thanks to the recent research advancements in the field of agricultural sciences. Novel techniques, such as next generation sequencing (NGS) (which quickly and inexpensively provides genome-wide genetic information on living organisms) and new plant breeding techniques (NBT) (new approach to genome editing) have also been developed. We are using these technologies to achieve genetic improvement of rice with the goal of securing stable rice production in unfavorable environments.

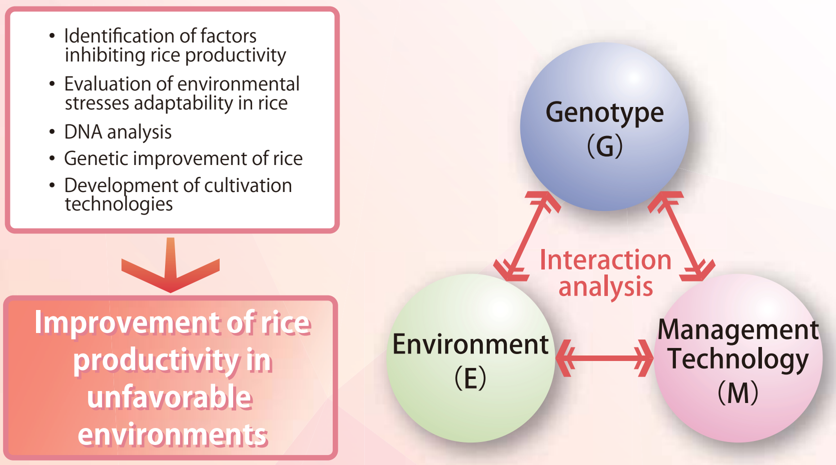

Growth inhibition of rice under drought stress conditions


Research activities for development of new rice varieties with tolerance to environmental stresses

2) Development of cultivation techniques to increase rice productivity in unfavorable environments in Africa

Rice yields in Africa have remained low due to various biotic and abiotic stresses including drought, cold temperatures in highlands, high salinity, low-fertility soils, rice blast disease, and rice yellow mottle virus. To increase rice yields in such unfavorable environments, it is necessary to genetically improve rice crops to enhance adaptability to unfavorable conditions. The stress tolerance and crop productivity observed in the actual farm fields, however, are not only determined by the genetic traits of crop varieties but also affected by cultivation environments and the cultivation management strategies used.

Through collaboration with our research colleagues, we are carrying out field surveys to evaluate factors inhibiting rice productivity. Furthermore, we are growing rice lines into which we have incorporated the QTLs associated with improved adaptability to environmental stresses and improved rice yields. In addition, we are carrying out rice cultivation trials in a controlled artificial environment as well as in the actual farm fields to identify both the rice traits suitable for the cultivation environments in Africa and the QTLs that are associated with these traits, and to understand the cultivation conditions that enable the incorporated QTLs to function effectively.




Conducting cultivation trials in Kenya


Research under controlled environments in Nagoya University

3) Development of flood-adaptive rice cultivation technology

Since the late 1990s, the world has witnessed a rapid increase in major flooding events. Flood management approaches employed in Asian regions, which involve the use of newly developed or improved irrigation techniques, are not sufficient to avoid the damage of devastating floods that hit these regions, where vulnerability of crop cultivation to floods still poses a serious problem. In flood-prone regions, rice must be planted during the deepwater flood phase of the rainy season in order to prevent rice crops from sustaining damage from dryness during the late stage of growth. Inevitably, this puts the rice crops at risk of flood damage during the early stage of growth.

In addition to reevaluating the double-transplanting technique that has been used in the low-lying swamps along the east coast of Sumatra and the west coast of Peninsular Malaysia, we have been investigating the growth response of the locally grown rice varieties to floods to identify the traits associated with flood adaptation of rice varieties that are grown in several different regions with varying water depth levels and varying periods of deepwater flood phase. Our goal here is to ensure stable production of rice crops in flood-prone regions through the use of traditional techniques, and to improve cultivation technology by using fertility management strategies that not only help mitigate the harmful effects of submergence stress but also facilitate recovery from flood damage.


Uprooting of seedlings for the first transplanting


Rice seedlings growing on a raft for 2 weeks prior to the first transplanting

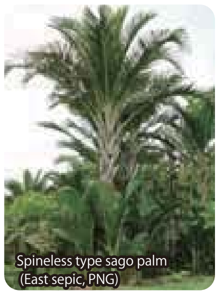

First transplanting (second transplanting will be done after 20 days)

■International Sago Palm Project for food security improvement

Agricultural production must increase by 70% globally to feed the world's population that is projected to reach 9 billion by 2050. Climate change and diminishing underground resources (including oil) also pose serious challenges to food security, and we need to focus on how we can enhance agricultural production/productivity in a sustainable way while minimizing post-harvest biomass losses. In view of this, our research group focused its attention on sago palms that grow naturally in Southeast Asian and South Pacific regions.

This palm adapts well to infertile/acid soils or brackish-water regions that are generally unsuited for crop cultivation. Furthermore, one palm can yield approximately 300 kg of starch. Sago is a staple food for local residents, and is used as an ingredient in biscuits, noodles, and other food products. Although it is not generally known, sago flour is used to knead buckwheat noodles and udon noodles in Japan. As an ingredient of choice for people with food allergies, sago has recently been used in a number of cosmetics as well. With only 10% of the wild and semi-cultivated sago palm stands believed to be harvested for use today, there is much room left for further exploitation of this economic plant.

In our laboratory, we are investigating the mechanism through which sago palms adapt to saline and acidic soils. Furthermore, we are carrying out field surveys to monitor the growth of sago palms to inform our efforts to develop an effective cultivation management strategy that enables stable growth of sago palms. We are also undertaking the following activities as part of a joint international research project: use remote sensing to estimate the area of the land on which sago palms are growing and to identify areas suitable for growing sago palms, develop technology to make sweeteners from the residue from sago starch extraction, and estimate the socioeconomic impact of the new technology.


Spineless type sago palm (East sepic, PNG)


Measurement of physiological parameters at the pilot farm of sago palm in Southeast Sulawesi, Indonesia


Sago palm field in Southeast Sulawesi, Indonesia