Wed. Sep 8, 2021

Plenary Room

Symposium | Symposium | S-01 - S-05

Climate Change and Advancing Rice Production in Asia

Chair: Jun-Ichi Sakagami (Kagoshima University, Japan)
1:55 PM - 4:30 PM Plenary Room

[S-01] Reduced Stomata Density and Size: The key to improve WUE in Climate-ready Rice

Mutiara K. Pitaloka[1], Robert S. Caine[2], Christopher Hepworth[3], Emily L. Harrison[2], Jen Sloan[2], Cattleya Chutteang[1], Chutima Phuntong[1], Rungsan Nongngok[1], Theerayut Toojinda[5], Siriphat Ruengpayak[4], Siwaret Arikit[1,4], Julie E. Gray[2], ○Apichart Vanavichit[1,4,5] (1.Department of Agronomy, Faculty of Agriculture, Kasetsart University,Thailand, 2.Department of Molecular Biology and Biotechnology, University of Sheffield, UK, 3.Department of Animal and Plant Sciences, University of Sheffield, UK, 4.Rice Science Center, Kasetsart University, Thailand, 5.National Center of Genetic Engineering and Biotechnology (BIOTEC), National Science and Technology Development Agency (NSTDA), Thailand)

2:00 PM - 2:20 PM

[S-02] Maximizing Rice Production and Quality under Climate Change

○Junhwan Kim, Wangyu Sang, Pyeong Shin, Jaekyeong Baek, Dongwon Kwon, Yunho Lee, ChungIl Cho, Myungchul Seo (National Institute of Crop Science, RDA, Korea)

2:20 PM - 2:40 PM

[S-03] Global Climate Changes and Their Impacts on Crop Production

Toshihiro Hasegawa (Division of Climate Change Adaptation Research, Institute for Agri-Environmental Sciences, National Agricultural and Food Research Organization, Japan)

2:40 PM - 3:00 PM

[S-04] Challenges and Adaptation for Rice Production under Climate Change in Taiwan

Huu-Sheng Lur[1], ○Ming-Hwi Yao[2] (1.Department of Agronomy, National Taiwan University, Taiwan, 2.Taiwan Agricultural Research Institute, Council of Agriculture, Taiwan)

3:10 PM - 3:30 PM

[S-05] Farming Systems under Environmental Changes in the Mekong Delta of Vietnam

Nguyen Duy Can (College of Rural Development, Can Tho University, Vietnam)

3:30 PM - 3:50 PM

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3:30 PM - 3:50 PM

2:00 PM - 2:20 PM (Wed. Sep 8, 2021 1:55 PM - 4:30 PM Plenary Room)

[S-01] Reduced Stomata Density and Size: The key to improve WUE in Climate-ready Rice

(Thailand)
Mutiara K. Pitaloka[1], Robert S. Caine[2], Christopher Hepworth[3], Emily L. Harrison[2], Jen Sloan[2], Cattleya Chutteang[1], Chutima Phuntong[1], Rungsan Nongngok[1], Theerayut Toojinda[5], Siriphat Ruengpayak[4], Siwaret Arikit[1,4], Julie E. Gray[2], ○Apichart Vanavichit[1,4,5] (1.Department of Agronomy, Faculty of Agriculture, Kasetsart University,Thailand, 2.Department of Molecular Biology and Biotechnology, University of Sheffield, UK, 3.Department of Animal and Plant Sciences, University of Sheffield, UK, 4.Rice Science Center, Kasetsart University, Thailand, 5.National Center of Genetic Engineering and Biotechnology (BIOTEC), National Science and Technology Development Agency (NSTDA), Thailand)

Rice is among the lowest water-use efficient crops. To produce a kg of polished rice, 2.5 tons of water on average is needed. Rice plants utilize most of the uptake water for evapotranspirational cooling via stomata. In order to develop water-used efficient rice, reducing stomatal density and size may help optimizing transpiration and photosynthetic assimilation. Climate-ready, Nutrient-dense rice is an integrative approach to develop new rice varieties of the future agriculture. By pyramiding genes/QTLs controlling broad-spectrum resistance to biotic and abiotic stresses into high nutritional rice background, we have generated series of rice ideotypes to mitigate the effects of climate change and to cope with double malnutrition in 2050.

By forward screening on a large-scale M_5 fast neutron mutagenized population, four stomatal model lines were identified expressing distinct stomata density (High vs Low Density = HD vs LD), and size (Big vs Small Sizes = BS vs SS). Gas exchange analysis revealed that the stomatal model lines were not different in photosynthetic assimilation (*A*) and chlorophyll fluorescence. In response to increasing [CO_2], no difference in *A* from 100-600 ppm [CO_2] for all stomatal model lines but beyond the peak, SS was more responsive to increasing [CO_2] than any stomatal model lines. Nonetheless, HD had higher stomatal conductance (*gs*) and *gsmax* than any stomatal model lines. All stomatal model lines were also similar in rhythmic stomatal responses to ten minutes dark/light transition cycles, except SS was more rapid than BS in the initial stomata closure.

The stomatal model mutants did not show any significant difference in response on a short term water stress. Long-term water stresses had less impact on leaf drying, F_v/F_m, grain yield, and harvest index in LD and SS. In the field, all stomatal model lines and JHN wt had similar WUE in well-water treatment. Nonetheless, LD showed the highest WUE and biomass/plant than any stomatal model lines in the long-term water-stress treatment.

In addition, three cycles of forward screening for recovery from drought stresses on 971 M_5 lines revealed three drought-selected mutants showing good recovery. Surprisingly, when compared to the stomatal model lines, all drought-selected mutants had lower stomatal density similar to LD. Comparison under well-water and water-stress revealed the three drought-selected mutants and LD gained better water-used efficiency and more drought tolerance than BS, HD, and SS. This is a conclusive evidence linking LD, WUE, and drought tolerance.

It is not clear the impact of altered stomatal traits on transpirational cooling under heat and drought stresses. Our recent experiments on heat stress indicated that high stomata density (HD) were beneficial in high air temperature tolerance at reproductive stage while SS and LD accumulated higher canopy temperature than HD, BS, and JHN-wt. in a mild heat at 30℃. Nonetheless, SS and LD were cooler under water deficit.

Specific DNA markers associated with altered stomata traits were used for marker-assisted backcrossing to optimize high yielding, multiple resistance, grain quality, and water-use efficiency.

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[S-02] Maximizing Rice Production and Quality under Climate Change

(Korea)
○Junhwan Kim, Wangyu Sang, Pyeong Shin, Jaekyeong Baek, Dongwon Kwon, Yunho Lee, ChungIl Cho, Myungchul Seo (National Institute of Crop Science, RDA, Korea)

The crop growth model, Oryza2000, was simulated to study the temporal and spatial change of the rice productivity of South Korea based on the RCP 8.5 climate change scenario. In general, the decline rate of early ecotype yield was the fastest, followed by the medium-late and the medium. Finally, it was predicted that more than 25% reduction in yield would occur in most areas by the end of the 21st century. The rice quality was evaluated indirectly through the 1000grain weight obtained from the crop growth simulation. The simulation result showed that the 1000grain weight change was similar to the change pattern of rice yield. For adaptation measures, we had tried to shift seeding date. Shifting seeding date was a strategy to avoid low grain filling rate at high temperatures. As a result, shifting of seeding date could delay the decreasing rate of yield as scenario. However, shifting of seeding date could not be a perfect countermeasure to keep current yield level because of uncertainty of solar radiation in future climate condition. Therefore, based on the simulated results, it is necessary to conduct an actual field test every 10 or 15 years

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[S-03] Global Climate Changes and Their Impacts on Crop Production

(Japan)
Toshihiro Hasegawa (Division of Climate Change Adaptation Research, Institute for Agri-Environmental Sciences, National Agricultural and Food Research Organization, Japan)

Atmospheric concentrations of major greenhouse gases (GHG) such as carbon dioxide (CO_2), methane, and nitrous oxide have increased by about 50%, 160 %, and 23 %, respectively, since the preindustrial era (https://public.wmo.int/en), mainly as a result of anthropogenic activities. These changes have already raised air temperatures globally for the past 100 years and increased extreme climate events in various regions across the globe. There is a growing body of evidence that the long-term change in air temperatures and associated changes in precipitation amount and patterns have already been affecting crop production, but with varying degrees across different regions. As climate change progresses, the impacts will be greater, but they depend on various factors such as GHG emission scenarios, times, locations, and warming degrees. Since the last assessment report by the Intergovernmental Panel on Climate Change in 2014, a large body of literature has become available for the projected impacts using crop simulation models run under different representative GHG concentration pathways at different spatial scales. Recently, a global dataset has been developed by compiling more than 8000 simulation results from 203 independent studies, providing a valuable source of comprehensive analysis on the projected impacts on major crops. Here I first summarize the impacts of plausible climate change in the current century on the major crop yields, demonstrating that the sign and magnitudes of the effects are heavily dependent on the current temperature levels, with special references to Asian regions. The impacts of climate change also appear in various processes of food systems, including food prices, labor

capacity, transport, storage, and food safety, which ultimately undermine food and nutrition security. On the other hand, food systems are a major source of GHG, accounting for about 1/3 of the anthropogenic emission. In the later part of the presentation, I introduce some examples of complex interactions between food systems and atmospheric conditions that need better understandings to enhance synergies and reduce trade-offs between adaptation and mitigation measures.

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[S-04] Challenges and Adaptation for Rice Production under Climate Change in Taiwan

(Taiwan)

Huu-Sheng Lur[1], ○Ming-Hwi Yao[2] (1.Department of Agronomy, National Taiwan University, Taiwan, 2.Taiwan Agricultural Research Institute, Council of Agriculture, Taiwan)

Located in East Asia, the climate of Taiwan is governed by the East Asian Monsoon resulting in the strong seasonality of precipitation pattern and the topographic features further amplify the vulnerability to different natural disasters as compared to other countries. It is crucial to develop the resilient agriculture by improving Taiwan's future agricultural production systems with respect to the future trends of climate change. Paddy rice is the major crop produced in Taiwan, and the small fluctuations of rice yield could lead to serious impact on food security. Evaluation of the major crop production under the different effects of climate change would be essential for bettering the future strategies for enhancing food security. Crop production simulation frequently employs the future climate data predicted by global climate models. The effects of climate change on rice production were evaluated based on the future climate data of four different climate scenarios provided by the United Nation's Intergovernmental Panel on Climate Change. Results indicated that total rice production would decrease by approximately 5%–15%, and this could be the consequence of the reduction of the number of growing days and the undergrowth of grains associated with the poor photoassimilation of vegetative organs due to global warming. Analysis of the future Representative Concentration Pathway (RCP) 8.5 scenario showed that rice yields will decrease in near-term, mid-term, and long-term horizons of the century by 5.1%, 12.5%, and 22%, respectively, especially in northern and eastern of Taiwan. These results are consistent with evaluation results concerning other Asian countries. Climate change refers to not only the changes in average temperatures but also the intensity and frequency of extreme weather events, and the unpredictability of natural disasters has increased the uncertainties for understanding the future changes of crop production. The limitation of existing atmospheric models for predicting disaster occurrence, especially heavy rainfall or strong wind events. The current crop model could simulate various specific disasters but not including typhoons and heat waves which are one of the most important disasters in Asia causing yield reduction during the harvesting season or the flowering stages of crops. The present study analyzed the meteorological changes that have caused the reduction of rice production in Taiwan over the past 60 years. These data were used with the predicted frequency of different climatic scenarios in the future to estimate the effects of future disaster factors on rice yield. Moreover, the approach to establishing a resilient system for rice production that would withstand the various effects of climate change has been considered. In particular, the water used for rice cultivation accounts for approximately 50% of the total water resources in Taiwan. As the traditional policy, farmers are offered with subsidies and undergo fallowing during drought periods. This paper introduces an advanced system to change current farming practice into the dry-field direct seeding as an adaptative farming method to water shortages in farming regions. The present findings provide new

insights on farming systems for climate change adaptation.

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[S-05] Farming Systems under Environmental Changes in the Mekong Delta of Vietnam

(Vietnam)
Nguyen Duy Can (College of Rural Development, Can Tho University, Vietnam)

The Mekong Delta is the most important agricultural area of Vietnam and has often been described as the "Rice Bowl of Vietnam". This Delta provides to more than half of food production and over 95% of rice for export from Vietnam. From long time ago, rice monoculture is a predominant system of agricultural production of the Delta. The reason for this is the environmental conditions such as land and water resources are favorable for rice growing. In addition, other than rice, there are a great potential for fruit trees, fish, shrimp rearing, and to develop diversification of rice-based farming or integrated farming systems in the Delta. Although specialization is the global trend in agriculture, integrated farming systems have emerged in the Mekong Delta of Vietnam during the last two decades. An important motive was the desire to improve the livelihoods, the diet of the nuclear families and to adapt to environmental change. Integrated farming systems are often considered equal to extensive or low-input farming systems and to sustainable agriculture, but usually receives low incomes. The transformation of the farming systems from an extensive, low-input system into an intensive, industry farming system associated with changes in government policy, production technologies and environmental changes. Recently agriculture in Southeast Asia, especially in the Mekong Delta of Vietnam is vulnerable to climate change. Therefore, adaptation measures are required to sustain agricultural productivity, to reduce vulnerability, and to enhance the resilience of the agricultural system to climate change. There are many adaptation practices in the production systems to reduce the effects of climate change. Some farming systems and government policy toward agriculture contributes to adaptation to environmental changes.
This paper focusses on two issues. The first issue presents a systematic review of the historical development of the predominant production systems under environmental changes in the Mekong Delta with major characteristics, performance, perspectives and with reference to other Southeast Asian countries. In the second one, as climate change has already begun, adaptation or the modification of farming practices and production to be discussed – and also the major options in the agricultural sector for adaptation to climate change.