

Predicting rice productivity under future climates

Toshihiro Hasegawa, NIAES, Japan

The projected increase of atmospheric carbon dioxide (CO₂) and climate change will have significant impacts on future agricultural productivity. The elevated atmospheric CO₂ will promote growth and yield of rice. The primary effect of elevated CO₂ concentration ([CO₂]) on crop productivity is enhancement of photosynthesis, which has been well studied for many years using various experimental facilities. The magnitude of the enhancement reported depends on experimental conditions as well as other environmental and/or management factors. Among various experimental facilities that have been used in elevated CO₂ studies, free-air CO₂ enrichment (FACE) systems, which do not have enclosures and therefore a minimum of artifacts, are usually regarded as providing the best estimates of yield responses to elevated [CO₂] in the open field. Across all species, fewer FACE than chamber experiments have been conducted, though the rice FACE system has been running at two sites (Japan and China) for more than four years. Many data have been accumulated, leading to reviews of the yield responses of a range of plant species to FACE. To expand on these reviews, this paper summarizes the FACE effects on photosynthesis, biomass, and yield of rice in order to examine the magnitude of the growth and yield enhancement in comparison with those of other C₃ species responses. Warmer climates, on the other hand, can reduce crop yield: Higher temperatures will shorten crop growth duration that will limit the biomass production. Heat and water stresses are more likely to occur under warmer climates in the future: This can lead to severe damages on the reproductive organs that are generally of significant importance for economic yield. There are still large uncertainties as to whether biotic stresses increase under future climates. The net change of the crop productivity will depend on the extents of these counteracting effects of future climates, and the magnitude and even the direction of the change will be subject to an uncertainty due to the lack of our capability to predict the respective and interactive effects. Recently, attempts have been made to reduce some of these uncertainties and I present here some interactive effects of elevated [CO₂] and stress factors on rice growth and yield based on findings obtained under FACE experiments.