Research on Impact Assessment of Combined Effect of Ozone and Temperature on Rice Production in Asian Countries and Developing Sustainable Cultivation Technologies

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[Abstract]

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Total of 60 varieties of rice plants (*Oryza sativa* L.) were exposed to ozone for whole cultivation period in 2008 to 2010 under ambient or a warming condition using open top chambers. Most of *japonica* varieties were more tolerant to ozone-induced yield loss than *indica* ones. Grain production in Asian countries estimated by the mean yield response curve in *indica* varieties potentially reduced about 7.7% in 2005. If anthropogenic NOx emission in this area will increase 50% more in 2005, it will suggest 9.9% reduction.

Gas production *in vitro* digestion system in cow was inhibited in the high ozone dose received rice straw. Lignin and phenolics as well as protein content increased in the straw exposed to high level of ozone. This suggested ozone exposure reduced straw quality for animal feeding resources.

Limiting the duration of ozone-exposure to identify the most effective period of ozone exposure on yield loss suggested that ozone exposure from the late vegetative growth period to early reproductive stage could show larger yield reduction rather than that for the vegetative or grain maturing stage.

We have identified many molecular markers to evaluate sensitivity of rice cultivars to high temperature and/or ozone by DNA microarray analysis of gene expression and some metabolite determination in rice seedlings, panicles, and seeds of several cultivars. Various gene expression markers associated with visible injury were found in rice seedlings exposed to ozone. The difference in accumulated amount of sakuranetin by ozone between ozone tolerant and sensitive cultivars was suitable for evaluation of the ozone sensitivity. A novel method to select tolerant rice cultivars against high temperature and/or ozone by using gene expression markers selected

based on correlation with effects on yield, biomass, grain sterility, or quality was developed.

To develop a diagnostic DNA array to detect ozone stress in *Arabidopsis* or rice, handmade DNA arrays that consisted of *Arabidopsis* or rice marker genes were applied to plants grown in the field at normal or elevated temperature conditions. The results indicated that the diagnostic DNA array can be applicable in plants grown in the outdoor condition and detect acute or chronic ozone stress. Furthermore, we have developed the rice stress diagnostic DNA array successfully.

We have identified the *APOI* gene involved in yield-loss caused by ozone by QTL analysis. The results indicate that ozone-induced reduction in grain yield in ‘Habataki’ occurs as a consequence of reduction in the primary rachis number and the total spikelet number by suppression of the *APOI* gene by ozone.