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Ozone Pollution and Rice Production in Asia: Significance, Physiological Response of Rice and Development of Tolerant Genotypes

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Abstract

Surface ozone concentrations have been rising in many Asian countries in recent years due to environmental pollution accompanying economic development. Ozone is an air pollutant that is formed in the earth's troposphere as a consequence of photochemical reactions of precursor gases such as nitrous oxides or volatile organic compounds. Ozone causes visible leaf damage ("bronzing") and negatively affects plant growth by hampering photosynthesis. Rice yield reductions up to 15 percent due to ozone pollution have been estimated in areas where ozone level exceeds 80 ppb, which is frequently the case in India and China. A powerful strategy to prevent such yield losses is the development of tolerant rice varieties. We therefore aim to identify genetic factors associated with ozone tolerance in rice, and to understand the underlying physiological mechanisms. We carried out experiments using three week old rice seedlings and exposing them to 100 ppb ozone for 14 days. Dry weight development and visible leaf damage (leaf bronzing) were used as tolerance indicators. We assessed genotypic differences for tolerance to elevated ozone, and identified quantitative trait loci (QTL) in a mapping population derived from contrasting parents Kasalath (a tolerant *Indica* landrace) and Nipponbare (an intolerant modern *Japonica* variety). The effects of QTLs were confirmed using chromosome segment substitution lines. This approach yielded three conclusive QTLs: two QTLs were associated with leaf bronzing and one with dry weight. We then carried out experiments with substitution lines aimed at identifying the physiological basis underlying these QTLs. Results suggested that leaf bronzing was strongly associated with the ascorbic acid status, whereas dry weight reductions were related to photosynthetic carbon assimilation. In ongoing experiments we now intend to obtain a more detailed understanding of the physiological processes underlying tolerance QTLs. We investigate whether photosynthesis under ozone stress is limited by stomatal regulation or by biochemical limitations such as Rubisco activity, and whether contrasting genotypes differ in this regard. The potential application of these results for the development of ozone tolerant rice varieties and its contribution to food security in Asia will be discussed.

Keywords: Genetic resources, oxidative stress, ozone, photosynthesis, QTL, rice

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