Evaluation of environmental stress on roadside trees in Kyoto city using stable carbon isotope ratio

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Roadside trees have many important roles and functions such as absorption / trapping of air pollutants, preventing heat reflections of the road surface by the formation of tree canopy, and as a result, prevention of temperature rising in urban area in summer. The increase in air pollutants and atmospheric temperature by industrialization and urbanization are serious enviromental problems in Japan as well as in other industriarized and developping countries, and thus, the roles of roadside trees such as alleviating urban warming and reducing air pollutants are very important in these countries. However, many roadside trees seem to "reducing activity", e.g., fallen leaves and increased numbers of dead branches, in the summer. Our previous studies showed that the influence of air pollutants (Kume et al. 2006), as well as a combination of environmental stresses caused by soil and air drought, which are affected by urban warming, reduced photosynthetic capacity in roadside trees (Kagotani et al. 2013). However, it is difficult to evaluate the decline of the physiological activity of roadside trees from their appearance, because photosynthetic capacity often declines during the summer without any changes in their appearance. In addition, significant interspecific differences were found in the decline of photosynthetic capacity in the summer, which was about 50% decrease in *Prunus yedoensis*, contrasting the no decrease in *Ginkgo biloba* (Hanba et al. 2010). However, genetic and physiological factors inducing such interspecific differences in reduction in photosynthetic capacity have not been clarified.
In order to maximize the functions of roadside trees mitigating the high temperature of summer, it is essential to suppress "decline of activity in summer" due to combined environmental stress including air pollution and drought. In order to evaluate the activity of roadside trees, the "4 rank evaluation method" which evalluate the activity by their appearance has been widely performed (Science and Technology Agency Resource Research Committee). However, in this method, it is not possible to evaluate the roadside trees that only the physiological activity is declining. If we can distinguish the influence of environmental stress before its effect appears on their appearance, we can take measures to improve activity of roadside trees by appropriate management. Previous studies showed that stomatal closure occurs at the earliest stage among a series of reactions in response to environmental stress such as air pollution and drought stress. Since the carbon stable isotopic ratio (δ^{13}C) of the photosynthetic product in the leaf reflects the averaged stomatal pore opening, it is widely used for stress determination of natural plants. Although there is a possibility that it can be applied to plants in urban areas, there are only a couple of applications in urban areas, because there are no established methods for correcting the influence of atmospheric δ^{13}C of fossil fuels on leaf δ^{13}C (Wang et Al. 2011).
We used δ^{13}C of roadside tree leaves for major roadside trees to determine the environmental stresses on the roadside trees through stomatal closure in urban areas in Kyoto City. We focus on environmental stress such as (1) drought stress and (2) air pollutants. We performed drought experiment for major roadside trees to investigate their physiological responses. We also performed environmental monitoring and measurement of physiological functions of roadside trees in Kyoto city. The main results obtained so far are as follows. (1) In response to artificial soil drought, remarkable differences were found in physiological functions among species of roadside trees. Specifically, some species sensitively closed stomatal pores in response to drought and maintaining water content in plants, but the other species maintained photosynthetic function by stomatal closure in response to drought. In addition, one month'

drought did not affect $\delta^{13}C$ of leaves of roadside trees. (2) We selected some study sites with different air pollutant levels in Kyoto city, and the physiological functions and $\delta^{13}C$ of *Ginkgo biloba* and *Rhododendron* x *pulchrum* were examined. As a result, no difference was found between the study sites in both tomatal pore opening and leaf $\delta^{13}C$ for the tall tree *G. bilova*, but for the shrubs *R. pulchrum*, the stomata tended to close in the study site where the air pollutant level was high, with the high values of $\delta^{13}C$ in leaves. These results suggested that evaluation of the effect of long - term environmental stress on roaadside trees is possible using $\delta^{13}C$ of leaves at the site where roadside trees are being planted.

Keywords: Stable carbon isotope ratio, Photosynthesis, Stomata, Atmospheric polllutant

