学 位 論 文 要 旨

Combined effects of hydrogen peroxide and ozone on growth and physiological functions of soybean plants
ダイズの生長および生理に対する過酸化水素とオゾンの複合影響

環境資源共生科学専攻 環境保全学大講座
CATTLEYA CHUTTEANG

Crop response to future air pollution stress is important information for crop production in the future. Ozone (O_3) and peroxides are recognized as significantly damaging air pollutants to plants. Presently information on ambient peroxides both hydrogen peroxide (H_2O_2) and organic peroxide concentrations is limited not only in Thailand and South East Asia but also in Japan. The objectives of the present study were to accumulate data of H_2O_2 concentration in Tokyo and Thailand for understanding annual and seasonal characteristics of ambient H_2O_2 in Japan and Thailand, and to investigate the effect of single O_3 and combined O_3 and peroxides on physiological responses and growth of two Japanese and two Thai soybean cultivars.

Hydrogen peroxide concentrations were measured in Tokyo University of Agriculture and Technology, Fuchu, Tokyo, Japan (lat. 35.7 ^{o}N long. 139.5 ^{o}E), Kasesart University, Kamphaeng Saen, Nakhon Pathom (lat. 14.0 ^{o}N long. 100.0 ^{o}E) and Mae-On, Chiang Mai (lat. 18.8 ^{o}N long. 99.2 ^{o}E), Thailand in 2009, 2010 and 2011. During the measurement periods, the monthly average H_2O_2 concentration in Tokyo ranged from lower than detection limited to 2.2 ppbv, and showed lower values in May, June and November 2010 and become zero in January to May 2011. In Chiang Mai, the monthly average H_2O_2 concentration was slightly higher than that of Tokyo, ranging from 1.2 to 3.1 ppbv. The monthly average H_2O_2 concentrations in Nakhon Pathom were three to four times higher than those of Tokyo and Chiang Mai in the same period except March to July 2011. The diurnal characteristics of H_2O_2 concentrations from October to December 2009 at Tokyo and Chiang Mai were similar and high around noon and low in the morning and late afternoon. Nevertheless, the pattern

of diurnal characteristics in 2010 at Chiang Mai was high in the morning and gradually decreased in the afternoon and it was different from Tokyo. In the case of Nakhon Pathom, the variation was high each time. Thus, the diurnal characteristics varied from place to place and year to year. A positive correlation between atmospheric H_2O_2 and O_3, and air temperature in Tokyo was found. The monthly average levels of H_2O_2 concentration in Nakhon Pathom measurement site ranged from 2 to 10 ppbv in 2010 and 2011, and these concentrations reach the levels that are harmful to soybean plants when combined with O_3 of 50 ppbv or higher.

The study of effects of peroxides and O_3 on physiological responses and growth of four soybean cultivars was conducted at Tokyo University of Agriculture and Technology, Fuchu, Tokyo. Two Japanese soybean cultivars, Tachinagaha (TC), and Chamame (CM) and two Thai soybeans, A75 and Sorjor 5 (SJ5) were selected as plant materials. Four treatment plots were set up; those are a control plot (C plot: free of O_3 and peroxides), O_3 50 ppbv (O plot), O_3 50 ppbv and peroxides 2-3 ppbv (OP1 plot) and O_3 50 ppbv and peroxides 4-5 ppbv (OP2 plot). We found that combined O_3 and 4-5 ppbv of peroxides (OP2 plot) caused severer damage than the OP1 plot and single O_3 (O plot) to leaf injury, chlorophyll content and photosynthetic rate, and reduced total dry weight and pod dry weight. The net photosynthetic rate (A) in OP plots was reduced by both low stomatal conductance (gs) and high CO_2 concentration in intercellular space (Ci). While A in O plot was reduced by the low gs only. In combined O_3 and peroxides exposure, SJ5 was the most sensitive cultivar in leaf injury, photosynthetic rate, biomass and pod dry weight, while CM showed less sensitivity for photosynthetic rate and pod dry weight. In addition, the sensitive soybean cultivar (SJ5) showed the highest gs in C, O, and OP1 plots while the tolerant cultivar (CM) show the lowest gs in O, and OP1 plots on 10 days after exposure.