Effect of Haze and Urban Atmospheric Pollutants on Agricultural Crops and Forest Species

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Introduction

Forest clearing fires are among the most primitive processes to prepare the land for cultivation (Carvalho et al., 1995) and it is still implemented by a lot of local farmers. The suspended particulate matter produced scatters and absorbs incoming solar radiation, reducing the amount of sunlight that reaches the surface. Moreover, combustion of vegetation is never completely efficient and in addition to water and carbon dioxide, varying amounts of CO, CH_4, H_2O, hydrocarbons, particulates, etc., are produced (Cofer III et al., 1997). The products of these burning processes were to represent the major components of haze, which occurred in Malaysia. Forest fire in Sumatera, Kalimantan and local emissions have been proved as the main sources of particulate matter which were the most significant pollutants that contributed to the degradation of air quality and reducing visibility and health. During the haze episode, several reports have indicated that biomass burning was the dominating source of particulate matter. Biomass burning is recognized as a significant source of emission on a global basis, produces a wide range of trace gases including CO, CO_2, CH_4, NMHC, NOx, N_2O, CH_3Cl and CH_3Br and various particulate into the atmosphere (Fang *et al.*, 1999). Several studies were carried out under this project between 1998 to 2001. The main objective of the studies is to determine the effects of haze and atmospheric pollutants on growth response of selected agro-forest species. The experiments also provided some information about the physiological mechanism involve in determining the growth reduction in those selected species with special emphasis on haze and light extinction. Seedling of agriculture crops and forest species were established in the growth chambers and subjected to atmospheric pollutants accordingly. The plants that were selected in this study including rice, *Shorea leprosula* (meranti tembaga), *Shorea ovalis* (meranti kepong), *Mallotus paniculatus, Macaranga triloba* and ornamental plant species. Changes in growth, yield and other physiological parameters were monitored and analyzed for the plants that exposed to simulated air pollutants and normal ambient condition as control.

Materials and Methods

The study was conducted on the rooftop of Department of Environmental Science Building, Universiti Putra Malaysia (UPM) at Serdang. The closed fumigation chamber used in this study was 0.91m in length, 0.76m in width and 0.91m in height. The chamber was made of perpex with wooden base and iron framework. First experiment was aimed to determine the direct effects of elevated CO_2 and O_3 enhancement on physiological aspects and growth performances of rice. The seedling rice (*Oryza sativa*) of Malaysian cultivar (MR221) were exposed to four types of treatments namely 350 ppm CO_2 and 10 ppb O_3 conditions, 660 ppm CO_2 and 10 ppb O_3, and 350 ppm CO_2 and 33 ppb O_3. In another experiment, rice straw (*Oryza sativa* L.) and lalang (*Imperata cylindrica*) were burned to simulate the burning of biomass. Malaysian rice cultivars MR1 and MR211 were exposed to the product of this biomass burning. The rice seedlings were grown in a closed fumigation chamber, where they were exposed to the product of rice straw and lalang burning, respectively. Three selected ornamental plant species namely *Catharanthus roseus (Linnaeus), Impatiens balsamina* and *Crinum X 'Cape Dawn'* were exposed to 1 ppm, 3 ppm and 5 ppm SO_2 in fumigation chamber (Abdullah et al., 2000). Four parameters were evaluated or measured for the purpose to determine the effects of SO_2 on the three selected ornamental plant species. The parameters were leaf injury index, fluorescence signals, leaf area ratio and plant height. In this study, the air temperature and relative humidity inside the close fumigation chamber and the ambient air were monitored manually by using the thermohumid sensor (Thermic Model 2100A, Eto-Denki, Japan). The sensor was located at the center of the chamber to monitor the microclimate condition inside the chamber and at the center between the fumigation chamber and the ambient site to monitor the microclimate condition for ambient air. Photon flux density (PFD) was measured inside the fumigation chamber and ambient by using quantum sensors (LI-190SA, Li-Cor Inc., Lincoln NE) manually.

Results and Discussion

A progressive stimulation in photosynthesis of seedlings exposed to elevated CO_2, indicates by doubling of P_{max} (Abdullah, et al., 1999). There were no consistent effects of ozone on plant height and tillering, which differ from other related studies. Seedling grown under ambient condition indicated the photosynthetic light saturation was at about 700 $\mu mol\ m^{-2} s^{-1}$ of PFD, while P_g for both elevated CO_2 and O_3 treatments began to saturate at about 400 $\mu mol\ m^{-2} s^{-1}$ of PFD. The photosynthetic capacity of Malaysian rice (MR 221) treated with elevated CO_2 was 10 $\mu mol\ m^{-2} s^{-1}$ as compared to the value of photosynthetic capacity under ambient condition, which was 6.0 $\mu mol\ m^{-2} s^{-1}$ only. The results indicated that under elevated CO_2 the dry weight of seedlings exposed to 700 ppm CO_2 was greater by 22 % than the control seedlings exposed to about 300 ppm CO_2 after 80 DAP, while the dry weight decreased in seedlings exposed to O_3. Although the biomass burning produced higher amount of H_2S but it showed insignificant difference ($P>0.05$) between treatments for gases concentration. The enhancement of CO_2 increased the plant heights, number of tiller, relative growth rate for (dry weight) whole plants, roots, leaf and stem. Chlorophyll content for lalang burning was higher by 10.9%, 10.7% for cultivar MR1 and MR211, respectively, as compared to rice straw burning. The lalang burning stimulate the growth rate of rice seedlings more than the rice straw burning. Chlorophyll fluorescence indicated that the photosynthetic rate of these cultivars increased after the biomass exposure. Scanning Electron Microscope (SEM) pictures showed the trapped particles were attached to each other (without boundary between adjacent particles) and had affected the closure of stomata on the leaves. This suggested that the biomass particles were liquid droplets. The effects on the tropical forest and pioneer species were including leaf injuries, depression of net photosynthesis, and decline in relative growth rate in terms of height, leaf area and dry weight. The leaf injuries included interval bleaching for matured leaves and red-brown discoloration for young leaves. Scanning Electron Microscope (SEM) pictures showed the trapped particles were attached to each other and had affected the closure of stomata on the leaves. Moreover, it reduced the absorption of carbon dioxide form the atmosphere and the intensity of sunlight reaching the interior of the leaf, and suppressing growth of the plants. Thus, the chronic injury appeared as a bleaching of the chlorophyll reveals the presence of red, brown or black pigments or yellowing of the leaf in these species plants. Consequently, it caused the reduction of growth performance and yield. The effects of SO_2 on ornamental plant species included leaf injury, depression of net photosynthesis and decline in height growth rate. *Catharanthus roseus (Linnaeus)* and *Impatiens balsamina* developed typical visible symptoms of injury when exposed to 1 ppm, 3 ppm and 5 ppm SO_2. However, *Crinum X 'Cape Dawn'* did not show any visible injury for 1 ppm, 3 ppm and 5 ppm SO_2 treatment. The leaf injury of *Catharanthus roseus (Linnaeus)* and *Impatiens balsamina* included interval bleaching (white) for matured leaves and red-brown discoloration for young leaves. As the treatment continued, the necrosis effect appeared on some leaves. The leaf injury symptoms could be clearly observed on the first, second and fourth day after exposure (DAE) for 5, 3 and 1 ppm treatment, respectively. *Impatiens balsamina* found to be most sensitive to SO_2 compared to *Catharanthus roseus (Linnaeus)* and *Crinum X 'Cape Dawn'*. *Crinum X 'Cape Dawn'* was the most resistant among the three species. It did not show any effects on leaf injury index, F_V/F_M ratio, leaf area ratio and relative growth rate of height for all of the treatment. *Impatiens balsamina* found to be the most sensitive plant to SO_2 compared to *Catharanthus roseus (Linnaeus)* and *Crinum X 'Cape Dawn'*.

Conclusions

It can be concluded that a doubling in the ambient CO_2 concentration leads to almost a doubling of gross photosynthetic rate at saturating light (10 µmol $m^{-2} s^{-1}$). The results of this study confirmed that increased photosynthetic rate stimulate plant growth in terms of biomass accumulation. For O_3 treatment, higher photosynthetic rate did not cause greater biomass production. It is because the increases in substrates have been used for detoxification and repair processes. Malaysia rice cultivars (MR1 and MR211), which was exposed to the product of *lalang* burning showed higher photosynthesis efficiency and growth rate increment as compared to rice straw burning. Scanning Electron Microscope (SEM) photographs showed that the liquid droplets of the simulated haze had physically clogged the stomata opening and caused impeding normal gas exchange. Resolutely, long-term exposure to high SPM concentration may inhibit the growth and physiological performance of the tropical forest species and agricultural crops. In conclusion, *Impatiens balsamina* and *Catharanthus roseus (Linnaeus)* were more suitable to be established as indicator plant to SO_2.

Benefits from the study

The effects of haze and atmospheric pollutants on growth response of selected agro-forest species were determined. The study also provided qualitative understanding of the relationship between haze and ozone concentration and their impact on forest and agriculture species. The findings had been presented in seminar, proceedings, conferences and in journals.

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