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Alteration of Antioxidant and Pigment of Landscape Plants as an Urban Air Quality Monitoring

Pangesti Nugrahani, Sukendah and Purnomo Edi Sasongko
Departemen of Agrotechnology, Faculty of Agriculture, UPN,
Veteran Jawa Timur, Surabaya, Indonesia

Abstract: This study was conducted to obtain information on the alteration of some ornamental landscape plants antioxidants (ascorbic acid) and pigments (chlorophyll and carotenoid), caused by urban air pollution. Analysis of leaf pigments (chlorophyll and carotenoids) performed by spectrophotometric method and ascorbic acid content was analysed by DCPIP titration methods. Data were analyzed using analysis of variance. Levels of chlorophyll a, chlorophyll b and total chlorophyll of plants located in the motor vehicle emission pollution area, reduced by 40% compared with plants grown in a pollution free area. Carotenoid levels also decreased by 3%. There are no statistically significant changes in the levels of leaves ascorbic acid of plants growing in polluted area. This parameter can not be used as indicators of air pollution. The design of air quality monitoring sensor system can be integrated with changes in levels of leaf pigments: chlorophyll a, chlorophyll b and total chlorophyll.

Key words: Antioxidant, pigment, landscape, air pollution, monitoring, chlorophyll

INTRODUCTION

Air pollution is being the most important things of the severe problems world facing today. The impact of such anthropogenic is responsible for variety human diseases and the plant community. Air pollutants cause environmental stress for plants and can change leaf structure, physiology or biochemistry. Since, the plant's organs are exposed to the atmosphere and the leaves continuously exchange gases, a pollutant is reflected on the plant health. These plants can be effectively used as bioindicators for urban air quality monitoring. Landscape plants in the city are recognized as a design element of streetscape, furthermore they may play a role as a beautification agent as well bioindicators.gh.

Monitoring of urban air pollution using plants has several advantages over conventional physico-chemical monitoring. Ultrastructural responses of leaf surface have been successfully used as bioindicators since leaf cuticles and epidermis are the first part of the plant to be exposed to air pollutants. The initial stages of responses involve damage in cell membranes, changes in enzymatic processes and subsequent deviations in cell structures and metabolism. Reduction in growth of vascular species by air pollution is preceded by changes in physiological processes, inhibition of photosynthesis and alteration in chlorophyll content (Joshi and Swami, 2009).

Plants respond to the presence of air pollution by some form of response such as injury or changes in the leaf. These changes often cause a variety of invisible and visible symptoms at leaf level. The changes observed in the leaf surface structures, epidermal features, enzymatic processes and deviations in cell structures and metabolism of plants at polluted area in comparison to healthy ones were modifiable traits which may serve as useful indicators/monitors of air pollution.

Various changes induced by air pollutants in plants with respect to morphological, anatomical and physiological characteristics have been recorded (Tripathi and Gautam, 2007). At the beginning of the stress, the plant responds by a decline of one or several physiological functions such as the photosynthetic performance, transport of metabolites, uptake and translocations of ions.

Abiotic stress factors such as air pollutions are external signals that are sensed by plant functional receptors. The signal transduction within a plant cell leads to induced metabolic responses, activation of gene expression, enzyme formation, synthesis of stress proteins, stress metabolites and stress hormones during the first response phase (Taylor, 1978). As already mentioned, that photosynthetic performance declines at the beginning phase of stress. Furthermore, plant stress considerably changes the chemical and photosynthetic

Corresponding Author: Pangesti Nugrahani, Departemen of Agrotechnology, Faculty of Agriculture, UPN, Veteran Jawa Timur, Surabaya, Indonesia

pigments of plant leaves (chlorophyll a, chlorophyll b and carotenoids) were reported (Govindaraju *et al*., 2010; Chauhan, 2010a, b; Rohacek *et al*., 2008).

The contaminants accumulated in the plants trigger the stress on the plants. In general factors that impose stress on plants tend to trigger a plant's innate defense mechanism to cope up with the stress. A wide range of protective mechanisms exist in plants which involve non-enzymic antioxidants and enzymic antioxidants. The non-enzymatic defense includes Vitamin-E, C and A, glutathione, carotenes and ubiquinol (Manno *et al*., 2010). The increase in antioxidant enzymes proves the plants efficacy to overcome the pollutants stress (Rajalakshmi *et al*., 2011). Ascorbic acid, a natural antioxidant in plants has been shown to play an important role in pollution tolerance (Joshi and Swami, 2009).

To maintain its functional and structural integrity, a plant organism has to be resistant towards unfavorable factors. Each organism has a unique range of genetically deter-mined and phylo-genetically adapted physiological resistance within which a factor affecting it is tolerable. If a stress factor surpasses this range the plant has to trigger additional energy and physiological-biochemical mechanisms to survive under un-favorable conditions (Mandre, 2002).

Visible and invisible symptoms are responses to alterations of plants physiological functions and metabolic disorders. In case of plant's invisible symtoms, nowadays researchers have developed techniques to measure the symptoms that presented in plants. It involved management information technology by internet and computerized.

This research was done to provide information of the air pollution impact on plants to complete the data obtained by physical and chemical analysis. The data would be prepared to support such a prototype that could be employed in future works as a practical and powerful tool to give, through observation of symptoms on plants, a precise and reliable quantitative description for investigate disorder on biochemicals process of plants growing on polluted sites.

MATERIALS AND METHODS

The study was conducted in Surabaya City, Indonesia. Landscape plant species selected based on the smallest Air Pollution Tolerance Index (APTI) (Nugrahani, 2008). These are *Mussaendah philippica* (Nugrahani, 2008; Verma *et al*., 2006; Akosy and Ozturk, 1997; Culotta *et al*., 2005; Meletiou-Christou *et al*., 2011) and *Ipomoe* sp. (Verma *et al*., 2006). Plant samples were randomly assigned on the outer side at each location. Leaf samples were taken from each sample leaf plant is located in the middle (stems). Leaf sampling was repeated three times, each about 100 g.

Three monitoring stations covering heavy traffic roads, fairly dense traffic road and nursery areas as site control is: Station 1: Ahmad Yani street-Mayangkara fly-over; Station 2: Ir. Sukarno road median MERR; Station 3. Wonorejo Nurseries.

Estimation of total chlorophyll, carotenoids and total ascorbic acid was analyzed according to the method chosen. Total chlorophyll and carotenoid content will be measured in accordance with Chouhan (2010a) that has been adapted from AOAC method. Samples were analyzed with the help of a spectrophotometer. Absorbance is read at 645-663 nm for chlorophyll, 480, 645 and 663 nm for carotenoids. The concentration of chlorophyll and carotenoid absorption coefficient were calculated by Arnon equation (Hendry and Grime, 1993). Tests carried out with ascorbic acid DCPIP titration method (Sadasivam and Manickam, 1992; Kumar *et al*., 2012). Ascorbic acid content calculated on the basis of the theory that ascorbic acid can eliminate the blue color of DCPIP solution. Statistical analysis of data was performed using ANOVA with SPSS (Ver. 16.0, SPSS). The difference compared to the same species between areas contaminated by the control region.

RESULTS AND DISCUSSION

Testing on alteration of leaf pigments and antioxidants: Leaf pigments were tested in this study was the levels of chlorophyll a, chlorophyll b, total chlorophyll and carotenoid of the samples. Plant samples have grown on area 1-3 with different traffic load. Figure 1 showed average contents of chlorophyll and carotenoids (mg/g) of Mussaenda, Oleander and Ipomoea at the different site area (Site 1-3). Notation letters indicate differences in the value of the Tukey HSD test ($p = 0.05$).

There were differently chlorophyll a, chlorophyll b and total chlorophyll average content of the three plants in control area compared to these one in the polluted area. The decrease in average levels of chlorophyll a, chlorophyll b, total chlorophyll and carotenoid between polluted and control areas respectively were 44.42, 41.75, 43.25 and 3.28%.

Analysis of variance leaf pigment content of each plant species showed significantly differences by Tukey HSD test ($p = 0.05$). Chlorophyll a and total chlorophyll on Oleander were different with Ipomoea. Plant chlorophyll a. Likewise, the levels of total chlorophyll and carotenoid levels. However, the levels of chlorophyll b third plant species did not differ significantly (Fig. 2). Figure 2 is

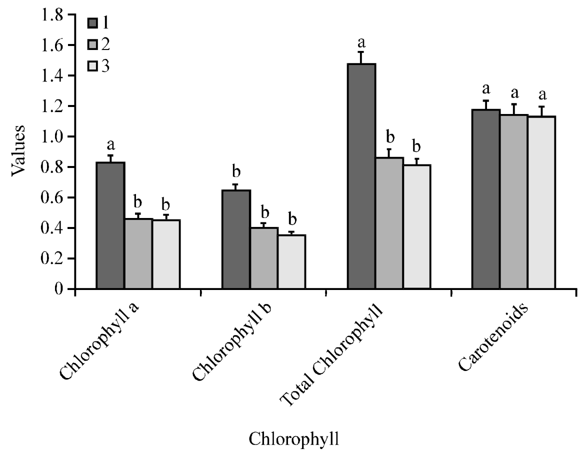

Fig. 1: Chlorophyll a, chlorophyll b, total chlorophyll and carotenoids content of the plants growing up on unpolluted site (1) and polluted site (2 and 3)

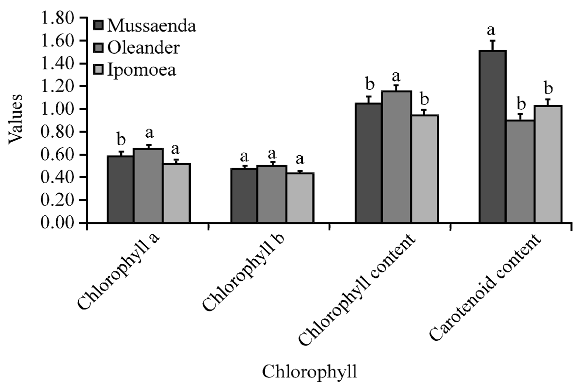

Fig. 2: Chlorophyll a, chlorophyll b, chlorophyll total and carotenoids of three different species

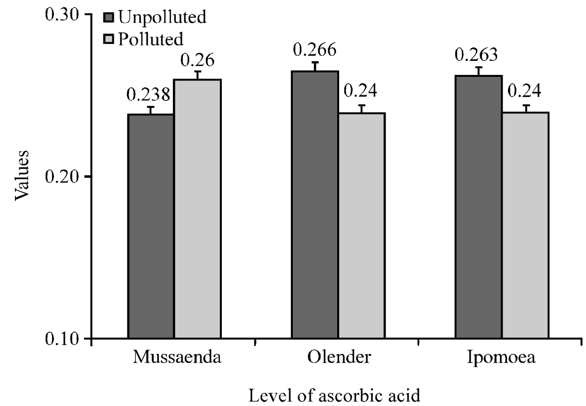

Fig. 3: Levels of ascorbic acid plants at two different locations

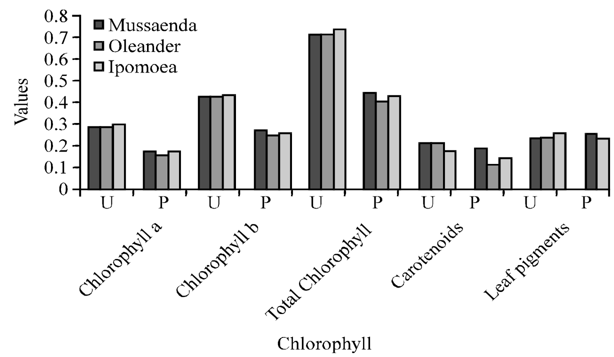

Fig. 4: Leaf pigments and ascorbic on three species of ornamental plant models

presented the average results testing on leaf pigments plant species. Oleander's chlorophyll a levels was higher ($p = 0.05$), than Ipomoea was as well as total chlorophyll content. Chlorophyll b content of the three species of plants showed no difference. Mussaenda plant carotenoid levels was higher ($p = 0.05$) than those of Ipomoea and Oleander. The ascorbic acid content of Mussaenda grown in the region without pollution was higher than ascorbic content of plants grown in polluted areas (Fig. 3 and 4).

Based on statistical analysis of test results ascorbic acid content of leaves, it is known that ascorbic acid levels third leaf plant species showed no significant difference (p = 0:05). Similarly, levels of ascorbic acid in plants without pollution and polluted locations. Figure 3 showed the testing result of leaf pigments and ascorbic acid in the leaves of three species of plants growing at the polluted and unpolluted locations. Leaf pigment levels observed in this study include the levels of chlorophyll a, chlorophyll b, chlorophyll total and carotenoid levels. Figure 1 shows that the levels of chlorophyll a, chlorophyll b and total chlorophyll of leaves decreased significantly ($p = 0.05$). The decrease in leaf chlorophyll content of the plants in the control area were reaching >40%. Chlorophyll is the main photosynthetic pigment for plants. Air pollutants entered into the leaf tissue caused some changes in leaf chlorophyll content. Material of air pollution is one of the environmental stressors on plants. Changes in leaf chlorophyll content, a parameter that has long been studied as an indicator of environmental stress due to air pollutants (Taylor, 1978). Some plants showed a decrease in chlorophyll content as a result of exposure to air pollutants (Meletiou-Christou *et al*., 2011). But on the other hand is also reported that there are some plants that have elevated levels of chlorophyll as a result of exposure to air pollutants. *Azadirachta indica*, *Mangifera indica* and *Cassia fistula*, *Pongamia pinnata, Saraca indica*, *Bauhinia variegata* (Tripathi and Gautam,

2009) is a plant which reported an increase in chlorophyll content in the polluted area. Agbaire and Esiefarienrhe (2009) also proved that plants growing in polluted areas have higher chlorophyll content. Likewise Seyyednejad and Koochak (2010), mentions that *Albizia lebbeck* and *Callistemon citrinus* growing in polluted areas have higher total chlorophyll than those grown in areas where the air is clean. Variations in leaf chlorophyll content as a result of exposure to air pollutants by Cui *et al*. (2006) is very specific depending on the characteristics of the species. Photosynthetic pigment levels were not statistically increased but support the stability of plant assimilation (Cuit *et al*., 2006). Testing of plant chlorophyll content provides information about the physiological status of the plant which is very useful in the study of agriculture and ecosystems as related to levels of nitrogen and in the process of photosynthesis (Serrano, 2008). Although, all three plant models in this study showed a decrease in chlorophyll content significantly (Fig. 1), research keeping in view of the magnitude of alteration or change in the levels of chlorophyll, the plants growing in polluted areas with air pollution free zone. Alteration, chlorophyll content integrated with sensor systems that can provide information more quickly, accurately and efficiently. Until now, research on changes in leaf chlorophyll content as a result of exposure to air pollutants, still remain to be done in order to establish a better system fitomonitoring (Meletiou-Christou *et al*., 2011).

The changes of antioxidant level (ascorbic acid) in this study showed no significant value, both between species and between locations. Ascorbic acid is a compound that is easily oxidized and dissolved in water. Changes in ascorbic acid content of the leaves of plants in polluted locations and not affected by the pollution varies according to the season (seasonal). At the time of this study (May-August), the rain fall in Surabaya is quite high. Anticipated weather conditions affect the levels of ascorbic acid enough leaves. Changes in ascorbic acid levels in this study can not be used as a source of differentiation or indicators of air pollution.

CONCLUSION

Changes in leaf pigment levels as a form of plant response to the presence of air pollutant gases can be used as bio-indicators of air quality. Chlorophyll a, chlorophyll b and total chlorophyll content of plants located in polluted area, decreased by 40% compared with those one grown in unpolluted area. The carotenoid levels of also decreased by 3%. Changes in the levels of antioxidants ascorbic acid in the leaves of plants growing in polluted area were not statistically significant. This parameter can not be used as indicators of air pollution. The design of air quality monitoring sensor system can be integrated with changes in levels of leaf pigments: chlorophyll a, chlorophyll b and total chlorophyll.

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