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EFFECTS OF AUTOMOBILE POLLUTION ON THE PHENOLOGY AND PERIODICITY OF SOME ROADSIDE PLANTS

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Abstract

The phenology of *Alstonia scholaris* and *Pongamia pinnata* was significantly ($p<0.05$) affected in the Karachi city polluted environment. Plants were highly affected by pollutants at Gulshan-e-Iqbal, Nazimabad, Shahrah-e-Faisal and M.A. Jinnah Road as compared to Karachi University Campus. Leaf length, width and area of *A. scholaris* were found lowest in July-September at M.A. Jinnah Road as compared to Shahrah-e-Faisal, Nazimabad, Gulshan-e-Iqbal and Karachi University Campus, respectively. Leaf length, width and area of *P. pinnata* were significantly ($p<0.05$) reduced in January-March at the highly polluted sites of M.A. Jinnah Road as compared to Karachi University Campus. In this study, *A. scholaris* was comparatively less affected to automobile pollution of the city as compared to *P. pinnata*. It is, therefore, suggested that *A. scholaris* should be given more preference for future plantation in the city areas, particularly along the roads.

Introduction

Karachi city, the 25th largest city of the world, with a population of 10 million demands a large transport system for carrying people and goods from one place to another. The buses and minibuses are the primary modes of conveyance, which carry an estimated 70 % of the passenger traffic. According to Karachi Traffic Engineering Bureau, the total number of all types of motor vehicles on the roads of Karachi were estimated to be 930,000 in 1997, which amounts to over 30 % of all the vehicles in the country (Ghauri *et al.*, 1999). Whereas according to the Excise and Taxation Department of the Government of Pakistan, the number of registered vehicles in Karachi, during the period 1987-88 were 595,099. The traffic in the city is not only noisy but also producing hazardous environmental effects on plants. Most of the automobiles emit black smoke due to incomplete combustion of fuel. These toxic materials such as carbon particles, unburned and partially burned hydrocarbons, fuels, tar materials, lead compounds and other elements, which are the constituents of petrol and lubricating oils, are deposited on the surface of plants. These pollutants have individual as well as synergistic effects on plants (Qadir & Iqbal, 1991).

Trees in cities face an exceptionally stressful growing environment due to air pollution, environmental degradation, pressure for land space, destruction of green areas to accommodate urban development which suppresses performance and shorten life span (Gilbertson & Bradshaw, 1985; Sawidis & Reiss, 1995; Jim, 1996, 1997, 1998; Webb, 1998). Air pollution can reduce growth and yield, with or without leaf injury (Brandt & Heck, 1967). The phenology and productivity of *Ficus bengalensis* L. and *Eucalyptus* sp. were found highly affected due to automobile exhausts (Bhatti & Iqbal, 1988).

Automobile emission significantly reduced the productivity, leaf area and leaf dry weight of *Guaiacum officinale* L., *F. bengalensis* and *Eucalyptus* sp. at the polluted sites of Karachi as compared to control. The phenological observation for woody ornamental plants in Athens city showed reduction in the shoot diameter and total leaf area up to 60 % due to lead pollution (Chronopoulos *et al.*, 1996). A significant ($p<0.05$) decline in leaf area, fresh and dry weight and moisture content of the roadside plant, *Bougainvillea spectibilis* Willd. was observed by Hussain *et al.* (1997).

Alam and Ahmad (1998) investigated the effect of environmental pollution on the phenological behaviour of *Croton bonplandianum* populations. The vegetative, flowering and fruiting period of the two populations was studied and it was observed that the life cycles of the railway yard population at Patna junction (India) were shorter than the undisturbed population. The plants were growing in adverse biotic conditions and the environmental factors played a major role in affecting the phenolgical behaviour of both the populations.

The aim of the present research was to investigate the effects of automobile pollution on the phenology and periodicity of two important plants growing in different areas of Karachi city.

Materials and Methods

Site description: Karachi is situated along the Arabian Sea coast at latitude of 24° 48' N and longitude of 66° 55' E. The soil is calcareous, marine in origin and belongs to the upper tertiary period. Moving away from the coast, the ground rises gently forming a large plain to the north and east on which the city is built. The city is between 1.5 and 37 m above sea level. Chaudhry (1961) has characterized the climate of Karachi as subtropical maritime desert. Whereas, the bioclimate of Karachi determined by Holdrige (1947) comes in the category of "Tropical desert bush formation". Average wind velocity is 12 $m.s.^{-1}$ during June to July and 3.5 $m.s.^{-1}$ from January to March. During the monsoon season southwest winds blow from the sea towards the coast, whereas during the northeast monsoon their direction is reversed. Therefore, pollutants are pushed inland during the southwest monsoon season and are blown out to sea during the northeast monsoons (UNEP, 1992).

The hot and humid rainy season, which is variable, lasts from June to September. Minimum rainfall is 1 mm in the month of October, whereas the maximum rainfall (85 mm) occurs in the month of July. The winter season is very short (November 15 to February 15), while summer is long (April to October). Temperature is mild with no frost. Dew formation is quite common, the relative humidity is high and the differences in day and night temperatures are great. The climatic conditions at the control site (Karachi University Campus) are not different from other sites of the city.

The urban area is disturbed mainly by autovehicular activities, at all main traffic networks (Gulshan-e-Iqbal, Nazimabad, Shahrah-e-Faisal and M.A. Jinnah Road) whereas, Karachi University is relatively a clean area.

Collection of leaf samples: The common roadside trees like *Alstonia scholaris* R. Br., and *Pongamia pinnata* (L.) Merrill, having similar growth and DBH (Diameter Breast Height) were chosen from each site. The samples influenced by traffic and exposed to sunlight were obtained from road edge at a distance of 1 m. at the beginning of each season. Twenty-five fresh leaf samples from each individual of a species were randomly collected from each area at two-meter height throughout the plant canopy as a

representative sample. Quantitative characters of the leaves such as length, width and area were recorded periodically (during different periods), July to September, October to December, January to March and April to June, respectively. Water regime was more or less similar for all the trees growing in the study areas. All measurements were based on three replicates. The data collected for various parameters from different sites was statistically calculated by analysis of variance techniques (ANOVA) and Duncan's Multiple Range Test (Steel & Torrie, 1960).

Results

The leaf size of *Alstonia scholaris* and *Pongamia pinnata* was greatly reduced in the polluted environment as compared to Karachi University Campus (Figs. 1-2). Plants were found more affected by pollutants at M.A. Jinnah Road as compared to other polluted areas of the city. The effects of autoemission on leaves of *A. scholaris* varied from site to site (Fig. 1). The periodical study indicated that the leaf length and width were significantly ($p<0.05$) affected during July-September at M.A. Jinnah Road as compared to Shahrah-e-Faisal, Nazimabad, Gulshan-e-Iqbal and Karachi University Campus (Table 1). The lowest leaf area of *A. scholaris* was also found at M.A. Jinnah Road followed by Shahrah-e-Faisal, Nazimabad, Gulshan-e-Iqbal and Karachi University Campus.

Table 1. Significance level L.S.D. ($p<0.05$).

L.S.D. Variables	*Alstonia scholaris*				*Pongamia pinnata*			
Season	**P1**	**P2**	**P3**	**P4**	**P1**	**P2**	**P3**	**P4**
Leaf length (mm)	15	5	16	6	11	13	11	6
Leaf width (mm)	2	3	5	7	6	6	6	5
Leaf area (sq. mm)	422	312	388	225	512	692	614	403

Symbol used: P1= July-September, P2= October-December, P3= January-March, P4= April-June

The present study also reveals that *P. pinnata* growing in the polluted site of the city showed significant reduction in all the leaf parameters as compared to Karachi University Campus (Table 1). A reduction in leaf size of *P. pinnata* was observed during January to March at M.A. Jinnah Road as compared to Shahrah-e-Faisal, Nazimabad, Gulshan-e-Iqbal and Karachi University Campus (Fig. 2). The leaf length of this species was also significantly ($p<0.05$) affected during January to March at highly polluted sites of M.A. Jinnah Road as compared to Karachi University Campus.

Discussion

Automobile emissions contribute most of air pollution problems. Trees in cities are subjected to a widespread pressure of autovehicular emission. Among plant organs, the leaf is the most sensitive part to be affected by air pollutants. The sensitivity rests on the fact that the major physiological processes occur in the leaf. Therefore, at its various stages of development, the leaf serves as a good indicator of air pollutants. Pollutants derived from the autoemission can directly affect the foliage of plants by entering the leaf, destroying individual cells, and reducing the plant's ability to produce food. Reduction in leaf length, width and area of roadside plants was the witness of bad effects of the city environment. It is found that the plants growing close to the busy road of the city are highly affected by autoemission. The inhibitory effects on the growth of plants

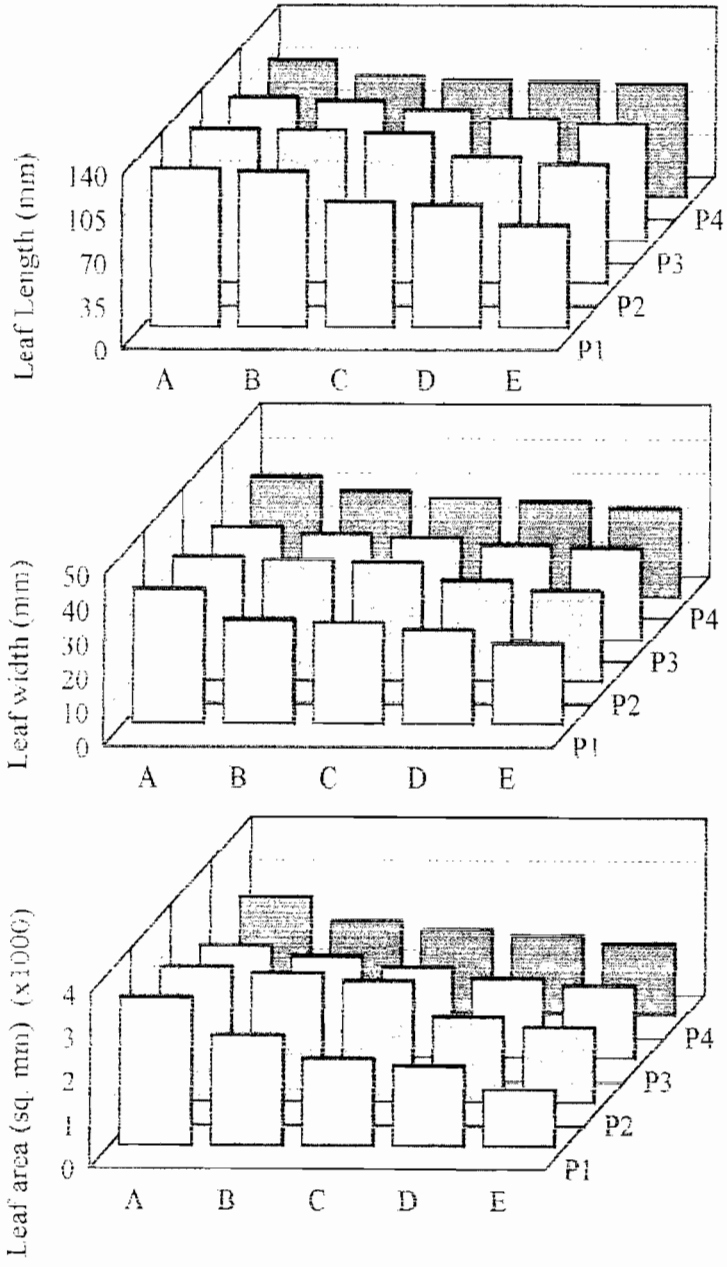

Fig. 1. Effects of autoemission on leaf length, width and area of *Alstonia scholaris*.

A= Karachi University Campus B= Gulshan-e-Iqbal
C= Nazimabad D= Shahrah-e-Faisal
E= M.A. Jinnah Road

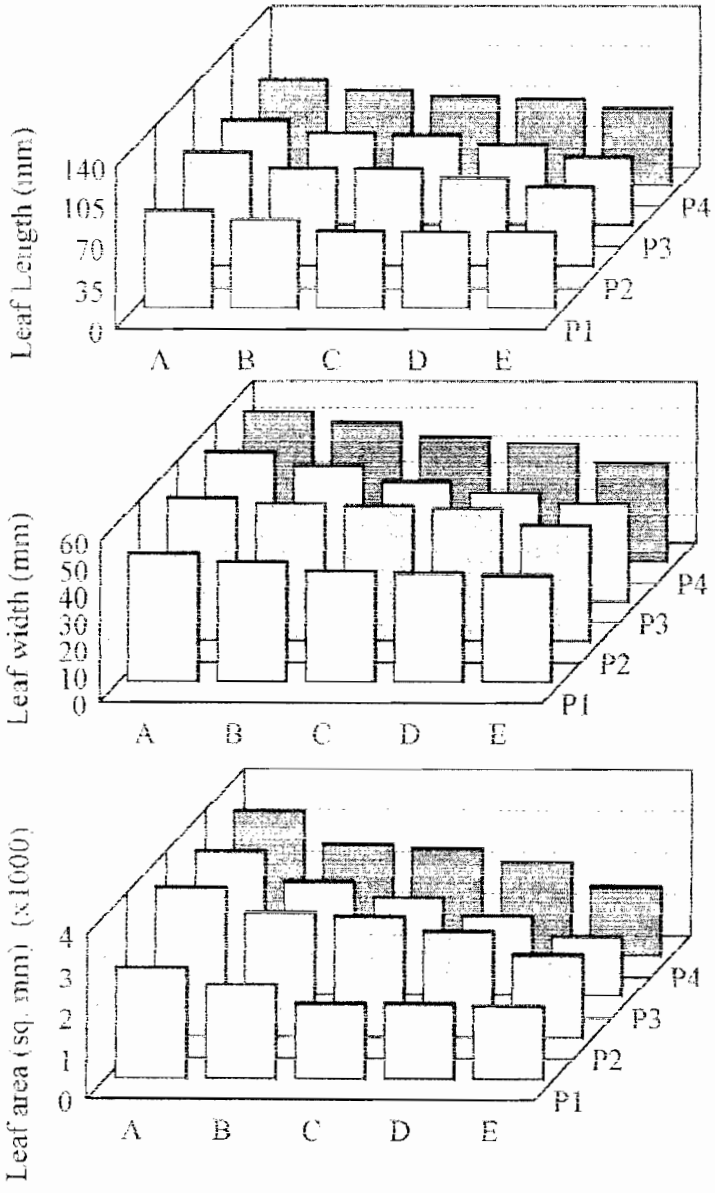

Fig. 2. Effects of autoemission on leaf length, width and area of *Pongamia pinnata*.

A= Karachi University Campus B= Gulshan-e-Iqbal
C= Nazimabad D= Shahrah-e-Faisal
E= M.A. Jinnah Road

are due to the presence of toxic materials in the autoemission. The air pollution interferes with the phenology of plants. Time of flowering, senescence, shed of fruit, maturation of fruits and emergence of new leaves, all these process are disturbed by air pollution (Bhatti & Iqbal, 1988). Palaniswamy *et al.* (1995) also concluded that automobile exhaust gases could affect seedling development and growth of crop plants. Air quality is known to be influenced by pollutant emission rates (Heggie & Hawke, 1986; Derwent & Kay, 1988). In an urban area, meteorological conditions, traffic density and building geometry may modify concentration and time of pollutant peak occurrence and seasonal patterns (Pandey *et al.*, 1995). Data on daily pattern of air pollutants and traffic density on all sites are available, however, some data on the levels of SO_2 (100-134 $\mu g\ m^{-3}$), CO (7-5 mg. m^{-3}), NO_2 (38-63 $\mu g.\ m^{-3}$) were recorded at M.A. Jinnah Road (Ghuari *et al.*, 1988). Similarly, Yousufzai (1991) had also found high level of Pb (4527 ppm), Cd (4.5 ppm), Zn (2215 ppm) and Cu (275 ppm) and number of vehicles (1,29,675) daily at M.A. Jinnah Road.

The results of the present study testify the grave situation faced by trees growing at the polluted sites. Like other cities, emissions from motor vehicles are the most important source of air pollution at all polluted sites of the city. Trees are dying as a result of prolonged exposure of exhaust emission especially at M.A. Jinnah Road. The buildings along the street, resulting in a tunnel-like structure, which affect the dispersion of pollutants especially at the M.A. Jinnah Road. The pollutants at M.A. Jinnah Road were found to be influenced by the above factors and also due to heavy flow of traffic. The leaf growth of *Alstonia scholaris* and *Pongamia pinnata* was significantly affected at the polluted environment of the city as compared to clean area. *Alstonia scholaris* (commonly known as Dita bark tree) is a beautiful evergreen tree with a tall stem and dark green shiny leaves in whorls of 4 to 10. It exudes a milky juice on cutting. It is found in tropical Australia, Africa, India to Indonesia and cultivated in Pakistan for ornamental purposes. *Pongamia pinnata* (L.) Merrill is a medium sized, almost evergreen tree and spreading shady crown. It is indigenous to the foothills of the Himalayas, but cultivated in plains for its ornamental value.

Leaf size of both the species reduced progressively depending on the level of pollution at the city sites. During July to September, the leaf length, width and area of *A. scholaris* were significantly affected at M.A. Jinnah Road. Strong solar radiation and air temperature normally found high (nearly 33° C or more at mid-day) in July (Beg *et al.*, 1987). Bruckmann & Langensiepen (1981) showed a significant positive correlation between ozone concentration, temperature and solar radiation. This relationship between temperature, solar radiation and concentration of O_3 may lead reduction in plant growth at polluted sites. Significant reduction in leaf size for *P. pinnata* was also found during January to March at M.A. Jinnah Road as compared to other less polluted sites of the city. The reduction in leaf size of *A. scholaris* and *P. pinnata* might be due to the large surface area of their leaves which is available for exposure to any pollutant. During winter, the air velocity is low, the average temperature during daytime is 18° to 22° C. Fog is formed in winter when atmospheric humidity increases. The fog in Karachi mixes with smoke to form smog and there is a continuous tendency for the pollutants to descend toward ground level and also on the aerial parts of the plants. Moreover, the reduction in leaf parameters could be attributed to high level of autodust fall on the aerial parts as well as slow growth of plants.

Excessive quantities of air borne particulate matters cover the leaves, clog the stomata, thereby both reducing the absorption of carbon dioxide from the atmosphere and the intensity of light reaching the interior of leaf, and suppressing the growth of plants. Bhatti & Iqbal (1988) had reported reduction in leaf length of *Ficus bengalensis* L. at the

polluted sites. A significant ($p<0.05$) decline in leaf area of a roadside plant, *Bougainvillea spectibilis* Willd. has been observed by Hussain *et al.* (1997). In the aerial parts of the plant, the growth reduction appears to be a consequence of the inhibition of photosynthesis which affects the chlorophyll metabolism due to cadmium toxicity (Somashekaraiah *et al.*, 1992). Light intensity at the polluted sites was also low (Shams & Iqbal, 1986) which could result in less photosynthesis and eventually less growth of plants. The deposition of large foliar pollutant burdens may not only increase the absorption of pollutants by the plants but may also result in greater contamination of the soil underneath by throughfall and litterfall (Venanzoni & Werner, 1988; Witting & Neite, 1989). Leaf size of both the species reduced progressively depending on the level of pollution at the city. Consequently, species responses to environmental variables may differ from those commonly found under non-stress conditions (Pysek, 1994)). Low reduction in leaf growth of both tree species was observed at M.A. Jinnah Road, Shahrah-e-Faisal and Nazimabad as compared to Gulshan-e-Iqbal and Karachi University Campus. It is obvious from the results that the local sources, particularly automobile, play a major role in characterizing air quality of the urban environment. Higher levels of lead and cadmium in foliage of some roadside trees were reported by Ara *et al.* (1996) and Khalid *et al.* (1996). The traffic density at Gulshan-e-Iqbal was considerably low which accounts of its minimum pollution load on both plant species. Significantly, higher frequencies of clogged stomata (with particulate matter) were found in the leaves of some common roadside plants (*Albizzia jublibrissin* and *Ficus bengalensis)* due to vehicle exhaust emission as compared to those from unpolluted locality (Kazmi *et al.*, 2002).

Overall study for phenology and periodicity of the two plant species reveal that most of the plants growing in the polluted city environment are badly affected by autoemission. However, *Alstonia scholaris* was a comparatively tolerant species, which could resist the polluted environment. It is therefore, suggested that *A. scholaris* should be given more preference for further plantation in the city, particularly along the busy roads.

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