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Full Length Research Paper

Effect of auto exhaust emission on the phenology of *Cassia siamea* and *Peltophorum pterocarpum* growing in different areas of Karachi

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The response of plant species to different seasons and environmental pollutants is of important interest to researchers. Observations were made on *Cassia siamea* and *Peltophorum pterocarpum* plants growing in the polluted and other less polluted areas of Karachi. The phenology of *C. siamea* and *P. pterocarpum* was significantly ($p<0.05$) affected in the polluted environment of Karachi. 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. Leaflet length of *C. siamea* was found lowest in July-September at M.A. Jinnah Road as compared to Shahrah-e-Faisal, Nazimabad, Gulshan-e-Iqbal and University Campus. Leaflet width and area of *C. siamea* were significantly ($p<0.05$) reduced in January-March at the highly polluted sites of M.A. Jinnah Road. Leaflet length, width and area of *P. pterocarpum* were found lowest in October-December at M.A. Jinnah Road as compared to other areas of city and University Campus. Leave dry weight of the two species was found lowest at M.A. Jinnah Road as compared to Shahrah-e-Faisal, Nazimabad, Gulshan-e-Iqbal and University Campus. Leaf dry weight of *C. siamea* and *P. pterocarpum* was significantly ($p<0.05$) reduced in January-March and July-September, respectively at M.A. Jinnah Road than to other less polluted sites of the city. *P. pterocarpum* was found comparatively less affected to automobile pollution of the city as compared to *C. siamea*. It is therefore, suggested that *P. pterocarpum* should be given more preference for further plantation in the city, particularly along the busy roads. Keeping such record of phenological data would be helpful in understanding the current trend of environment impact on plant growth.

Key words: Autoexhaust emission, phenology, roadside plants, *Cassia siamea, Peltophorum pterocarpum,* urban pollution, Karachi, Pakistan.

INTRODUCTION

The industrial activities and the uncontrolled development of large cities, especially during the recent past, have resulted in the contamination of soil, water and air. Burning or combustion of fuels contributes a considerable amount of pollutants to air (Sawidis et al., 1995). Pakistan is a developing country and the major cities like Karachi, Lahore, Faisalabad and Hyderabad are suffering by environmental pollution problems. In industrialized cities like Karachi, where the population is rapidly increasing day by day, automobile emission is a major source of atmospheric pollution (Qadir and Iqbal, 1991). Over 30% of all the automobiles of the country are plying in Karachi (Ghauri et al., 1999) and 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

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compounds and other elements which are the constituents of petrol and lubricating oils deposit on the aerial parts of plants. These pollutants in combinations cause greater or synergistic effects to plants (Qadir and Iqbal, 1991). Preeti (2000a) observed that leaves of *Thevetia nerifolia* and *Cassia siamea* growing in the polluted environment showed reduction in growth. Preeti (2000a) also found that compound leaves showed greater damage than narrow simple leaves and the portion of injured area was 15.57% in *T. nerifolia* and 22.33% in *C. siamea.* In another study conducted on the foliar epidermal traits of *C. simea*, Preeti (2000b) found increase in densities of stomata, trichomes and epidermal cells, longer trichomes and reduction in size of epidermal cells at polluted sites as compared to at reference site.

Air is the invisible, tasteless, odorless mixture of gases that surrounds the earth. Some gases in this amalgam can be harmful in higher concentrations. Some components, such as oxides of nitrogen or sulfur are always present, but excessive quantities can impair human health and agricultural production and kill forests (Treshaw and Anderson, 1991). Regional air quality has been deteriorated over the last 20 years due to population explosion, industrialization and urbanization. Trees in cities face an exceptionally stressful growing environment such as air pollution, environmental degradation, traffic congestion, destruction of trees and green areas to accommodate urban development which suppress performance and shorten life span (Gilbertson and Bradshaw, 1985; Iqbal and Shafiq, 1999; Jim, 1996, 1997, 1998; Sawidis and Reiss, 1995; Webb, 1998). Bhatti and Iqbal (1988) noticed that the phenology and productivity of *Ficus bengalensis* L., and *Eucalyptus* sp., were highly affected due to automobile exhausts. They also concluded that automobile emission significantly reduced the productivity, leaf area and leaf dry weight of *Guaiacum officinale*, *F. bengalensis* and *Eucalyptus* sp., at the polluted sites of the city as compared to control. The phenological observation for woody ornamentals plants in urban environment of Athens city showed reduction in the shoot diameter and total leaf area upto 60% due to high burden of 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* was observed by Hussain et al. (1997).

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

Cassia siamea (Kassod tree) is a moderate sized, well-shaped evergreen tree with a dense crown. It is native to South India. This tree is largely planted for ornamental purposes. The tree grows fairly rapidly, and is easy to cultivate. The tree is also cultivated in gardens of Karachi and Sindh. *Peltophorum pterocarpum* (Yellow Flame tree) is native to Ceylon and North Australia, commonly cultivated as roadside tree in gardens and in plains of Pakistan. The aim of the present study was to investigate the effect of pollutants from automobile exhaust emission on the phenology of *C. siamea* and *P. pterocarpum* growing in different areas of Karachi city.

MATERIALS AND METHODS

Site description

Karachi is situated on the coast along the Arabian Sea at a latitude of 24° 48' N and longitude of 66° 55' E. The soil is calcareous and marine in origin. Chaudhry (1961) has characterized the climate of Karachi as subtropical maritime desert. Average wind velocity is 12 ms^{-1} during June and July and 3.5 ms^{-1} from January to March. During the southwest monsoon season, 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 (Beg et al., 1987; UNEP, 1992).

The hot and humid rainy season, which is variable, lasts from June to September. Minimum rainfall is 1.0 mm in the month of October whereas, the maximum rainfall (85.0 mm) occurs in the month of July. The winter season is very short lasting from middle of November to middle of February. 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 sites in the city included all main traffic network (Gulshan-e-Iqbal, Nazimabad, Shahrah-e-Faisal and M.A. Jinnah Road) are disturbed mainly by autovehicular activities whereas, Karachi University is relatively a clean area (Figure 1).

Collection of leaf samples

Leaves samples of roadside trees like *C. siamea* Lamk and *P. pterocarpum* D.C. Backer ex K. Heyne influenced by traffic activities were obtained from road edge at a distance of 1 m. 25 fresh leaf samples from each individual of a species having uniform growth form were randomly collected from each area at 2 m height throughout the plant canopy to give representative average sample. Quantitative characters of the leaves such as, leaflet length, width, area and dry weight were recorded periodically at regular interval of three months viz, P1 (July-September), P2 (October-December), P3 (January-March) and P4 (April-June). All the measurements were based on three replicates. The data collected for various leaf parameters from different sites was subjected to statistical analysis (Steel and Torrie, 1980).

RESULTS

The leaf size of *C. siamea* and *P. pterocarpum* was

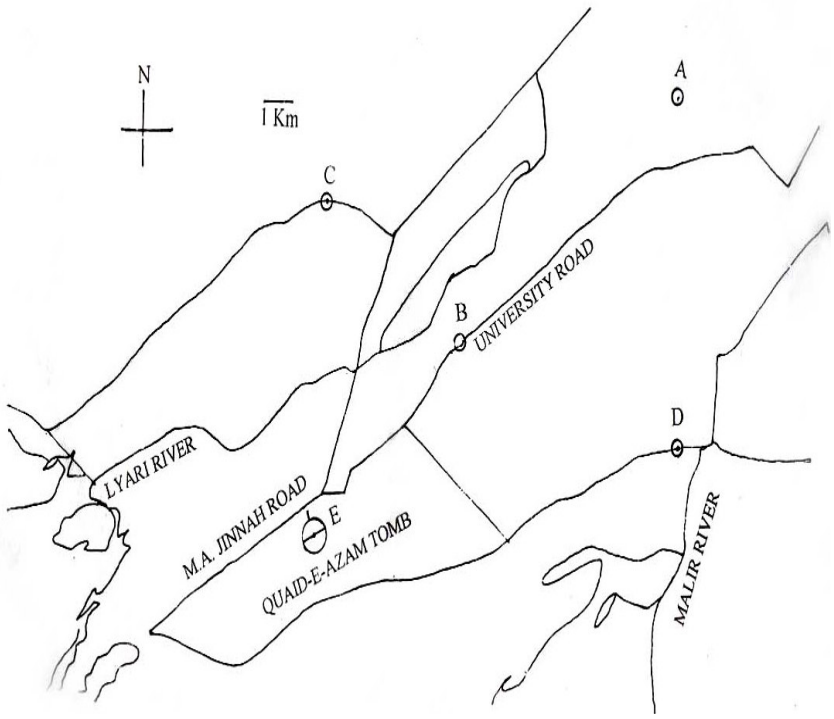

Figure 1. Map of the study area (A = Karachi University Campus, B = Gulshan-e-Iqbal, C = Nazimabad, D = Shahrah-e-Faisal, E= M.A. Jinnah Road).

Table 1. Leaflet parameters of *Cassia siamea* and *Peltophorum pterocarpum* growing in different areas of Karachi.

L.S.D. variables	*Cassia siamea*				*Peltophorum pterocarpum*			
Period of sampling	P1	P2	P3	P4	P1	P2	P3	P4
Leaflet length (mm)	4.4	7.2	5.0	4.0	2	2	3	2
Leaflet width (mm)	1.7	1.6	1.5	1.6	1	1	1	1
Leaflet area (sq.mm)	80	108	73	71	23	21	22	21
Leaflet dry weight (g)	0.002	0.001	0.008	0.008	0.002	0.002	0.001	0.003

P1 = July-September, P2 = October-December, P3 = January-March, P4 = April-June.
Significance level L.S.D. ($p<0.05$).

significantly ($p<0.05$) affected in the polluted environment as compared to plants growing at Karachi University Campus (Table 1). Both plant species were greatly affected to pollutants at M.A. Jinnah Road as compared to other polluted areas of the city and University campus (Figures 2 - 3).The effect of autoemission on leaflet growth of *C. siamea* varied from site to site (Figure 2). The periodical study indicated that the leaflet length was significantly ($p<0.05$) affected in July-September at M.A. Jinnah Road as compared to Shahrah-e-Faisal, Nazimabad, Gulshan-e-Iqbal and Karachi University Campus. The lowest leaflet width and area of *C. siamea* was found in January-March at M.A. Jinnah Road followed by Shahrah-e-Faisal, Nazimabad, Gulshan-e-Iqbal and Karachi University Campus. Leaflet dry weight of *C. siamea* was significantly affected at all the sites of the city. The leaflet dry weight of *C. siamea* was highly affected in January-March at M.A. Jinnah Road as compared to Shahrah-e-Faisal, Nazimabad, Gulshan-e-Iqbal and Karachi University Campus.*P. pterocarpum* growing in the polluted site of the city showed significant reduction in all leaf parameters as compared to Karachi University Campus. A significant ($p<0.05$) reduction in leaflet size of *P. pterocarpum* was observed in October-December at M.A. Jinnah Road as compared to Shahrah-e-Faisal, Nazimabad, Gulshan-e-Iqbal and Karachi University Campus (Figure 3). The periodical study indicated that leaf sample of *P. pterocarpum* collected from the polluted sites of the city showed reduction in leaflet dry weight as compared to Karachi University Campus.The leaflet dry weight of *P. pterocarpum* was significantly low in July-September at M.A. Jinnah Road as compared to other less polluted sites of the city. *P. pterocarpum* showed maximum leaflet dry weight in October-December at

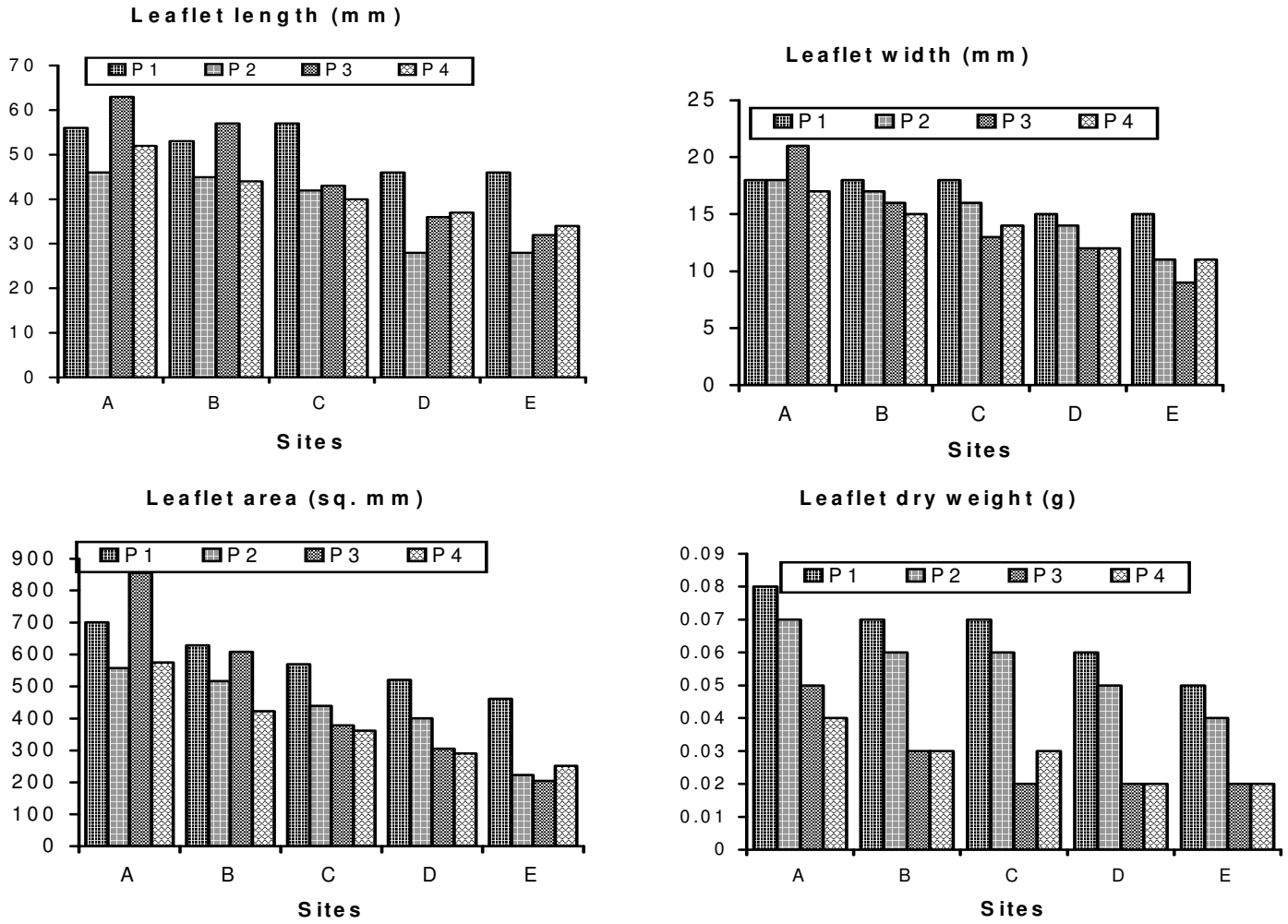

Figure 2. Effect of auto emission on leaflet length, width, area and dry weight of *C. siamea*. P1 = July-September, P2 = October-December, P3 = January-March, P4 = April-June. A = Karachi University Campus, B = Gulshan-e-Iqbal, C = Nazimabad, D = Shahrah-e-Faisal, and E = M.A. Jinnah Road.

Karachi University Campus as compared to Gulshan-e-Iqbal, Nazimabad, Shahrah-e-Faisal and M.A. Jinnah Road. *P. pterocarpum* was found comparatively less affected to automobile pollution of the city as compared to *C. siamea*.

DISCUSSION

Air pollution due to vehicular emission mostly arises from cars, buses, minibuses, wagons, rickshaws, motorcycles and trucks could threaten the health of human beings, trees, crops and animals. Air pollution in the city of Karachi is rising to an alarming state rapidly since the last few decades due to heavy automobile activities. Rapid increase in automobile activities and traffic congestion contributes most of air pollution problems, resulting in damage to the plants growth (Table 1). The plants growing adjacent to roadsides of the city exhibited considerable damage in response to automobile exhaust emission (Iqbal and Shafiq, 1999; Shafiq and Iqbal, 2003, 2005).

Of all the plant parts, the leaf is the most sensitive part to be affected by air pollutants. The sensitivity rests on the fact that the major portions of the important physiological processes are concentrated in the leaf. Therefore, the leaf at its various stages of development, serves as a good indicator to 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 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 was 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 are due to the presence of toxic material in the autoemission. The air pollution interferes with the seasonal variations, which takes place

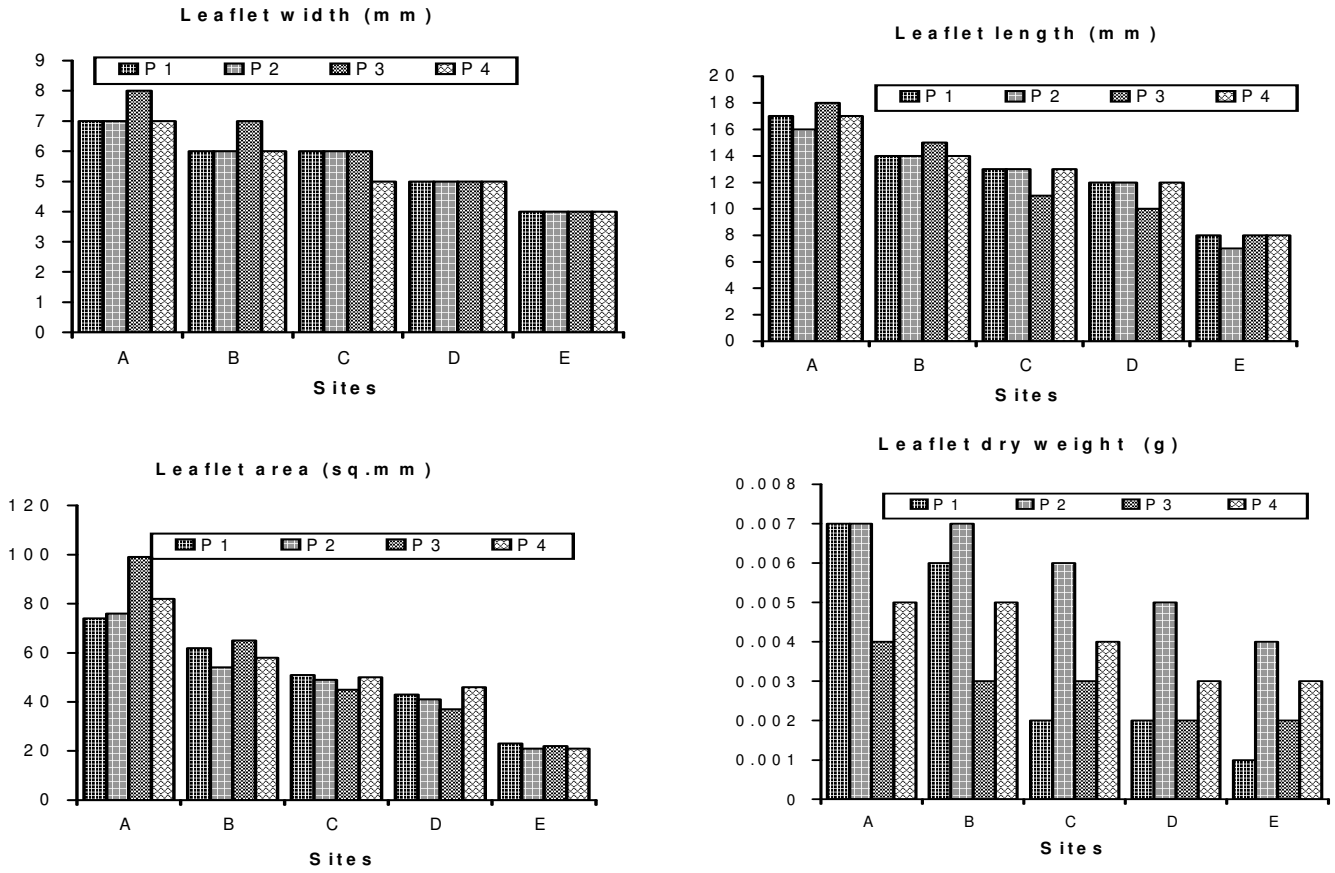

Figure 3. Effects of auto emission on leaflet length, width, area and dry weight of *P. pterocarpum*. P1 = July-August-September, P2 = October-November, December, P3 =January-February-March, P4 = April-May-June. A = Karachi University Campus, B = Gulshan-e-Iqbal, C = Nazimabad , D = Shahrah-e-Faisal, and E = M.A. Jinnah Road.

Table 2. Estimated emission of pollutant from automobiles in Pakistan (tons x 10^3).

Pollutant	Year 1996	Year 1997	Year 2000
CO	6,000	6,500	8,000
HC	1,250	1,340	1,650
NOx	440	460	540
SO_2	69	72	85
PM^{10}	125	135	160
Total No. of vehicles	3,276,000	3,515,000	4,291,000

Source: Qureshi (2000).

in plants. Time of flowering, senescence, shed of fruit, maturation of fruits and emergence of new leaves, all these processes are disturbed by air pollution (Bhatti and Iqbal, 1988).

The results of the present study testify this grave situation faced by trees growing at the polluted sites. Trees are dying as a result of prolonged exposure of exhaust emission especially at M.A. Jinnah Road. Leaf growth of *C. siamea* and *P. pterocarpum* was significantly affected at the polluted environment of the city as compared to clean area. Leaf size of both tree species reduced progressively depending on the level of pollutant in the city. During the present investigation it was observed that the trees were more sensitive to air pollutants at M.A. Jinnah Road as compared to other less polluted areas of the city. In October-December, the leaflet length of *C. siamea* was significantly affected at M.A. Jinnah Road. Significant reduction in leaflet width and area for *C. siamea* was found in January-March at M.A. Jinnah Road as compared to other less polluted

sites of the city. The reduction in leaflet size of *C. siamea* as compared to *P. pterocarpum* might be due to the large surface area of their leaves that is available to exposure to any pollutant. A significant ($p<0.05$) decline in leaf area of a roadside plant, *Bougainvillea spectibilis* has been observed by Hussain et al. (1997). The leaflet length of *P. pterocarpum* was highly affected in October-December season at M.A. Jinnah Road as compared to other sites of the city. The decrease in leaf parameters could be attributed to high level of automobile pollutants in the environment and excessive fall of autodust on their aerial parts. Excessive quantities of air borne particulate matters cover the leaves, clogg the stomata, thereby reducing both 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 and Iqbal (1988) reported reduction in leaf length of *Ficus bengalensis* at the polluted sites. Atmospheric pollutants after making their entry through stomata of leave cause reduction in leaf size of plants due to damage of photosynthetic tissues. Since plant growth and production depend on phyotosynthetically functional leaf size of the species. The relationship between plants growing in polluted and unpolluted areas helps in understanding the impact of air pollution on the growth of plants. As a result, a significant amount of information can be gathered and loss of plant species may be related either directly or indirectly through matching of the findings of the research. A basic understanding of the factors that mediate this relationship can be valuable in developing sound management practices and plantation of tolerant species in the polluted environment of the area.

The problem of air pollution due to automobile activities is not a new one but the importance of its impacts on plants growing along the busy road has recently become apparent. Plants growing at M.A. Jinnah Road are greatly affected by the increase in autovehicular activities. This research provides significant ($p<0.05$) phenotypic variation in the foliage of roadside plants receiving different types of toxic pollutants. Our investigation suggests that phenotypic studies could be useful diagnostic markers for studying the impact of air pollution on plant growth. Urban roadside plants are exposed to a various types of toxic pollutants, including gaseous NOx from vehicle exhausts, particulate materials, including heavy metals. These pollutants may alter the morphology, physiology and biochemistry of the sensitive plants, and exposure to the pollutants in combination may be more harmful to plants than exposure to the individual pollutants. There is also evidence that species are damaged from vehicular emission stress. A significant decline in leaf growth of *Alstonia scholaris* and *Pongamia pinnata* was investigated at M.A. Jinnah Road (Shafiq and Iqbal, 2003). Data presented showing the effects of roadside pollution due to autovehicular exhaust emission on the leaflets growth of both tree species growing at Karachi University Campus (Control site) and in the urban polluted sites (Gulshan-e-Iqbal, Nazimabad, Shahrah-e-Faisal and M.A. Jinnah Road) at Karachi city. Leaves taken from the polluted sites showed decline in length, width and area. Leaflets from the polluted sites especially at M.A. Jinnah Road showed excessive covering with black particles derived mostly from the badly maintained automobile. High temperature and low wind due to construction of high rising buildings at the highly polluted site of the city have the potential to influence on the local air quality and on plant growth. There is still a serious lack of knowledge of the impact of air quality on vegetation in the urban areas.

Overall, the study reveals that both plant species growing in the polluted city environment are badly affected by autoemission. However, *P. pterocarpum* was found comparatively tolerant species, which could resist the polluted environment of the city to some extent. It is therefore, suggested that *P. pterocarpum* should be given more preference for further plantation in the city, particularly along the busy roads. Further studies on the pattern of fruiting and yield of plant species associated with the impact of pollutants are suggested. There is a need to set limits on how much of a pollutant is allowed in the air. The exchange of experience and information from the developed countries on this aspect of pollution impact on plants might be useful. Our goal must be to have clean air for flora and fauna. We should take necessary steps to get rid of the ever increasing pollution.

REFERENCES

Alam SP, Ahmad MS (1998). Effect of environmental pollution on the phenological behavior of *Croton bonplandianum* population. In: Abstracts on pollution, position, and prospects. Oriental College Patna, City, India.

Beg MAA, Yousufzai AHK, Mehmood SN (1987). Air pollution in Karachi. Pak. J. Sci. Ind. Res. 30: 60-66.

Bhatti GH, Iqbal MZ (1988). Investigations into the effect of automobile exhausts on the phenology, periodicity and productivity of some roadside trees. Acta Soc. Bot. Pol. 57: 395-399.

Chaudhry II (1961). The vegetation of Karachi. Vegetation 10: 229-246.

Chronopoulos J, Chronopoulos-Sereli A, Papafotiou M (1996). The capability of adaptation of woody ornamental plants to the urban environment of Athens. Gartenbauwissenschaft 61: 197-200.

Ghauri B, Lodhi A, Salam M, Mirza MI (1999). Enrichment of toxic lead in Karachi aerosols. Sci. Vision 5: 10-16.

Gilbertson P, Bradshaw AD (1985). Tree survival in cities; the extent and nature of the problem. Arbor. J. 9: 131-142.

Hussain F, Sher Z, Shah Z, Durrani MJ (1997). Effects of air borne particulate pollutants on the growth of some roadside cultivated plants. Pak. J. Plant Sci. 3: 73-82.

Iqbal MZ, Shafiq M (1999). Impact of vehicular emission on germination and growth of Neem (*Azadirachta indica*) tree. Hamdard Medicus XLII: 65-69.

Jim CY (1996). Roadside trees in urban Hong Kong: Part II. Species composition. Arbor. J. 20: 279-298.

Jim CY (1997). Roadside trees in urban Hong Kong: Part IV. Tree growth and environmental condition. Arbor. J. 21: 89-99.

Jim CY (1998). Pressure on urban trees in Hong Kong: Pervasive problem and possible amelioration. Arbor. J. 22: 37-60.

Preeti A (2000a). Study of leaf area damage of urban and rural environment in Agra. Acta Ecol. 22: 96-100.

Preeti A (2000b). The effect of auto exhaust pollution on leaf surface of *Cassia siamea* (L); a roadside tree. Acta Ecol. 22: 101.106.
Qadir SA, Iqbal MZ (1991). Growth of some plants raised from polluted and unpolluted seeds. Int. J. Environ. Stud. 39: 95-99.
Qureshi IH (2000). Air pollution and human health. Proc. Pakistan Acad. Sci. 37: 109-117
Sawidis T, Reiss HD (1995). Effects of heavy metals on pollen tube growth and ultra structure. Protoplasma 185: 113-122.
Sawidis T, Manasidis A, Zachariadis G, Stratis J (1995). A study of air pollution with heavy metals in Thessaloniki City (Greece) using trees as biological indicators. Arch. Environ. Contam. Toxicol. 28: 118-124.
Shafiq M, Iqbal MZ (2003). Effects of automobile pollution on the phenology and periodicity of some roadside plants. Pak. J. Bot. 35: 931-938.
Shafiq M, Iqbal MZ (2005). The impact of auto emission on the biomass production of some roadside plants. Int. J. Biol. Biotechnol. 2: 93-97.
Steel RGD, Torrie JH (1980). Principles and Procedures of Statistics. A biometrical approach, 2nd Ed. McGraw Hill Book Co., New York.
Treshaw M, Anderson FK (1991). Plant stress from air pollution. John Wiley and Sons, London.
UNEP (United Nation Environmental Program), (1992). Urban Air Pollution in Megacities of the World. Blackwell Publishers, Oxford.
Webb R (1998). Urban forestry in Kuala Lumpur, Malaysia. Arbor. J. 22: 287-296.