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Seedling growth of *Adenanthera pavonina* L. in polluted soils of Karachi railway track

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ABSTRACT: The seedling growth performance of *Adenanthera pavonina* L. in polluted soils of different railway tracks viz. Karachi Cantt. Station, Malir Halt, Malir 15, Landhi Junction and University Campus (control) was studied under in pots under natural field conditions. The results showed that the root, shoot and seedling size, number of leaves, plant cover, leaf weight ratio of *A. pavonina* seedlings were significantly ($p<0.05$) reduced in Karachi Cantt. Station soil as compared to University Campus soil. Similarly, shoot, root and seedling size, plant cover, seedling dry weight of *A. pavonina* were significantly ($p<0.05$) increased in soils of Landhi Junction as compared to soil of University Campus. A better seedling growth of *A. pavonina* was also found in soil of Malir 15 followed by Malir Halt. A significant variation in the the physico-chemical characteristics of the railway tract soil sample was observed. The soil of Malir Halt, Malir 15 and Landhi Junction railway tracks was sandy clay loam while the Karachi Cantt. Station and University Campus had clay loam textured soil. A significant variation in chemical characteristics of railway track soil such as maximum water holding capacity, bulk density, chloride contents, available sulfur, and exchangeable sodium as compared to University Campus soil observed. Whereas, porosity, calcium carbonate, organic matter, electrical conductivity, total dissolved salts and exchangeable potassium were low in railway tracks soil. The present study demonstrated that the growth of *A. pavonina* was significantly ($p<0.05$) reduced in Karachi Cantt. Station soil as compared to soils of other sites. © JASEM
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KEY WORDS: *Adenanthera pavonina*, railway track, pollution, seedling growth, soil.

Introduction
The major urban cities of Pakistan likewise Karachi, Lahore, Faisalabad, Peshawar, Quetta and Hyderabad are suffering by a series of environmental pollution related problems since last couple of decade very rapidly due to anthropogenic and automobile activities. Among the major urban cities, Karachi is the coastal and the largest city of Pakistan and has only natural sea port of the country. The establishment of cities near the seaports plays an important role in economic activity of the countries around the world. The fast economic growth, industrial and transport activities are common issues of environmental pollution problems in coastal urban areas and the transportation of goods through ports steadily increased (Bailey and Solomon, 2004). The transportation of goods through railway is an important and cheap mode of conveyance. The emission of gases and pollutants from the railway engines is considered an important source of environmental pollution all over the world as supported by different researchers (Galera, et al., 2011; Talotte et al., 2003). The emission from a diesel "locomotive" engine and its impact on air quality was earlier reported by Corfa et al. (2004) and explained how in the early morning, during workdays, intensive activity observed at both bus and railway stations in France and how the pollution is accumulated in the station courtyard and the impact on the close vicinity.

Dincer and Elbir (2007) identified the emissions from the diesel locomotives and railcars are nitrogen oxides (NOX), hydrocarbon compounds (HC), carbon monoxide (CO), particulate matter (PM), sulfur dioxide (SO_2) and carbon dioxide (CO_2). The particles and heavy metals such as copper, zinc, manganese, chromium, nickel, and lead have been recorded in the environment due to railway activities (Burkhardt et al. 2008). Most of the released metals were particles emitted by friction processes with iron, followed by copper, zinc, manganese, chromium, nickel, vanadium and lead due to regular operation within the Swiss Federal Railways (SBB) network (7200 km tracks). The changes and abnormalities of stomata, number of stomata per unit area, number of epidermal cells per unit area and stomatal index for *Croton bonplandianum*, *Cannabis sativa* and

Calotropis procera were found due to diesel engines emission (Rani et al. 2006).

Soil of an area has a great impact on plants growth hence plants and soil are strongly influenced by each other (Kim et al. 1995). The survey of 40 sites exposure to diesel engine exhaust emission for respirable dust, elemental, organic and total carbon was measured. The results suggested that the measurement of elemental carbon could be used as an indicator of exposure to diesel engine exhaust emissions (Groves et al. 2000). Similarly the soil, polluted by petroleum based products loses its biological activity, negative effect on the biochemical and physicochemical characteristics of soils (Kucharski and Wyszkowska 2001, Wyszkowska et al. 2001). The changes in the physic-chemcial properties of the soil such as texture, water holding capacity, organic matter, calcium carbonate, pH, available sulfur and heavy metals affect the plant growth. Changes in leaf water relations under water stress were examined (Saito and Terashima 2004). Sulphur is predominantly available to plants as sulphate in soil and the sulphur demand is fulfilled by its uptake through the roots (Herschbach et al. 2005).

Adenanthera pavonina L. belongs to family Fabaceae is a tree native to tropical Asia. The red lensshaped 'circassian seeds' are curiosities with travelers, used for necklaces and ornamentals. The tree is sometimes called peacock flower fence, or red sandalwood tree. The tree produces large quantities of red seeds which are used as beads. In Fiji, it is found naturalized along roads, in dry forest and occasionally in dense forest, at elevations from near sea level to about 600 m (Smith 1985). The plant has been reported to be used medicinally for various ailments in tropical Asia. A red powder made from the wood is also used as an antiseptic paste. In ancient Indian medicine, the ground seeds are used to treat boils and inflammations. A decoction of the leaves is used to treat gout and rheumatism (Smith 1985). The seeds powder of *A. pavonina* reported to used in controlling the root rot diseases on mung bean (*Vigna radiata* L.) and (*Cicer arietimun* L.) by Ahmed et al. (2009).

Apart from roads, railways are one of the principal means of transportation. The specificity of rail transportation causes environmental problems (Wiłkomirski et al. 2012). There is an increasing concern about the effects of environmental pollution on plant growth by emissions of various environmental hazards emitted by railway transportation activities all around the world. The importance of tree in urban environment cannot be ignored. *A. pavonina* is a fast growing multipurpose tree species widely cultivated in the urban environment of city of Karachi. There is no information available on the impact of railway track polluted soil on the growth of *A. pavonina*. The aim of the present study was to investigate the effects of polluted soils collected from the Karachi railway tracks and compared with the Karachi University Campus soil (served as control site) on seedling growth and biomass productivity of *A. pavonina*.

MATERIALS AND METHODS

The soil samples of different polluted sites near the main railway tracks (Karachi Cantt. Station, Malir Halt, Malir-15, Landhi Junction) and non polluted site the Karachi University Campus were obtained at 30 cm depth and were brought to the laboratory in polythene bags. The soil samples were air dried and then sieved through 2 mm sieve. The healthy seeds of *Adenanthera pavonina* were collected randomly from the Karachi University Campus. The experiment was conducted under natural field conditions at the Department of Botany, University of Karachi. The top ends of the seeds were slightly cut with a clean scissor to remove any possible dormancy. The seeds were sown in large pots having garden soil at 1 cm depth and watered regularly. After two weeks of their germination, uniform size seedlings were transplanted in pots of 7.0 cm in diameter and 9.8 cm in depth containing the soil of Karachi Cantt. Station, Malir Halt, Malir-15, Landhi Junction and University Campus. There were five replicates for each soil and the experiment was completely randomized. The seedlings were irrigated after two days intervals. Pots were reshuffled weekly to avoid light/shade or any other environmental effect. After 8 weeks of growth, the seedlings were removed from pots and washed their roots with water. Root, shoot and leaves were separated to dry in an oven at 80ºC for 24 hours. Data on seedling root and shoot length and leaf area was obtained. Oven dried weights of root, shoot, leaves and total seedling dry weights were taken by electrical balance. Root/shoot ratio, leaf weight ratio, specific leaf area and leaf area ratio were determined as mentioned by Rehman and Iqbal (2009).

Mechanical analysis of soil was carried out in order to determine sand, silt and clay in percentage by Hydrometer method (Bouyoucos 1962). Maximum water holding capacity (M.W.H.C.) of soil was determined by the method of Keen (1931) while bulk density was determined according to Birkeland (1984). Calcium carbonate was determined by acid neutralization as described by Anon (1954). Soil pH was determined by direct pH reading meter (MP-220, Mettler, Toledo). Chlorides were found through titration by Mohr's Method (Allenet al., 1974).

Amount of organic matter was done according to Jackson (1958). Total Organic Carbon (TOC) was determined by converting organic matter and using the conversion factor 1.724 (organic matter/1.724 = g organic carbon) as carried out by Nelson and Sommers (1996). Soil available sulfur was determined by turbidity method as mentioned by Iqbal (1988). Electrical Conductivity (E.C.) and Total Dissolved Salts (T.D.S.) were determined by direct AGB 1000 electrical conductivity meter. Exchangeable sodium and potassium were carried out by flame photometer as determined by Richards (1954).

Data of various growth parameters of *A. pavonina* and different variables of soil samples was statistically analyzed by analysis of variance (ANOVA) and Duncan's Multiple Range Test at $p< 0.05$ level on personnel computer using statistical software COSTAT ver. 3.

RESULTS AND DISCUSSION

The seedling growth performance of *Adenanthera pavonina* L such as root, shoot lengths, seedling size, number of leaves, leaf area, plant circumference, seedling dry weight, root / shoot ratio, leaf weight ratio, specific leaf area and leaf area ratio in soil of railway track from Karachi Cantt. Station, Malir Halt, Malir 15, Landhi Junction was responded differently as compared to soil of University Campus (Table 1). The results showed that shoot length (20.78 cm), root length (15.46 cm) and seedling size (36.24 cm) were enhanced in the soil of Landhi Junction as compared to University Campus. The seedling growth of *A. pavonina* significantly ($p<0.05$) reduced for shoot length (9.28 cm), root length (5.30 cm), seedling size (14.58 cm), number of leaves (9.0) and leaf area (3.04 cm^2) than University Campus, Malir Halt, Malir-15 and Landhi Junction soils. Plant circumference (51.62 cm) of *A. pavonina* grown in Landhi Junction soil was high while, Karachi Cantt. Station soil significantly ($p<0.05$) diminished plant circumference (26.16 cm) in comparison with University Campus soil. Seedlings grown in Landhi Junction soil demonstrated significant ($p<0.05$) increase in seedling dry weight (1.64 g) of *A. pavonina* followed by Malir-15 and Malir Halt soil where as, prominent reduction was examined in Karachi Cantt. Station soil with relation to University Campus. Leaf weight ratio was high (0.37) in plants developed from the soil of Malir-15 when correlated with University Campus soil. *A. pavonina* raised from the soil of Malir-15 represented significant ($p<0.05$) increase in number of leaves (44), leaf area (7.30 cm^2), leaf weight ratio (0.37) and specific leaf area (29.20 cm^2g^{-1}). On the other hand, a significant reduction was observed in specific leaf area (20.14 cm^2g^{-1}) of *A. pavonina* in correlation with the plants grown on University Campus soil. Leaf area ratio was high (9.50 cm^2g^{-1}) in Karachi Cantt. Station soil than that of University Campus (8.35 $cm^2 g^{-1}$). A significant ($p<0.05$) reduction was investigated in leaf area ratio of the seedlings grown in Landhi Junction soil and was 4.43 $cm^2 g^{-1}$ which was less than other polluted points of railway tracks and University Campus.

Soil analysis of study area demonstrated that maximum water holding capacity, bulk density, porosity, chloride contents, pH, organic mater, total organic carbon, sulfur, electrical conductivity, total dissolved salts, extractable sodium and potassium were high in polluted area soil as compared to University Campus soil (Table 2 a and b). Polluted area soil was clay loam to sandy clay loam in texture while, University Campus had soil of clay loam in texture. Maximum water holding capacity was high (31.11 %) in Karachi Cantt. Station soil and it was low (23.84 %) in Malir-15, while moderate in University Campus soil. Bulk density and porosity were high (1.47 gcc^{-1}) and (54 %) in Malir Halt and Malir-15 soil, respectively as compared to University Campus. Chloride contents were high (875 mgL^{-1}) in Karachi Cantt. Station soil and low (80 mgL^{-1}) in Landhi Junction soil, while in University Campus soil chloride was absent. University Campus soil had pH 7.00 and polluted area soil was alkaline in nature with pH ranges 7.25 to 8.00. Organic matter and total organic carbon (4.82 % and 2.79 g) were high in soil of Landhi Junction. Available sulfur (150.00 $\mu g g^{-1}$) was found high in soil of Malir 15 and low (58.75 μg^{-1}) in University Campus soil. Electrical conductivity (19.00 $dScm^{-1}$) and total dissolved salts (13.90 mgL^{-1}) were found high in soil of Karachi Cantt. Station and were low in Malir 15. Karachi Cantt. Station soil had high extractable sodium and potassium and low in Landhi Junction soil.

Flora of an area normally depends on soil characteristics and environmental factors necessary for their growth and distribution. The soil near railway tracks of Karachi was found polluted by many factors such as cleaning and washing of train engines and coaches at railway stations, engine emission and leakage of oil on tracks which directly affects the plants near railway station. Pollutants derived from the railway emission can directly affect the foliage of plants by entering the leaf, destroying individual cells and reducing the plant's ability to produce food due to which reduction in shoot, root, seedling length, leaf area, plant circumference and biomass was occurred. The inhibitory effects of soil of Karachi Cantt. Station on seedlings growth of *A. pavonina* may be due to the discharge of toxic waste material during cleaning, washing and repairing activities. The polluted seed of *Albizia lebbeck, Dalbargia sissoo* and *Peltophorum roxburghii* showed significant decrease in germination percentage at Nazimabad, Liaquatabad, Gulshan-e-Iqbal (Mahmood and Iqbal 1989). Total chlorophyll, carotenoid, leaf area, plant height, fresh, dry biomass, corm yield, corm number, corm size, flower production, length of stigma and style, fresh and dry biomass of flower of *Crocus sativus* were significantly reduced by automobile emission (Rafiq et al., 2008). Pb concentration in soil of *D. sissoo* and *Cannabis sativa* decreased with increasing distance from the road (Pirzada et al. 2009).

Plants are excellent indicators of the state of the soil (SBB 2001). In the present study drastic effects of railway track soil were observed on growth performance of seedling of *A. pavonina* as compared to control site soil. The growth parameters of *A. pavonina* seedlings (shoot, root and seedling length, number of leaves, leaf area, plant cover, seedling dry weight, root / shoot ratio, leaf weight ratio, specific leaf area and leaf area ratio) were recorded in soil of Karachi Cantt. Station, Malir Halt, Malir 15, Landhi Junction as compared to University Campus soil. The reduction in seedling growth of *A. pavonina* in Karachi Cantt. Station soil might be due to under lying edaphic factors such as high electrical conductivity, total dissolved salts, chloride contents, extractable sodium and potassium in the soil. These results were supported by the study of Shereen et al., (2005) who reported that salinity caused a significant suppression in early seedling growth after transplantation in a saline solution. These findings were also favored by Rehman and Iqbal (2009) that the highest amount of total soluble salts restricted the growth of *Prosopis juliflora* populations. The nutrient availability to plants is highest at 6.5 pH and lowest toxicity (Haris et al. 1996). High pH of soil generally could also affect plant growth and nutrient availability (Williams 2003). In comparative studies the growth of *A. pavonina* was found better in Landhi Junction soil. The soil collected from Landhi Junction had better maximum water holding capacity, bulk density, porosity and moderate calcium carbonate and pH than other areas soil which might support the growth of *A. pavonina*. Soil characteristics normally correlated with plant growth and soluble salts produced a significant impact on plant maturity (Tivy 1982). The enhancement in seedling growth of same species in the area was significantly associated with maximum water holding capacity of soil, calcium carbonate, pH, chloride, exchangeable sodium and potassium. Soil acidity and the levels of main plant nutrients (N, P, Ca, Mg) are the most important factors influencing plant growth in railway tracks. The soil sample having soil pH value ranged from 7.25 to 8.0 and are in close agreement with respect to basement soil reaction. It is worth mentioning that Wilkomirski et al. (2012) reported the pH varied from 7.37 to 8.00 in H_2O in Poland. Murray et al. (2000) also recorded mean soil pH in the range from 7.2 to 8.3 depending on the area three inactive railway yards on the Island of Montreal (Canada). In present study the soil characteristics of the study area were found affected. Mehmood and Iqbal (1995) had reported a significant effect of soil characteristics resulted in a negative impact on the distribution of vegetation. A significant variation in physio-chemical parameters of soil (M.W.H.C., bulk density, soil porosity, sand, silt, clay soil texture class and $CaCO_3$, Cl, pH, Organic matter, total organic carbon, sulfur, electrical conductivity, total dissolved salts, exchangeable sodium and potassium of different sites) were also observed. Results showed that seedling growth parameters of *A. pavonina* significantly $p<0.05$ decreased in the soil of Cantt Station in comparison to control. The highest seedling growth of *A. pavonina* was observed in Landhi Juncion soil as compared to control. The highest seedling growth and biomass of the *A. pavonina* seedlings was due maximum percentage of organic matter.

Conclusion: The conclusion which could be drawn from this study is that the seedling growth of *A. pavonina* was severely affected in polluted soil of Cant Station due various types of activities such as repairing activities and release of emission exhaust from train engine. *A. pavonina* was more sensitive to railway exhaust emission. This sensitivity for different growth parameters was more prominent in soil of cant station. The study also concluded that maximum water holding capacity, bulk density, porosity, chloride contents, pH, organic matter, total organic carbon, sulfur, electrical conductivity, total dissolved salts, extractable sodium and potassium were high in polluted area soil as compared to University Campus soil.

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Table 1. Effects of different soils on growth variables of *Adenanthera pavonina* in field conditions.

Sites	Shoot length (cm)	Root length (cm)	Seedling length (cm)	No. of leaves	Leaf area (cm^2)	Circumference (cm)	Seedling dry weight (g)	Root/shoot Ratio	Leaf Weight Ratio	Specific Leaf Area ($cm^2 g^{-1}$)	Leaf Area Ratio ($cm^2 g^{-1}$)
A	11.90±0.27b	7.38±0.42b	19.28±0.66b	14±1.17b	3.51±0.11a	32.26±0.96b	0.42±0.01b	0.30±0.01a	0.32±0.23b	23.40±2.22b	8.35±0.52b
B	9.28±0.50a	5.30±0.21a	14.58±0.70a	9±0.80a	3.04±0.07a	26.16±0.85a	0.32±0.01a	0.32±0.02a	0.30±0.08ab	25.33±2.33a	9.50±0.49a
C	12.42±0.43b	7.96±0.31b	20.38±0.56b	22±1.17c	4.23±0.32b	35.40±0.58c	0.61±0.02c	0.32±0.02a	0.33±0.15abc	20.14±2.34c	6.93±1.17c
D	19.44±0.75c	12.62±0.83c	32.06±1.62c	44±0.75d	7.30±0.18c	39.22±0.82d	1.38±0.03d	0.34±0.01a	0.37±0.03bc	29.20±0.50d	5.28±0.18c
E	20.78±0.82c	15.46±0.25d	36.24±0.95d	36±2.10e	7.28±0.20c	51.62±0.48e	1.64±0.01e	0.35±0.01a	0.36±0.02c	24.26±0.34b	4.43±0.11d

Symbol used: **A** = University Campus **B** = Karachi Cantt. Station **C** = Malir Halt **D** = Malir 15 **E** = Landhi Junction

Numbers followed by the same letter in the same column are not significantly different according to Duncan Multiple Range Test at $p<0.05$ level.
± Standard Error

Table 2(a): Physical properties of soil.

Sites	**M.W.H.C. (%)**	**B.D (gcc^{-1})**	**Porosity (%)**	**Sand (%)**	**Silt (%)**	**Clay (%)**	**Soil texture class**
A	26.59±0.18b	1.36±0.3b	49±1.00a	24.34±0.91a	44.28±0.10a	31.42±1.01a	**Clay loam.**
B	31.11±0.24c	1.34±0.4b	49±2.00a	41.80±1.00b	29.00±0.50b	29.20±1.00a	**Clay loam**
C	24.17±0.11a	1.47±0.01c	44±1.00a	60.80±0.94c	31.00±0.50b	08.20±0.44b	**Sandy clay loam**
D	23.84±0.30a	1.23±0.03a	54±3.00b	64.08±1.00c	13.00±0.50c	22.92±0.55c	**Sandy clay loam**
E	**24.45±0.01a**	**1.43±0.01bc**	**46±0.50a**	**60.08±0.20c**	**11.00±0.10c**	**28.92±0.10a**	**Sandy clay loam**

Table 2(b): Chemical properties of soil.

Sites	**$CaCO_3$ (%)**	**Cl (mgL^{-1})**	**pH**	**O.M. (%)**	**T.O.C. (g)**	**S (μgg^{-1})**	**EC ($dScm^{-1}$)**	**TDS (mgL^{-1})**	**Ex. Na (ppm)**	**Ex. K (ppm)**

A	21.6±0.01a	00.00±0.00a	7.00±0.02a	4.50±0.03c	2.61±0.13b	58.75±0.04a	19.0±0.50a	13.9±0.40a	190.00±6.00b	**156.00±3.00a**
B	13.0±0.40d	875.0±10.00e	7.25±0.04b	4.39±0.03a	2.55±0.01b	142.50±4.00d	19.6±0.30a	14.1±0.55a	1340.00±25.00d	**180.00±7.00a**
C	16.7±0.20c	190.0±2.00d	7.40±0.01c	3.35±0.02a	1.94±0.01a	71.25±1.00b	4.4±0.20b	3.3±0.20b	300.00±15.00c	**160.00±11.00 a**
D	14.7±0.10b	100.0±3.00c	8.0±0.04d	3.90±0.01b	2.26±0.01c	150.00±4.00d	1.5±0.40c	1.1±0.20c	120.00±5.00a	**80.00±6.00b**
E	**17.4±0.29c**	**80.0±5.00b**	**7.50±0.07c**	**4.82±0.02d**	**2.79±0.01d**	**91.25±3.00c**	**2.1±0.20c**	**1.6±0.20c**	**100.00±2.00a**	**80.00±3.00b**

Symbol used:
A = University Campus **B** = Karachi Cantt. Station **C** = Malir Halt **D** = Malir 15
E = Landhi Junction

M.W.H.C. = Maximum Water Holding Capacity **B.D.** = Bulk Density
$CaCO_3$ = Calcium carbonate
Cl = Chlorides **OM** = Organic matter
T.O.C. = Total Organic Carbon
EC = Electrical Conductivity **TDS** = Total Dissolved Salts
Ex. Na = Exchangeable sodium
Ex. K = Exchangeable potassium

Numbers followed by the same letter in the same column are not significantly different according to Duncan Multiple Range Test at $p<0.05$ level.
± Standard Error

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