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The Effects of Industrial Soil Pollution on *Prosopis juliflora* Swartz Growth Around Karachi

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Abstract. Study of the effect of soils of towel, garment, rubber and ply-wood factories of Korangi and Landhi industrial estates of Karachi and that of the University of Karachi on the growth of *Prosopis juliflora* Swartz plants growing in these areas demonstrated detrimental effect of industrial soils on the growth of plants of all the areas particularly on the plants growing at the University site.

Keywords: plant growth, *Prosopis juliflora*, soil pollutants, industrial pollution

Introduction

Rapid industrialization and phenomenal growth in population have created environmental pollution problem in Karachi city (Iqbal and Shafiq, 1999a). Major contributors to the environmental degradation include the industrial sector. Naqvi and Khattak (1995) reported increased amount of heavy metals, chromium, nickel, copper and lead in the waste effluents of Landhi Industrial Trading Estate of Karachi, Pakistan. Kullberg (1974) has described damages to vegetation caused by industrial effluents particularly to water plants. Iqbal and Qadir (1973) observed higher reduction in seed germination, root and shoot length in seeds collected from the industrial polluted areas as compared to other areas. Various kinds of industrial pollutants have adverse effects on *Triticum aestivum* var. UP-262 (Habib and Iqbal, 1996). Physical properties of soil, such as soil strength, bulk density, texture and structure, influences greatly the root penetration, growth and yield of various crops (Gerard *et al*., 1982).

Prosopis juliflora (Family, Mimosaceae) is a perennial deciduous thorny shrub/small tree, used as forage for cattle. It provides fuel wood; its timber stabilizes sand dunes and it is used as shade plant and wind breaker also (Khoshoo and Subramanyam, 1985). *P. juliflora*, *Abutilon indicum* and *S. holosericea* are distributed world-wide (Atiq-ur-Rehman and Iqbal, 2008). It is found in South Africa, India, West Indies and Mexico and has been recorded in Pakistan as well. *P. juliflora* is the most dominant species of plants growing in the Karachi University and is among the eight leading species of plants growing in the vicinity of Korangi and Landhi industrial areas (Atiq-ur-Rehman, 2007). In soil of Malir river, some heavy metals such as lead, copper and zinc were detected in large amounts, which influenced the composition of plant communities at this locality (Qamar-uz-Zaman and Iqbal, 1994).

In the present study, an effort has been made to study the destructive and hazardous role of towel, garment, rubber and ply board industries etc. in the proximity of Korangi and Landhi industrial places of Karachi, with reference to their effect on growth of *P. juliflora* in comparison to that of the Karachi University soil and plants.

Materials and Methods

The experiment was conducted in greenhouse at the Department of Botany, University of Karachi under uniform natural environmental conditions. Healthy and uniform-sized seeds of *Prosopis juliflora* Swartz, were chosen from Korangi and Landhi industrial areas of Karachi and Karachi University Campus. Due to hard seed coat, the seeds were slightly cut at one end and sown in garden soil (loam soil) at 1 cm depth in large pots, and were irrigated daily. After 21 days, uniform-sized seedlings were transplanted to pots of 19.8 cm dia and 9.6 cm depth, in soils collected from a towel, a garment, a tech rubber and a tech ply board factories of the Korangi and Landhi industrial areas of Karachi at 0.30 cm depth. The soil of Karachi University was used as control. 50% Soil of the respective areas (including control) was mixed with 50% garden soil (one part manure + two parts fine sand), since, in the preliminary studies, pure soils of the industrial area hardly showed any response to seed germination and seedling growth. There were six replicates for each treatment and the experiment was completely randomized. Only one seedling was grown in each pot and plants were irrigated daily. Every week, pots were reshuffled to avoid light/shade or any other greenhouse effect. Seedling height, number of leaves and plant cover were recorded after every week for eight weeks.

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After eight weeks, number of leaflets and leaf area of each plant were recorded and all the plants of *P. juliflora* were carefully removed from the pots and washed thoroughly to measure root, shoot and seedling length. Root, shoot and leaves were separated for drying in an oven at 80 °C for 24 h. Oven-dried weight of root, shoot and leaves and total plant dry weight were determined. Root/shoot ratio, leaf weight ratio, specific leaf area and leaf area ratio were also determined as follows:

Determination of growth variables

$$\text{Root/shoot ratio} = \frac{\text{root dry weight}}{\text{shoot dry weight}}$$

$$\text{Leaf weight ratio} = \frac{\text{leaf dry weight}}{\text{total plant dry weight}}$$

$$\text{Specific leaf area } (cm^2/g) = \frac{\text{leaf area}}{\text{leaf dry weight}}$$

$$\text{Leaf area ratio } (cm^2/g) = \frac{\text{leaf area}}{\text{total plant dry weight}}$$

For soil analysis, two soil samples of each site were air-dried, lightly crushed and passed through a 2 mm sieve and kept in the laboratory. For mechanical analysis of soil, coarse sand was selected using 0.05 mm sieve (USDA, 1951). Maximum water holding capacity (W.H.C.) was measured by the method of Keen (1931). Soil organic matter was determined according to the methods of Jackson (1958). Calcium carbonate concentration was determined by acid neutralization as described by Qadir *et al.* (1966). Bower and Wilcox (1965) methodology was used to determine total soluble salts whereas**,** soil pH was recorded by a direct MP 220 pH Meter (Mettler, Toledo). Available sulphate in soil was determined by the turbidity method as described by Iqbal (1988), using a colorimeter (Photoelectric Colorimeter AE-11M). Soil analysis was also conducted for heavy metals. In this regard, one g dried soil sample was taken in 50 ml beaker and digested with 5 ml concentrated nitric acid (HNO_3) + 5 ml concentrated perchloric acid ($HClO_4$), through heating at 90 °C for two and a half hours. Thereafter, little amount of distilled water was added in the digested residue and filtered through Whatman filter paper No. 42. Solution was made up to 50 ml using distilled water and was diluted 10 times for copper, zinc and chromium analyses by atomic absorption spectrophotometer (Perkin Elmer Model No. 3100).

All data was statistically analyzed by ANOVA (Steel and Torrie, 1984) and DMRT (Duncan, 1955) ($p<0.05$) using personal computer software packages, Costat version 3.0 and SPSS version 10.0.

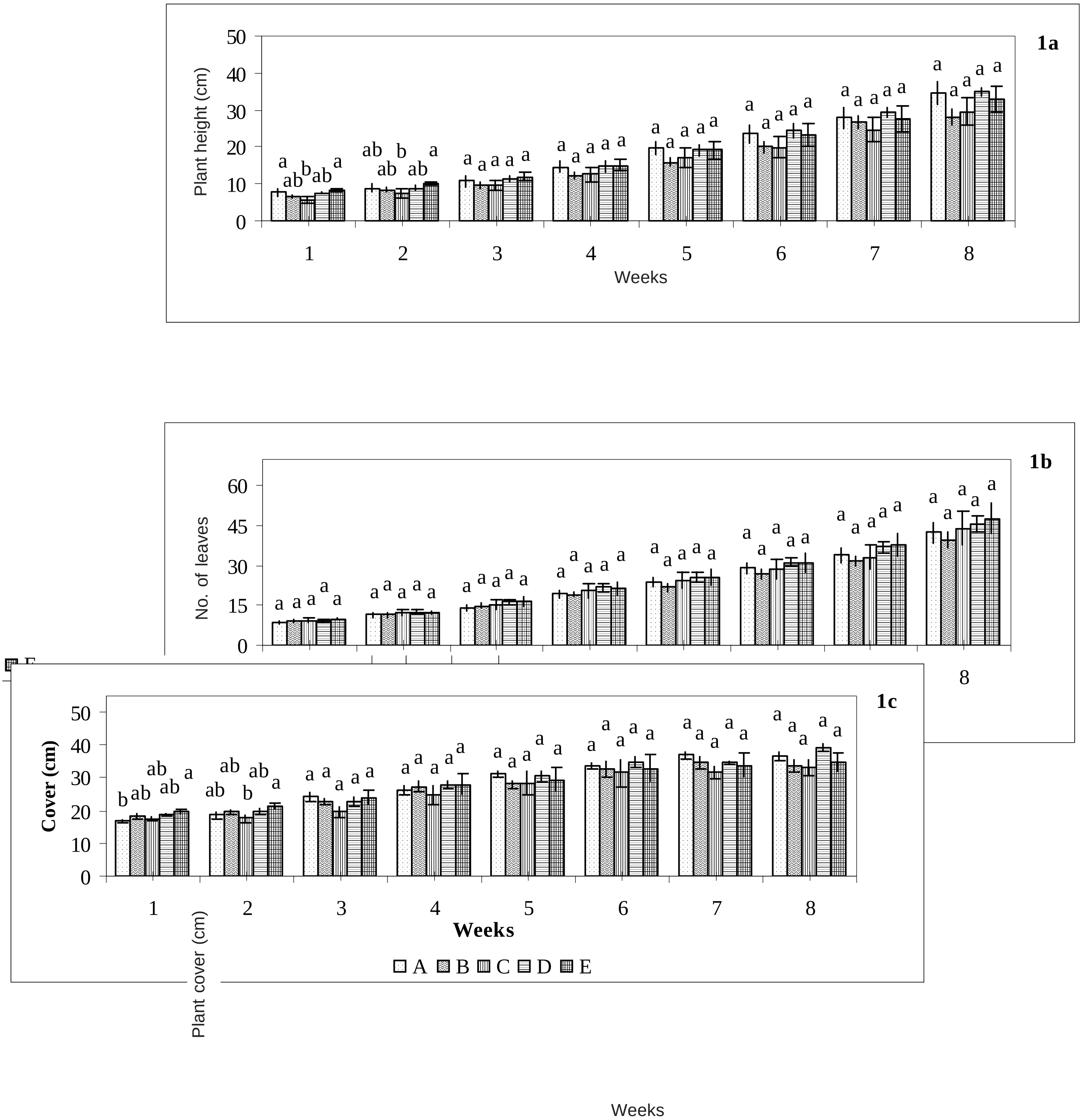
Reduction in percentage of growth was determined in treated soils of the factories relative to control soil using the following formula:

$$\text{Reduction in growth (\%)} = \frac{\text{growth in control soil - growth in treated soil}}{\text{growth in control soil}} \times 100$$

Results and Discussion

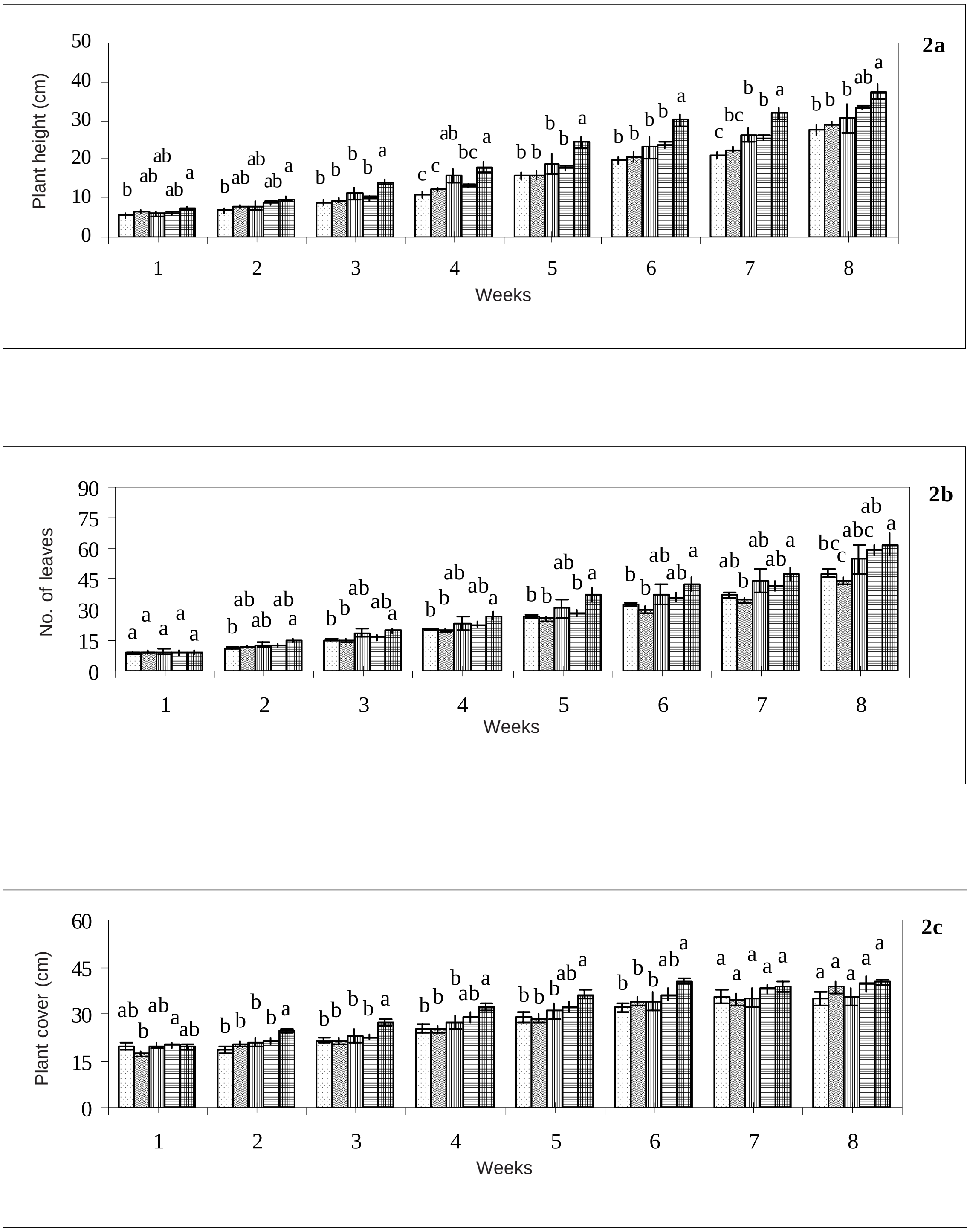
Plant height (28.00 cm) (Fig. 1a), number of leaves (39.33) (Fig. 1b) of *P. juliflora* of the university population were considerably retrogressed by the towel factory soil while the garment factory soil noticeably hampered the plant cover (33.17 cm) (Fig. 1c) comparative to the plant height (34.75 cm), number of leaves (42.50) and plant cover (36.58 cm) in the university soil. On the other hand, whole industrial zone soils augmented plant height, predominantly that of the tech ply board factory soil (37.50 cm) (Fig. 2a) as correlated to the plant height (27.67 cm) in university soil. Number of leaves declined only in the towel factory soil (44.17) (Fig. 2b) than in the university soil (47.83) while plant cover (40.17 cm) (Fig. 2c) was apparently amplified in the tech ply board factory soil relative to plant cover (35.08 cm) in the university soil. Atiq-ur-Rehman (2007) also reported earlier increase in growth in *Leucaena leucocephala, T. populnea, Peltophorum pterocarpum* and *Azadirachta indica* in a tech ply board factory soil comparative to other factories soils.

Almost aggregate growth assortments of *P. juliflora* from University area were poor except shoot dry weight in the towel factory in comparison to the garment, tech ply board and tech rubber factory soils. Drastically lesser growth was examined in shoot, seedling length, leaflets numbers, leaf area, leaf dry weight, root/shoot ratio and leaf weight/leaf area ratio of *P. juliflora* of university population in the towel factory soil correlatively to the university soil (Table 1 and 2). *P. juliflora* plants from industrial locations, had enhanced growth in the garment, tech rubber and tech ply board factories soils whereas the towel factory soil relatively more conversely affected the industrial plants. Number of leaflets, roots, shoots, leaves and total plant dry weight were conspicuously minimized in the plants of industrial estates growing on towel factory soil as compared to that of the university soil (Table 1 and 2). Total soluble salts were in appreciable quantity in the entire industrial soils particularly the towel factory soil had the highest amount of total soluble salts than the university soil (Table 3) which produced restricted growth in both the populations of *P. juliflora*. These results tally with those of Shereen *et al*. (2005) who reported that early seedling stage of rice plants showed that salinity caused a significant repression in seedling growth very soon after transplanting in a saline solution.



Soil code: ☐ = Karachi University; = Towel factory; = Garment factory; = Tech rubber factory; = Tech plyboard factory

Fig. 1. Plants from seeds of *Prosopis juliflora*, collected from Karachi University, in soils of different areas. (50% soil was mixed with 50% garden soil). Statistical significance was determined by analysis of variance; same letters in a row are not significantly different ($p<0.05$) according to Duncan's Multiple Range Test.



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Figs. 2. Plants of *P. juliflora* from seeds, collected from Korangi and Landhi industrial areas, in soils of different areas. (50% soil was mixed with 50% garden soil). Statistical significance was determined by analysis of variance; same letters in a row are not significantly different ($p<0.05$) according to Duncan's Multiple Range Test.

Table 1. Growth of two populations of *Prosopis juliflora* in soils of different areas

Plants	Treatment[a]	Root length (cm)	Shoot length (cm)	Seedling length (cm)	No. of leaflets	Leaf area (cm^2)	Root dry weight (g)	Shoot dry weight (g)	Leaf dry weight (g)	Total plant dry weight (g)	Root/ shoot ratio	Leaf/ weight ratio	Specific leaf area (cm^2/g)	Leaf area ratio (cm^2/g)
PJ[1]	A	22.07[b] ±2.19	36.00[a] ±2.66	58.07[ab] ±2.17	1102.56[a] ±104.52	127.20[a] ±13.70	0.17[a] ±0.01	0.28[a] ±0.04	0.44[a] ±0.05	0.89[a] ±0.10	0.65[a] ±0.11	0.49[a] ±0.01	295.54[ab] ±17.66	146.31[ab] ±9.15
	B	20.55[b] ±2.16	29.45[a] ±2.18	50.00[b] ±1.04	982.00[a] ±101.15	93.62[a] ±9.66	0.15[a] ±0.02	0.29[a] ±0.04	0.33[a] ±0.03	0.77[a] ±0.06	0.57[a] ±0.12	0.44[a] ±0.04	284.73[b] ±10.84	123.70[b] ±11.06
	C	21.77[b] ±0.88	31.01[a] ±3.78	52.78[b] ±4.13	1079.33[a] ±199.99	94.16[a] ±20.28	0.14[a] ±0.03	0.25[a] ±0.07	0.37[a] ±0.08	0.76[a] ±0.18	0.75[a] ±0.16	0.50[a] ±0.02	259.52[b] ±19.22	130.47[ab] ±11.81
	D	27.05[a] ±1.30	36.10[a] ±1.21	63.15[a] ±1.43	1131.11[a] ±90.01	117.87[a] ±8.07	0.19[a] ±0.03	0.30[a] ±0.03	0.43[a] ±0.02	0.92[a] ±0.07	0.61[a] ±0.04	0.47[a] ±0.01	274.64[b] ±14.65	130.16[ab] ±8.19
	E	20.13[b] ±1.19	34.27[a] ±3.52	54.40[b] ±3.13	1249.11[a] ±209.16	133.32[a] ±28.04	0.17[a] ±0.03	0.25[a] ±0.06	0.40[a] ±0.09	0.82[a] ±0.17	0.76[a] ±0.16	0.48[a] ±0.03	342.32[a] ±25.04	163.86[a] ±13.47
	LSD	4.76	8.23	7.68	437.86	51.18	0.07	0.15	0.17	0.37	0.36	0.07	52.76	31.75
PJ[2]	A	21.43[a] ±1.49	28.80[b] ±1.48	50.23[b] ±2.13	1287.78[b] ±107.48	125.45[b] ±13.39	0.22[bc] ±0.02	0.32[bc] ±0.03	0.46[b] ±0.03	1.00[bc] ±0.06	0.71[a] ±0.05	0.46[a] ±0.02	275.92[a] ±25.63	127.56[a] ±12.98
	B	22.90[a] ±1.73	30.57[b] ±1.26	53.47[ab] ±2.59	1166.56[b] ±63.83	143.46[ab] ±11.55	0.20[c] ±0.02	0.27[c] ±0.03	0.44[b] ±0.03	0.91[c] ±0.05	0.77[a] ±0.07	0.49[a] ±0.02	333.32[a] ±40.27	162.36[a] ±21.17
	C	25.30[a] ±3.09	31.68[b] ±3.87	56.98[ab] ±3.21	1468.78[ab] ±231.25	153.43[ab] ±23.57	0.30[ab] ±0.05	0.35[abc] ±0.08	0.52[ab] ±0.09	1.17[b] ±0.14	1.52[a] ±0.72	0.43[a] ±0.06	302.96[a] ±30.53	129.53[a] ±18.07
	D	22.17[a] ±0.93	34.13[ab] ±0.62	56.30[ab] ±1.24	1574.78[ab] ±101.74	156.23[ab] ±9.28	0.26[abc] ±0.02	0.44[ab] ±0.06	0.56[ab] ±0.04	1.26[ab] ±0.09	0.63[a] ±0.06	0.46[a] ±0.03	282.31[a] ±15.49	125.81[a] ±7.70
	E	21.30[a] ±2.66	38.70[a] ±1.72	60.00[a] ±2.29	1784.67[a] ±209.90	193.91[a] ±22.48	0.32[a] ±0.03	0.49[a] ±0.04	0.65[a] ±0.04	1.45[a] ±0.08	0.65[a] ±0.04	0.46[a] ±0.03	299.29[a] ±25.56	135.03[a] ±16.30
	LSD	6.21	6.12	6.93	457.77	49.76	0.08	0.14	0.15	0.26	0.95	0.10	83.44	46.39

Soil code: A = Karachi University; B = towel factory; C = garment factory; D = rubber factory; E = tech plyboard factory (50% sample soil + 50% garden soil); PJ[1] = seeds collected from Karachi University; PJ[2] = seeds collected from Korangi industrial areas; statistical significance was determined by analysis of variance; numbers followed by the same letters in the same column are not significantly different, according to Duncan's Multiple Range Test; LSD = least significance difference, values at $p<0.05$ level ± standard error.

Root, total plant dry weights and specific leaf area of University population were virtually subdued while only leaf weight ratio of industrial population was impeded by the garment factory soil. Atiq-ur-Rehman and Iqbal (2007a) also reported distinct repression in *L. leucocephala* plant in garment factory soil correlative to the Karachi university soil. Organic matter was deficient, whereas zinc concentration was greater in this soil relative to the university soil which might have caused decline in the growth of plants particularly in the plants of University site. This result is in agreement with the report of Iqbal and Shafiq (1999b) about adverse effects of Cu and Zn on seed germination and seedling growth of wheat of *Triticum aestivum* var. J 78 and var. P 85.

Leaf area, leaf dry weight, root/shoot and leaf weight/leaf area ratios and specific leaf area of the university population were restricted in the rubber factory soil. The tech rubber factory soil had elevated magnitude of coarse sand, literal concentrations of calcium carbonate and chromium and lowest quantity of water holding capacity as related to the university soil. Soil texture and water holding capacity presented factual correlation and influenced the growth in the rubber factory soil. Iqbal and Atiq-ur-Rehman (2002) reported that increase in concentration of Cr reduced the dry weight of *L. leucocephala*.

Root length and shoot dry weight of the university population was minimized by the tech ply board factory soil while root length and root/shoot ratio were simply deteriorated in industrial region population by the tech ply board factory soil as compared to the university soil. Available sulphate and copper concentration were adequately increased in the tech ply board factory soil in comparison to the university soil which might be considered decrease in growth of plants.

Table 2. Percentage reduction in growth of two populations of *Prosopis juliflora* in soils of different factories versus control

Plants	Soil	Plant height	No. of leaves	Plant cover	Root length	Shoot length	Seedling length	No. of leaflets	Leaf area	Root dry weight	Shoot dry weight	Leaf dry weight	Total plant dry weight	Root/ Shoot ratio	Leaf weight ratio	Specific leaf area	Leaf area ratio
PJ[1]	A	19.4	7.5	8	6.9	18.2	13.9	10.9	26.4	11.8	3.6+	25.0	13.5	12.3	10.2	3.7	15.5
	B	15.3	3.5+	9.3	1.4	13.9	9.1	2.1	26.0	17.6	10.7	15.9	14.6	15.4+	2.0+	12.2	10.8
	C	0.7+	7.1+	7.5+	22.6+	0.3+	8.7+	2.6+	7.3	11.8+	7.1+	2.3	3.4+	6.2	4.1	7.1	11.0
	D	5.0	12.2+	5	8.8	4.8	6.3	13.3+	4.8+	0.0	10.7	9.1	7.9	16.9+	2.0	15.8+	12.0+
PJ[2]	A	5.1+	7.7	9.7+	6.9+	6.1+	6.5+	9.4	14.4+	9.1	15.6	4.3	9	8.5+	6.5	20.8+	27.3+
	B	10.2+	14.3+	0.7+	18.1+	10.0+	13.4+	14.1+	22.3+	36.4+	9.4+	13.0+	17.0+	114.1+	6.5+	9.8+	1.5+
	C	21.1+	24.0+	13.0+	3.5+	18.5+	12.1+	22.3+	24.5+	18.2+	37.5+	21.7+	26.0+	11.3	0.0	2.3+	1.4
	D	35.5+	29.3+	14.5+	0.6	34.4+	19.5+	38.6+	54.6+	45.5+	53.1+	41.3+	45.0+	8.5	0.0	8.5+	5.9+

A = towel factory soil; B = garment factory soil; C = tech rubber factory soil; D = tech ply board factory soil; PJ[1] = seeds were collected from Karachi University site; PJ[2] = seeds were collected from Korangi industrial areas; + = percentage increase.

Table 3. Soil characteristics of Karachi University and industrial areas soils

Sites	Coarse sand (%)	W.H.C. (%)	Organic matter (%)	$CaCO_3$ (%)	Total soluble salts (%)	pH (µg/g)	Available sulphate	Cu (µg/g)	Zn (µg/g)	Cr (µg/g)
A	58±0[b]	27±0[b]	2.0±0.3[b]	17.8±0.3[c]	5.9±0.7[c]	8.4±0.0[a]	8±0d	0.002±0.002[c]	0.029±0.017[bc]	6.066±0.046[a]
B	24±2[d]	29±3[b]	2.1±0.2[b]	29.5±1.5[b]	14.0±2.0[a]	8.0±0.1[ab]	575±13[a]	0.023±0.012[b]	0.033±0.001[b]	4.139±0.093[b]
C	47±0[c]	31±2[b]	0.9±0.0[c]	24.5±0.5[b]	8.0±0.0[c]	8.3±0.1[a]	108±23[c]	0.008±0.002[bc]	0.090±0.002[a]	4.229±0.111[b]
D	88±1[a]	17±3[c]	1.1±0.1[c]	36.5±2.5[a]	12.0±0.0[ab]	8.2±0.1[ab]	401±11[b]	0.002±0.002[c]	0.019±0.002[bc]	6.899±0.978[a]
E	26±2[d]	40±0[a]	3.3±0.4[a]	17.5±1.5[c]	9.0±1.0[bc]	7.8±0.2[b]	608±45[a]	0.074±0.002[a]	0.003±0.002[c]	1.404±0.406[c]
LSD	5	8	0.8	5.4	3.8	0.4	86	0.02	0.027	1.738

A = Karachi university soil; B = towel factory soil; C = garment factory soil; D = tech rubber factory soil; E = tech ply board factory soil; W.H.C. = water holding capacity; numbers followed by the same letters in the same column are not significantly different; LSD = least significance difference; values at $p<0.05$ level; ± = standard error.

According to Bell *et al*. (1979), constant SO_2 concentration causes significant reductions in the dry matter accumulation and yield of *Lolium perenne* L. cv. S23. Additionally, most of the industrial sites soils had lower range of coarse sand and chromium concentrations and sufficient water holding capacity which may cause sufficient growth in industrial plant population.

Conclusion

It could be concluded that *Prosopis juliflora* plant population of the university campus was sensitive to industrial estates soils whereas the plant native to Korangi and Landhi industrial regions, remarkably tolerated minimum growth hindrance in industrial zone soils. Atiq-ur-Rehman (2007) as well reported that *Albizia lebbeck* growth was intensely retrograded while *T. populnea* growth was definitely greater in the soils of Korangi industrial sites. He also elucidated that *A. lebbeck* and *L. leucocephala* growth was severely restrained by dissimilar industrial soil ratios especially at enhanced concentration of 75% towel factory soil; *A. indica* seedlings were also harshly impaired in the towel factory soil. Atiq-ur-Rehman and Iqbal (2007b) also observed that *P. juliflora* from the university site was evidently obstructed by the industrial area soil extracts over the *P. juliflora* of industrial locations. So, towel factory soil was more deleterious for both of the populations especially for the University plant population and is excessively noxious for most of the plants.

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