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The effects of different soils types on seedling growth of *Gliricidia sepium* (Jacquin) Kunth ex Walp. *(Fabaceae)*

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Soil pollution due to industrial activities affecting growth performance of plants at regional and global level. This comparative study revealed the variable effects of soil of Karachi University Campus and Industrial area viz. Indus Battery, Universal Chemicals, Haroon Textile and National Foods Ltd. Factories treatment on the seedling growth performance of *Gliricidia sepium* Kunth ex Walp. in terms of root, shoot, seedling length, plant cover, number of leaves, leaf area, seedling fresh weight, root, shoot, leaf, total plant dry weight, root/shoot ratio, leaf weight ratio, specific leaf area, leaf area ratio. The treatment of Indus Battery Factory soil significantly ($p<0.05$) decreased root, shoot, seedling length and seedling dry weight of *G. sepium* as compared to Karachi University Campus, Universal Chemicals, Haroon Textile and National Foods Ltd. Factories soil treatment. The seedlings of *G. sepium* showed significantly ($p<0.05$) better root, shoot, plant cover, leaf size, number of leaves and seedling dry weight in soil of National Foods Ltd. as compared to Universal Chemicals and Haroon Textile. These findings provided an idea about the sensitivity of *G. sepium* seedlings in response to different soil treatment of industrial areas.

Keywords: industrially polluted soil, seedling growth, soil physico-chemical properties.

INTRODUCTION

Karachi is the largest industrial city of Pakistan. The indiscriminate discharge of pollutants from the industries located in Sindh Industrial Trading Estate (S.I.T.E.) areas are principal source of environmental pollution due to non-compliance of environmental regulations and implementation of proper discharge of industrial solid, liquid and gaseous wastes. The development of industrial projects showed a profound impact on the immediate environment and is responsible for a great threat to living organisms. The soil of the industrial area was affected by different types of pollutants likewise, solid waste, burning of fossil fuels, sewerage materials, particulate matter and heavy metals. The uptake of heavy metal produced negative impact on plant growth and environment (Weis and Weis, 2004; Suntonvongsagul et al., 2007; Shafiq and Iqbal, 2012; Shafiq et al., 2019). The addition of industrial pollutants in soil surface also affect the physiochemical properties of soil structure, soil pH, total dissolved salts, soil and exchangeable nutrients (Iqbal et al., 2008). The vegetation of the area absorbs the toxic substances form industrially polluted soils and translocate in their different parts.

Gliricidia sepium (Jacq.) Kunth ex Walp. is a multipurpose leguminous tree (Chadhokar, 1982; (Elevitch and Francis, 2006) belongs to the family *Fabaceae* and originated in Central America. This species provides green manure, fodder and fuel wood (Wise and Cacho, 2005). It grows well in areas with evenly distributed precipitation with an annual rainfall of 900 to 1500 mm and also performs well in seasonal dry periods. It tolerates rocky as well as shallow soils, which are characteristic of degraded lands due to erosion, and even in soils with heavy textures which are common in lower lying areas (De-Costa and Surenthran, 2005). In addition to increasing the soil organic matter, leaves of this tree increase soil nitrogen contents (Cherr et al., 2006). Application of *G. sepium* was shown to enhance the soil nitrogen contents in the top soil as compared to in the sub soil (Solangi and Iqbal, 2012).

The study of responses of plants' growth to toxic industrial pollutants has become the subject of great interest in recent years. A little work has been done on the impact of industrial area soil on plant growth and scanty literature is available on *G. sepium* seedling growth of agroeconomic important tree. This study aimed to compare the effects of five different soils collected from Karachi University Campus; Indus Battery Factory, Universal Chemicals factory, Haroon Textile Factory and National Foods Ltd. factory, on seedling growth of an important multipurpose leguminous tree, *Gliricidia sepium* (Jacquin) Kunth ex Walp. (Fabaceae).

MATERIALS AND METHODS

The seed germination and seedling growth experiments were carried out in greenhouse at the Department of Botany, University of Karachi, Pakistan. The vigorous and the same size seeds of *Gliricidia sepium* (Jacq.) Kunth ex Walp. were collected from the plant species growing in the Karachi University Campus. The micropyle ends of seeds were cut to some extent with scissors to break seed dormancy and seeds were sown in a garden soil at 1.00 cm depth in earthen pots and irrigated with tap watered daily. The same size seedlings were transplanted after two weeks in plastic pots of 20 cm diameter and 9.8 cm in depth having the soil of Karachi University Campus as control and industrial polluted soils. There were five replicates for each treatment and the pots were arranged in completely randomized design. One seedling was planted in each pot and the plants were watered regularly and pots were shuffled every week. Seedling growth parameters viz seedling height, number of leaves, leaf area and plant circumference were noted weekly for eight weeks. After eight weeks, the seedlings were taken out from pots, washed their roots with tap water and measured root, shoot and seedlings length, plant circumference, number of leaves and leaf area. The root, shoot and leaves were dried up in an oven at 80 °C for 24 hours and their oven dried weights were determined. The root/shoot ratio, leaf weight ratio, specific leaf area and leaf area ratio were also determined as described by Rehman and Iqbal (2009).

Table 1-2 showed the physical and chemical characteristics of different soils in our earlier studies (Kabir, 2014).

Percent reduction or promotion in different growth parameters of the plants grown in industrial soils of polluted sites was determined in comparison with a control site using the following formula (Grigalaviciene et al., 2005):

$$\textbf{\% Promotion / Reduction} = \frac{\textbf{Control - Treatment}}{\textbf{Control}} \times 100$$

Table 1: Physical characteristics of different soils.

Locality	M.W.H.C. (%)	B.D. (gcc^{-1})	Porosity (%)	Sand (%)	Silt (%)	Clay (%)	Soil texture class
A	22.30±1.14a	1.36±0.02ab	49.0±2.82ab	24.34±0.10a	44.28±0.10c	31.42±0.19d	Clay loam.
B	28.91±0.21b	1.27±0.11a	52.0±1.41a	29.30±0.15b	47.00±0.01d	23.70±0.14b	Silty loam
C	23.12±0.09a	1.55±0.11b	41.5±0.7c	38.80±0.16c	30.50±0.19b	30.70±0.56d	Sandy-loam
D	23.88±0.24a	1.46±0.09ab	45.0±2.82bc	59.80±1.38d	13.00±0.71a	27.20±0.64c	Sandy clay loam
E	23.91±0.21a	1.54±0.05b	42.0±1.40c	69.44±0.44e	11.00±1.0a	19.56±0.10a	Sandy loam
L.S.D. ($p<0.05$)	1.91	0.23	5.21	2.39	2.03	1.45	

Figures followed by the same letter in the same row are not significantly different according to Duncan Multiple Range Test at $p<0.05$ level. ± Standard Error, L.S.D. Least Significant Difference. (Source: Kabir, 2014). Sites: A = Karachi University Campus; B = Indus Battery factory; C = Universal Chemicals factory; D = Haroon Textile factory; E = National Foods Ltd. factory. Abbreviations: M.W.H.C. = Maximum Water Holding Capacity, B.D. = Bulk Density

Table2: Chemical characteristics of different soils

Locality	$CaCO_3$ (%)	Cl (mgL^{-1})	pH	O.M. (%)	T.O.C. (g)	S (μgg^{-1})	E.C. ($dS.cm^{-1}$)	T.D.S. (mgL^{-1})	Exchangeable	
									Na (ppm)	K (ppm)
A	21.60±1.2b	00±0.0a	7.00±0.15b	4.50±0.28a	2.61±0.03e	58.75±2.86b	19.00±0.3d	13.90±0.7d	190±10b	156±4b
B	31.65±0.27c	00±0.0a	6.54±0.06a	7.56±0.10b	4.38±0.02d	41.25±0.12a	33.20±0.6e	24.50±0.3e	410±10c	162±6b
C	14.15±0.31a	400±10c	6.81±0.05ab	3.23±0.12a	1.87±0.04c	40.00±3.0a	7.20±0.30b	5.20±0.30b	650±10e	197±6c
D	19.75±0.09b	710±25d	6.66±0.03a	3.26±0.09a	1.89±0.01a	45.00±3.0a	9.60±0.20c	7.10±0.10c	567±7.0d	207±8c
E	19.55±0.18b	140±5.0b	7.65±0.06c	3.42±0.08a	1.98±0.01b	125.00±4.0c	0.80±0.10a	0.60±0.10a	113±7.0a	74±6a
L.S.D. ($p<0.05$)	2.08	44.52	0.30	0.56	0.09	10.56	1.25	1.35	32.43	22.29

Figures followed by the same letter in the same row are not significantly different according to Duncan Multiple Range Test at $p<0.05$ level. ± Standard Error, L.S.D. Least Significant Difference (Source; Kabir, 2014). Sites: A = Karachi University Campus; B = Indus Battery factory; C = Universal Chemicals factory; D = Haroon Textile factory; E = National Foods Ltd. factory. Acronyms, symbols and formulae: $CaCO_3$ = Calcium Carbonate; Cl = Chloride; pH = Power of Hydrogen ion; O.M. = Organic Matter; T.O.C. = Total Organic Carbon; S = Sulphur; E.C. = Electrical Conductivity; T.D.S. = Total Dissolved Salts; Na = Sodium; K = Potassium. (Source: Kabir, 2014)

Statistical analysis

Data of different growth parameters were statistically analyzed by Analysis of Variance (ANOVA) and Duncan Multiple Range Test (DMRT) on personal computer at p<0.05 level using SPSS version 13 Software package. Pearson correlation was applied to investigate relationship between different soil characteristics and growth parameters of plants using the SPSS soft-ware version 13.0 through personal computer.

RESULTS

The seed germination and early seedling growth are an important and the critical stages of plant development. The seedling growth performance of selected plant species, *Gliricidia sepium* Kunth ex Walp. were raised in five different soil samples collected from Indus Battery Factory, Universal Chemicals, Haroon Textile, National Foods Ltd. Factories and Karachi University Campus (control) showed variation in their growth parameter. It was found mainly dependent on the treatment of soil types. The seedlings of *G*. *sepium* showed variable response in terms of root, shoot, seedling length, plant cover, number of leaves, leaf area, seedling fresh weight, root, shoot, leaf, total plant dry weight, root/shoot ratio, leaf weight ratio, specific leaf area, leaf area ratio when treated with soil of Indus Battery Factory, Universal Chemicals, Haroon Textile, National Foods Ltd. Factories as compared to Karachi University Campus (Table 3-6).

The treatment of Indus Battery factory soil significantly (p<0.05) decreased root, shoot, seedling length and seedling dry weight of *G*. *septum* as compared to Karachi University Campus, Universal Chemicals, Haroon Textile and National Foods Ltd. factories soil treatment. The seedlings of *G*. *sepium* showed significantly (p<0.05) better root, shoot, plant cover, leaf size, number of leaves and seedling dry weight in soil of National Foods Ltd. as compared to Universal Chemicals and Haroon Textile. These findings provided an idea about the sensitivity of *G. sepium* seedlings in response to different soil treatment.

The results showed that root, shoot, seedling length and seedling fresh and dry weight of *G*. *sepium* were significantly (p<0.05) increased in soil of National Foods Ltd. as compared to Karachi University Campus as well as soils of other industries (Table 3-4). The seedling growth parameters showed significant (p<0.05) reduction in soil of Indus Battery. The high percentage of reduction for seedling growth of *G*. *sepium* was recorded in soil of Indus Battery followed by Universal Chemicals.

The percentage reduction in soil of Universal Chemicals was reduced except root and shoot dry weights. In Haroon Textile growth parameters showed variation in percentage reduction.

Table 3: Growth of *Gliricidia sepium* in soils of different areas

Treatments	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Plant cover (cm)	Number of Leaves	Leaf area (Sq cm)
A	9.20 ± 0.58b	15.80 ± 0.66bc	25.00 ± 1.18b	21.60 ± 1.08c	43.60 ± 4.79b	0.85 ± 0.12b
B	6.00 ± 0.32d	12.70 ± 1.02d	18.70 ± 1.24c	23.00 ± 1.00c	45.60 ± 2.04b	0.72 ± 0.09bc
C	6.80 ± 0.37cd	14.00 ± 0.71cd	20.80 ± 0.97c	18.00 ± 0.95d	26.80 ± 3.07c	0.53 ± 0.05c
D	8.00 ± 0.95bc	17.18 ± 0.47b	25.18 ± 1.34b	28.80 ± 0.97b	62.80 ± 4.32a	0.87 ± 0.07b
E	11.60 ± 0.51a	27.80 ± 0.56a	39.40 ± 0.94a	35.00 ± 1.00a	63.60 ± 8.26a	1.53 ± 0.13a
L.S.D. (p<0.05)	**1.74**	**2.09**	**3.38**	**2.95**	**14.65**	**0.29**

Sites: A = Karachi University Campus; B = Indus Battery factory; C = Universal Chemicals factory; D = Haroon Textile factory; E = National Foods Ltd. factory. Numbers followed by the same letter in the same row are not significantly different according to Duncan Multiple Range Test at p<0.05 level. ± Standard Error, L.S.D. Least Significant Difference.

Table 4: Fresh, dry weights and ratios of different variables of *Gliricidia sepium* in soils of different areas

Treatments	Seedling fresh weight (g)	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^{-1})	Leaf area ratio (cm^2 g^{-1})
A	0.62 ± 0.04b	0.03 ± 0.002bc	0.05 ± 0.005b	0.06 ± 0.007b	0.14 ± 0.012b	0.61 ± 0.06a	0.41 ± 0.03ab	14.67 ± 2.00b	5.91 ± 0.80ab
B	0.31 ± 0.02c	0.02 ± 0.002c	0.03 ± 0.002b	0.03 ± 0.003b	0.08 ± 0.007b	0.66 ± 0.04a	0.34 ± 0.02cd	24.70 ± 3.17a	9.50 ± 2.20a
C	0.55 ± 0.03b	0.04 ± 0.003b	0.06 ± 0.009b	0.04 ± 0.004b	0.14 ± 0.016b	0.67 ± 0.04a	0.29 ±a 0.02d	12.92 ± 2.62b	5.08 ± 1.44b
D	0.61 ± 0.02b	0.03 ± 0.003bc	0.05 ± 0.003b	0.05 ± 0.003b	0.13 ± 0.009b	0.60 ± 0.03a	0.37 ± 0.01bc	17.34 ± 2.22b	5.16 ± 1.13b
E	1.44 ± 0.04a	0.08 ± 0.01a	0.12 ± 0.020a	0.16 ± 0.028a	0.36 ± 0.057a	0.67 ± 0.04a	0.44 ± 0.01a	10.52 ± 1.44b	4.73 ± 0.54b
L.S.D . (p<0.05)	**0.08**	**0.02**	**0.03**	**0.03**	**0.08**	**0.12**	**0.06**	**6.98**	**3.98**

Table 5: Pearson's correlation of soil physical characteristics and growth parameters of *Gliricidia sepium*

Growth parameters	M.W.H.C.	B.D.	Porosity	Sand	Silt	Clay
Root length	-0.444*	0.388	-0.371	0.515**	-0.488*	-0.365
Shoot length	-0.287	0.533**	-0.524**	0.781**	-0.710**	-0.660**
Seedling size	-0.344	0.508**	-0.496*	0.728**	-0.668**	-0.594**
Plant cover	0.002	0.273	-0.269	0.811**	-0.714**	-0.768**
Number of leaves	0.052	0.032	-0.027	0.584**	-0.517**	-0.539**
Leaf area	-0.119	0.271	-0.262	0.620**	-0.524**	-0.658**
Seedling fresh weight	-0.381	0.616**	-0.606**	0.751**	-0.694**	-0.596**
Root dry weight	-0.295	0.602**	-0.598**	0.611**	-0.554**	-0.524**
Shoot dry weight	-0.346	0.601**	-0.596**	0.626**	-0.596**	-0.437*
Leaf dry weight	-0.260	0.466*	-0.458*	0.628**	-0.557**	-0.578**
Total plant dry weight	-0.300	0.546**	-0.540**	0.636**	-0.580**	-0.534**

Abbreviation: M.W.H.C. = Maximum Water Holding Capacity; B.D. = Bulk Density

Table 6: Pearson's correlation of soil chemical characteristics and growth parameters of *Gliricidia sepium*

Growth parameters	$CaCO_3$	Cl	pH	O.M.	T.O.C.	S	E.C.	T.D.S.	Na	K
Root length	-0.276	-0.120	0.799**	-0.439*	-0.439*	0.788**	-0.556**	-0.555**	-0.658**	-0.646**
Shoot length	-0.268	-0.024	0.898**	-0.457*	-0.458*	0.935**	-0.676**	-0.673**	-0.618**	-0.788**
Seedling size	-0.280	-0.054	0.900**	-0.468*	-0.468*	0.923**	-0.663**	-0.661**	-0.652**	-0.773**
Plant cover	0.027	0.110	0.624**	-0.242	-0.242	0.761**	-0.441*	-0.436*	-0.503*	-0.643**
Number of leaves	0.155	0.157	0.320	-0.110	-0.110	0.464*	-0.205	-0.200	-0.365	-0.368
Leaf area	-0.028	-0.155	0.760**	-0.227	-0.227	0.835**	-0.429*	-0.426*	-0.669**	-0.761**
Seedling fresh weight	-0.373	-0.054	0.958**	-0.526**	-0.527*	0.957**	-0.743**	-0.741**	-0.621**	-0.801**
Root dry weight	-0.368	-0.105	0.853**	-0.438*	-0.439*	0.829**	-0.660**	-0.659**	-0.488*	-0.724**
Shoot dry weight	-0.406*	0.033	0.759**	-0.497*	-0.498*	0.735**	-0.671**	-0.669**	-0.394	-0.590**
Leaf dry weight	-0.236	-0.132	0.846**	-0.374	-0.374	0.863**	-0.583**	-0.581**	-0.606**	-0.759**
Total plant dry weight	-0.322	-0.077	0.837**	-0.434*	-0.434*	0.833**	-0.638**	-0.637**	-0.526**	-0.713**

*, ** Correlation is significant at the $p<0.05$ and $p<0.01$ levels, respectively (2-tailed)

Abbreviation: CaCO3 = Calcium Carbonate; Cl = Chloride; pH = Power of Hydrogen ion; O.M. = Organic Matter; T.O.C. = Total Organic Carbon; S = Sulphur; E.C. = Electrical Conductivity; T.D.S. = Total Dissolved Salts; Na = Sodium; K = Potassium

Figure 1: Growth of *Gelericidia sepium* in different soils (a) and after harvest (b)Sites:

A = Karachi University Campus soil; **B** = Indus Battery factory soil; **C** = Universal Chemicals factory soil; **D** = Haroon Textile factory soil; **E** = National Foods Ltd. Factory soil

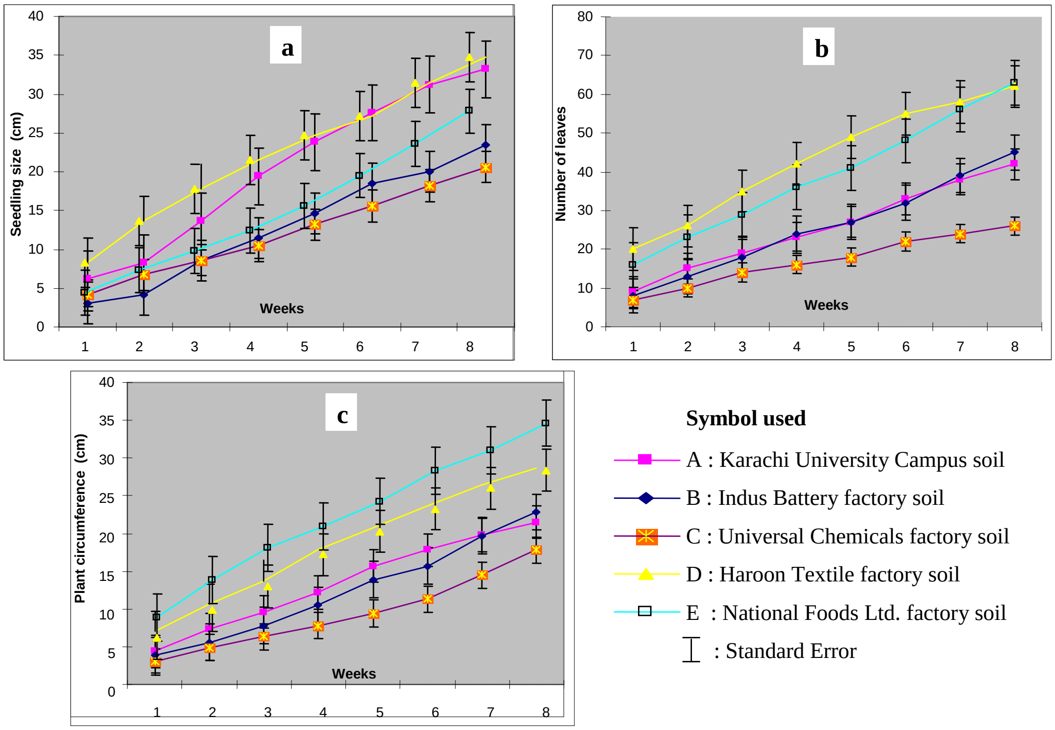

Figure 2: Seedling size (a), number of leaves (b) and plant circumference (c) of *Geliricidia sepium* growing in soils of different areas

The seedling growth analysis of *Gliricidia sepium* was carried periodically for seedling length, plant cover and number of leaves. The periodic growth of *G. sepium* showed that seedling size, number of leaves and plant circumference recorded for 8 weeks of observation showed great variation (Fig. 1). This variation was more prominent for seedling size of National Foods Ltd., which remained constant in 1st and 2nd week and increased in 2nd and 3rd week and then continued this increase for other five weeks. Number of leaves increased for seedlings raised from soil of Haroon Textile factory but during 8th weeks become equal to that was observed for seedlings grown from soil of National Foods Ltd. The plant circumference increased continuously from 1st to 8th weeks. This increment was more for seedlings raised from soil of National Foods Ltd., and reduced for Universal Chemicals factory.

The correlation in physical and chemical soil characteristics and growth parameters of *G. sepium* showed that most of the growth variables were significant ($p<0.05$ & $p<0.01$), negative and low to moderately correlated except sand which showed moderate to highly positive correlation with all growth parameters (Table 5). The maximum water holding capacity, was non-significantly correlated with different growth parameters at significance level $p<0.05$ & $p<0.01$. In soil chemical characteristics only pH and sulphur were significant ($p<0.01$), moderate to high and perfect positively correlated with all the growth parameters while, calcium carbonate and chloride contents were non-significantly correlated with different growth parameters at significance level $p<0.05$ or $p<0.01$ (Table 6).

DISCUSSION

A beer seedling growth of a species could be obtained if it is given the favorable environmental conditions. The correlation coefficient between growth parameters and soil characteristics was calculated. From the result of the present study it is indicated that soil of industrial area is modified due to pollutants released from different industries. Toxic nature of these pollutants varies significantly from industry to industry affecting growth of plant. The reduction of trend in different seedling growth parameters was not same but varied from industry to industry soil treatment. The seedling growth in Indus Battery and Universal

Chemicals factories were highly affected. The harmful industrial waste and effluent are increasing fastly in current years and their discharge on soil, canals, rivers and water course cause serious environmental related problems for normal growth of flora and fauna of the region (Kashem and Singh, 1998). Extreme quantity of toxic industrial pollutants regularly caused declined in plant growth and bio-chemical activities (Prodgers and Inskeep, 1981). Growth of *Pongamia pinnata* and *Albizia lebbeck* was also found significantly ($p<0.05$) decreased in seedlings raised from the contaminated seeds comparatively to control (Qadir and Iqbal, 1991).

In present study *G. sepium* growth variables were retarded in soil of Indus Batter factory as compared to soils of other industries and Karachi University soil. The sensitivity to different pollutants differs between plants and even between clones of the same species (Pukacka and Pukacki, 2000). Several environmental features can modify the findings of such investigations. For instance, verification of tolerance or sensitive for one assessed plant species could be altered for the period of different seasons depending on climatic and edaphic factors (Liu and Ding, 2008). It is recommended for a few species that toxicity of pollution is concerned with the primary phases of the life cycle (Honour et al., 2009). The long period, even low concentration contacts of industrial pollutants generate destructive effects on plant foliages with no visible injury and thus affecting the plant growth (Joshi et al., 2009). Different species vary in the extent of response to pollutant exposure, although differences were not dependent on taxonomic or functional groups (Honour et al., 2009).

The variation in seedling growth may be related with the amounts of industrial pollutants. This is related to the fact that some fundamental nutrients present in the industrial effluents are essentials but above a critical concentration, they become harmful. As growth of *G. sepium* was found better in soil of National Foods Ltd., which may be the result of more nutrient supply in soil that are being used to manufacture different food products. In soils of Indus Battery low nutrients supply and toxic effects of discharged pollutants inhibited growth of *G. sepium.* Similar findings were reported from the study of Panaskar and Pawar (2011a, b) which proved that textile pollutants were not inhibitory at low concentrations above a particular concentration growth and development of seedlings was affected. Hussain et al., (2010) reported that tannery effluents reduced in seedling growth along with total chlorophyll, protein and carbohydrate contents of sunflower. Zhao et al. (2009) reported that adverse effects of rubber crumb on turf grass growth might be attributed to some toxic substances releasing from crumb rubber. Miguel et al., (2002) reported that rubber exhibits high levels of sulfur, zinc and other heavy metals. Improvement in growth of *Adenanthera pavonina* to certain extend under rubber treatments is may be due to the resistance of this species against toxic substances present in rubber crumb (Rizvi et al., 2013). As better growth was observed in 10% and 20% rubber crumb treated *A. pavonina* plants, 30% rubber crumb treated plants showed highly declined growth than control. The seedling length of *G. sepium* followed the similar pattern of reduction in shoot as well as root length because root and shoot are exposed to either direct or indirect to different industrial pollutant discharges in air, water and soil. Iqbal and Shazia (2004) recorded the related decreased in root, shoot and seedling length along with seedling dry weight of *Albizia lebbeck* and *Leucaena leucocephala* by the use of different levels of lead (Pb) and cadmium (Cd).Different plant species which are growing in industrial area of Karachi are constantly exposed to industrial pollution which are continuously absorbed, accumulated and incorporated into their systems. It was reported that depending on their resistant or sensitivity level, plants showed visible changes along with reduction in different growth parameters. As industrial area plants are facing different challenges which would comprise on variation in the biochemical processes such as total chlorophyll and carotenoid or accumulation of certain metabolites (Agbaire and Esiefarienrhe, 2009). Overall results concluded that seedling growth of *G. sepium* in order of soil of Indus Battery, Universal Chemicals, Haroon Textile and National Foods Ltd. factories affected.

CONCLUSION

This study concludes that the treatment of Indus Battery Factory soil due to presence of toxic chemical compounds significantly ($p<0.05$) decreased seedling height and biomass of *G. septum* as compared to Karachi University Campus, Universal Chemicals, Haroon Textile and National Foods Ltd. Factories soil. The seedlings of *G. sepium* showed positively better root, shoot, plant cover seedling dry weight in soil of National Foods Ltd.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

MZI designed and supervised the experiment and MK performed the experiment. MS wrote the manuscript. ZRF and UH reviewed the article. All author read and approved the final version.

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