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GROWTH OF *SAMANEA SAMAN* (JACQ.) MERR. IN DIFFERENT SOILS OF INDUSTRIAL AREAS OF KARACHI

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ABSTRACT

The growth of *Samanea saman* was investigated in a green house in different soils of industrial areas (Sindh Industrial Trading Estate) of Karachi. The seedlings of *S. saman* which were grown in polluted soils of different industrial areas showed variation in many growth variables like root, shoot, seedling length, plant cover, leaf area, root, shoot, leaf dry weight, total plant dry weight, and various ratios as compared to plants grown in soil of University Campus. There was reduction in root, shoot, leaf and total plant dry weight of *S. saman* in Pakistan metal industry, Dalda Limited and Indus battery soil while, increase in root, shoot, and seedling length, plant cover and leaf area were observed in these industrial soils as compared to seedlings grown in University Campus soil. The industrial areas soils especially the Shafi tannery increased the growth variables of *S. saman* as compared to University Campus and other industrial soils. The soil of industrial areas was sandy clay loam to sandy and silt loam with high bulk density and chloride contents, low porosity, electrical conductivity and total dissolved salt, alkaline pH, high sulphur, sodium and potassium (except for Shafi tannery), as compared to University Campus soil which was clay-loam in texture. Highest amount of total dissolved salts and electrical conductivity was found in the soil of Indus battery followed by University Campus, Pakistan metal industry, Dalda limited and Shafi tannery.

Key-words: industrial area, *Samanea saman*, soil type, plant growth, salts.

INTRODUCTION

Karachi city has five industrial estates like Sindh Industrial Trading Estate (S.I.T.E.), Korangi Industrial Trading Estate (K.I.T.E.), Landhi Industrial Trading Estate (L.I.T.E.), North Karachi Industrial Trading Estate (N.I.T.E.) and Hub Industrial Trading Estate (H.I.T.E.). Sindh Industrial Trading Estate (S.I.T.E.) is densely populated town in western part of Karachi. The town is bordered by Gadap Town to the North, Liquatabad and North Nazimabad to the east across the Orangi stream, Layari and Saddar to the South across the Layari River and Kiamari to the West. SITE is the oldest and the largest industrial area of Pakistan, encompassing 4700 acres (19 km^2) area and contains approximately 2,516 factories which are discharging their wastes in the surrounding areas.

Problem of environmental pollution has existed for centuries and is still growing rapidly as a result of unplanned industrialization, particularly in developing countries (Naheed, *et al*., 1986). The hazard and fast industrial growth is causing an enormous environmental pollution affecting plants and human being. Abdel- Sabour & Aly, (2000) indicated that soils of industrial area showed significant accumulation of heavy metals reducing the plants growth. Heavy metals contamination affects the biosphere in many places world wide (Cunningham, *et al*., 1997; Raskin & Ensley, 2000). Excess concentrations of some metals in soil such as Cd (II), Cr (VI), Ni (II) and Zn (II) have caused the disruption of natural, aquatic and terrestrial ecosystems (Gardea-Torresdey, *et al*., 1996; Meagher, 2000). Unrestricted mining, municipal waste disposal practices and extensive use of agro-chemical have resulted in the addition of larger amount of metals in the environment (Ernst 1996; Millar *et al*., 2000). These metals persist indefinitely in soil there by posing an ever increasing threat to human health and agriculture (Leyval *et al*., 1995). Metallic contaminants (Pb, Cd, Cu, Zn, Cr, etc) destroy bacteria and beneficial micro-organisms in soil. Soil around the industrial areas has also been used to detect the accumulation and deposition of metal pollution (Kuo *et al*., 1983; Wahab & Hashem, 1995; Martinez & Motto, 2000). Along the sewage effluents channels of Malir river (Karachi), some heavy metals were found in soil, especially Pb (5-60 ppm), Cu (150-800 ppm) and Zn (20-360 ppm) which was polluted from the effluents of the industrial areas along with other sources, these metals polluted soil influenced the plant communities in the area (Zaman & Iqbal, 1994). According to Karunyal, *et al*., (1994) effects of tannery effluent (25, 50, 75 and 100%) have been studied on seed germination of *Oryza sativa, Senna holosericea* and *Leucaena leucocephala* which was inhibited by 25% and 50% and prevented by 75% and 100% effluent. As compared to control, the soil treated with tannery effluent was rich in Mg, Mn, Fe, Na and K ions. The effluent concentration at 75% and 100% killed the plants and only 25% was found to be suitable for fertilizer use.

Some plant species have the ability to survive and reproduce on soil containing high concentration of metals in forms that are toxic or inimical to other plants (Macnair & Baker, 1994). The ability of these plants to survive on metals polluted soils is not only due to their capacity to take up, translocate and sequester metals, but is also based on mechanisms that allow them to tolerate high levels of the element in root and shoot cells by alleviating their toxic effects (Salt *et al*., 1998). Major oil sands industrial companies are located in the Athabasca Oil Sands Deposit in northeastern Alberta, Canada. Exposure to oil sands effluents had an inhibitory effect on the germination of several plant species (tomato, clover, wheat, rye, pea, reed canary grass, loblolly pine); clover and tomato seed germination were most affected (Crowe, *et al*., 2002).

Different types of industries including garments, bones crushing, coloring, metal processing, pharmaceutical, textile, chemicals and battery manufacturing industries are present in the S.I.T.E. (Sindh Industrial Trading Estate) areas. These industries discharge different kind of waste effluents and solid wastes which are polluting the soil of nearby places, thus causing deleterious effects to plant growing around the industrial areas. In view of the destructive and hazardous role of industries of Karachi, it is necessary to investigate the effects of polluted soil of industrial areas on growth of different plant species. In the present study seedling growth of *S. samen* was evaluated in different soil of industrial areas as well as in University Campus. Physio-chemical analysis of soil was also carried out.

MATERIALS AND METHODS

The experiment was conducted in green house under the uniform environmental conditions at the Department of Botany, University of Karachi. Healthy and uniform size seeds of *Samanea saman* (Jacq.) Merr. were collected from the University Campus. The top ends of seeds were slightly cut with clean scissor to break dormancy and were sown in garden soil at 1 cm depth of soil in earthen pots and watered regularly. After two weeks of their germination, uniform size seedlings were transplanted in plastic pots of 20 cm in diameter and 9.8 cm in depth containing the soil of University Campus as control and industrial polluted soils. There were five replicates for each treatment and the experiment was completely randomized. Only one seedling was planted in each pot and the plants were treated with tap water regularly. Every week reshuffling of pots were also carried out to avoid light/shade or any other green house effects. Climatic data during growth experiment is shown in Appendix 1. Weather outlook (frequency) was determined by $X/\sum N$ x100, where X is No. of observations and $\sum N$ is sum of total No. of observations. Seedling height, number of leaves, leaf area and plant circumference were noted after every week. After eight weeks, seedlings were taken out from pots, washed their roots with water and measured root length, shoot length, seedlings length, plant circumference, number of leaves and leaf area. The root, shoot and leaves were dried in an oven at 80°C for 24 hours and their oven dried weights were determined. Root/Shoot ratio, leaf weight ratio, specific leaf area and leaf area ratio were also determined as described by Atiq & Iqbal, 2009.

Soil samples were obtained from the industrial areas and University Campus at 30 cm depth. These samples were brought to the laboratory in polythene bags for air drying. After drying soil was passed through 2 mm sieve. Mechanical analysis of soil samples were carried out by hydrometer method (Bouyoucos,1962). Maximum water holding capacity (M.W.H.C.) of soil was determined by the method of Keen (1931). Bulk density of soil was obtained according to Birkeland (1984). Calcium carbonate was determined by a method of acid neutralization (Qadir *et al*., 1966), while soil pH was recorded by direct pH reading meter (Mettler Toledo, MP 220). Chlorides were determined by Mohr's Method (Allen *et al*., 1974), where as organic matter was done according to Jackson (1958). Organic matter was converted into total organic carbon by using the conversion factor 1.724 (organic matter/ 1.724 = g organic carbon) as given by Nelson and Sommers (1996). Soil available sulfate was determined by turbidity method as described by Iqbal (1988). Soil Electrical Conductivity (EC) and Total Dissolved Salt (TDS) were determined by conductivity meter (AGB 1000, England). Exchangeable sodium and potassium in soil were determined by flame photometer as described by Richards (1954).

Analysis of variance was performed on each measured variable. The least significant difference ($p<0.05$) was used for multiple comparisons among treatment means. Descriptive statistics were calculated using the SPSS13.0 software package.

RESULTS

The results clearly indicated that soil samples of Shafi tannery significantly ($p<0.05$) favored seedling growth of *S. saman* as compared to University Campus and other industrial sites Table 1 (a & b) (Fig. 1). The root length in Shafi tannery soil attained the highest length of 7.70 cm, while for University Campus root length was measured as 6.0 cm. Shoot and seedling length recorded in soil of Shafi tannery were also high which have their value 14.96 cm and 46.80 cm, respectively. Shoot and seedling length in other industrial soils was also high as compared to University Campus soil. Shoot length in Indus battery soil was 11.20 cm, for Dalda Ltd. this length was measured as 11.84 cm and in Pakistan metal industry it was recorded as 11.57 cm while, in University Campus shoot length was measured as 10.54 cm. Similarly, seedling length followed the same pattern of increment as recorded for root and shoot length. Plant circumference (18.64 cm) was high in Shafi tannery as compared to control and other polluted sites. For Dalda soil and Pakistan metal soil this value for plant circumference were recorded as 15.98 cm and 17.72 cm, respectively. In Indus battery soil, low plant circumference (14.04 cm) was recorded as compared to University Campus (14.66 cm). Great number of leaves with comparatively high leaf area was recorded for Shafi tannery soil. Numbers of leaves along with leaf area in other industrial soil were high as compared to University Campus soil except the leaf area for Indus battery soil which was low (0.78 sq cm) than the leaf area (0.97 sq cm) determined for University Campus soil.

Appendix 1. Climatic data of Karachi during the growth period of *Samanea saman* (13-4-2008 to 15-6-2008)

Parameters	**Range**
Maximum Temperature (°C)	32-43
Minimum Temperature (°C)	23-31
Average Temperature (°C)	29-36
Atmospheric Relative Humidity (%)	29-72
Sun Shine (Hours)	12:43-13:42
Weather Outlook	**Frequency**
Hot & Warm/Humid	42.20
Fair/ Partly cloudy	15.63
Hot/Dry	9.38
Warm/Humid/Windy	7.81
Partly cloudy/Windy	7.81
Hot/Dusty	6.25
Hot/Dusty/Light rain	4.69
Fair/ Sunny	4.68
Partly cloudy/ light rain	1.56

Source: Daily Dawn, 2008

Table 1 (a). Growth of *Samanea saman* in soils of different areas.

Treatments	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Plant cover (cm)	No. of leaves	Leaf area (Sq cm)
A	6.0±0.59a	10.54±0.60a	16.54±0.76a	14.66±0.40ab	19.60±1.75b	0.97±0.28a
B	6.12±1.00a	11.20±0.97a	17.32±1.57a	14.04±0.31a	28.40±4.06bc	0.78±0.14a
C	6.62±0.65a	11.84±0.61a	18.46±1.18a	15.98±0.24bc	30.80±4.76c	0.98±0.26a
D	7.42±0.47a	11.57±0.69a	18.98±0.88a	17.72±0.86cd	32.40±2.48c	1.17±0.42a
E	7.70±0.96a	14.96±1.28b	46.80±2.06b	18.64±0.95d	38.80±0.37a	1.91±0.61a

Table 1(b). Growth of *Samanea saman* in soils of different areas.

Treatments	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	0.10±0.08ab	0.16±0.08a	0.29±0.01c	0.54±0.03c	0.60±0.03a	0.53±0.01b	3.42±1.09a	1.85±0.57a
B	0.07±0.05b	0.14±0.01a	0.11±0.006a	0.32±0.02b	0.59±0.05a	0.33±0.01a	7.50±1.53a	3.23±0.73a
C	0.12±0.10b	0.14±0.01a	0.11±0.02a	0.37±0.03ab	0.86±0.06b	0.29±0.04a	9.39±2.56a	2.56±0.56a
D	0.10±0.09ab	0.17±0.008a	0.13±0.008a	0.41±0.01b	0.66±0.07ab	0.33±0.02a	9.47±3.80a	2.88±1.01a
E	0.21±0.02c	0.26±0.01b	0.23±0.01b	0.70±0.01d	0.84±0.12b	0.33±0.02a	7.95±2.18a	2.74±0.89a

Abbreviation used: **A** = Karachi University **B** = Indus Battery factory **C** = Dalda Ltd. factory **D** = Pakistan Metal industry **E** = Shafi Tannery

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 soil characteristics of different soils

S#	Locality	M.W.H.C. %	B.D. gcc^{-1}	Porosity %	Sand %	Silt %	Clay %	Soil texture class
1	University Campus	22.30±1.14a 26.59	1.36±0.02ab	49±2.82ab	24.34±0.10a	44.28±0.10c	31.42±0.19d	Clay loam.
2	Indus Battery	28.91±0.21b	1.27±0.11a	52±1.41b	29.3±0.15b	47±0.01d	23.7±0.14b	Silty loam
3	Dalda Ltd.	23.12±0.09a	1.55±0.11b	41.5±0.7a	38.8±0.16c	30.5±0.19b	30.7±0.56d	Sandy-loam
4	Pakistan Metal Industry	23.88±0.24a	1.46±0.09ab	45±2.82ab	59.8±1.38d	13±0.71a	27.2±0.64c	Sandy clay loam
5	Shafi Tannery	23.91±0.21a	1.54±0.05b	42±1.40a	69.44±0.44e	11±1.0a	19.56±0.10a	Sandy loam

Symbol used: M.W.H.C. = Maximum Water Holding Capacity B.D. = Bulk Density ± Standard Error

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.

Dry weight of *S. saman* seedling grown in different soil samples was also obtained in order to compare their fitness in various soils. Root (0.21 g) and shoot (0.26 g) dry weight was high in Shafi tannery soil samples and almost same in Dalda and Pakistan metal soils while, low root (0.07 g) and shoot (0.14 g) weights were recorded in Indus battery soil. Leaf dry weight (0.29 g) was significantly ($p<0.05$) high for University Campus seedling as compared to industrial sites. For Shafi tannery leaf dry weight was recorded as 0.23 g while, low leaf dry weight was determined for all the other polluted sites. Based on root, shoot and leaf dry weight, total plant dry weight was high (0.70 g) in Shafi tannery which decreased to 0.54 g for the University Campus seedling. Total seedling dry weight for the other polluted sites lies between Shafi tannery and University Campus. Root/ shoot ratio was also high for Shafi tannery and other industrial sites as compared to this ratio calculated for University Campus. Some other leaf related parameters were also calculated for seedling growth of *S. saman* which includes leaf weight ratio, specific leaf area and leaf area ratio. Leaf weight ratio was high for University Campus seedling as compared to industrial areas. Specific leaf area was high in Pakistan metal industrial soil as compared to University Campus and all the others polluted sites. Leaf area ratio was comparatively high for seedling of Indus battery soil as compared to seedlings of all the other soils of industrial areas as well as University Campus.

Soil analysis of University Campus and industrial areas showed that low maximum water holding capacity was recorded for University Campus as compared to the industrial soil (Table 2 a & b). High bulk density with low porosity was recorded for Dalda Ltd. soil. The percentage of $CaCO_3$ (31.65 %) was high in Indus battery soil which decreased to 21.60 % for University Campus while, this percentage of $CaCO_3$ was low in other industrial soil samples. In Pakistan metal industry soil chloride contents was determined as 710 mgL^{-1} which was decreased in other industrial soils but chloride contents were not found in Indus battery as well as in University Campus soil. The industrial soils were acidic in nature except Shafi tannery in which pH value was determined as 7.65. Soil organic matter was high in Indus battery soil and low in other industrial soils as compared to University Campus. Sulphur contents were high in Shafi tannery along with low electrical conductivity and total dissolved salts. Electrical Conductivity (EC) and Total Dissolved Salt (TDS) were low in industrial samples as compared to University Campus soil except in Indus battery soil.

Table2(b). Chemical characteristics of different soils.

S #	Locality	$CaCO_3$ %	Cl mgL^{-1}	pH	O.M. %	TOC g	S μgg^{-1}	EC dS cm^{-1}	TDS mgL^{-1}	Exchangeable Na ppm	Exchangeable K ppm
1	University Campus	21.6±1.2 b	0±0.0 a	7.00±0.15b	4.50±0.28 a	2.61±0.03e 2.61	58.75±2.86b	19.0±0.3d	13.9±0.7d	190±10 b	156±4.0b
2	Indus Battery	31.65±0.27c	0±0.0 a	6.54±0.06a	7.56±0.10 b	4.38±0.02d	41.25±0.12a	33.2±0.6e	24.5±0.3e	410±10 c	162±6.0b
3	Dalda Ltd.	14.15±0.31a	400±10c	6.81±0.05ab	3.23±0.12 a	1.87±0.04c	40±3.0 a	7.2±0.30b	5.2±0.30b	650±10 e	197±5.5c
4	Pakistan Metal Industry	19.75±0.09b	710±25d	6.66±0.03a	3.26±0.09 a	1.89±0.01a	45±3.0 a	9.6±0.20c	7.1±0.10c	567±7.0d	207±7.5c
5	Shafi Tannery	19.55±0.18b	140±5.0b	7.65±0.06c	3.42±0.08a	1.98±0.01b	125±4.0 c	0.8±0.10a	0.6±0.10a	113±7.0 a	74±6.0 a

Symbol used:
$CaCO_3$ = Calcium Carbonate Cl = Chlorid
pH = Power of Hydrogen ion O.M. = Organic Matter
TOC = Total Organic Carbon S = Sulphur
EC = Electrical Conductivity TDS = Total Dissolved Salt
Na = Sodium K = 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

DISCUSSION

Samanea saman (Jacq.) Merr. (syn. *Albizia saman* (Jacq.) F. V. Muell.) plant commonly known as rain tree and is a member of family Fabaceae (Legume family). It has great importance for human society as it has a large size stem and umbrella shaped canopy. Due to its shady nature this species is planted along roadsides and parks. This species is successfully established in a wide range of climatic and soil conditions. *S. saman* is a large tree, native to tropical America, which has now become widespread throughout the humid and sub humid tropics. It provides an excellent protective shade, and produces highly palatable pods that are suitable as a dry season feed supplement. This tree is well adapted to a variety of environmental conditions (Durr, 2001). Unplanned industrial growth and discharge of all the by-products, garbage, pollution and industrial effluents with out any proper treatment are causing serious pollution problems in the study area. The industrial wastes and effluents are increased sharply in recent 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. They pollute productive soils, natural water system as well as ground water (Kashem & Singh, 1998).

Fig.1. Growth of *Samanea saman* in different types of soils (from left to right)
University Campus, Indus Battery Factory, Dalda Limited. Factory,
Pakistan Metal industry and Shafi Tannery

In the present investigation, the seedlings of *S. saman* were found well adapted to the polluted environment. Species growth performance (root, shoot, seedling length, plant cover, leaf area, root, shoot and leaf dry weight, total plant dry weight, root/shoot ratio, leaf weight ratio, specific leaf area and leaf area ratio) were responded differently. *S. saman* was found to be the most responsive species to improvement in growth performance grown in soil collected from Shafi tannery. Plants directly depend on the soil characteristics and climatic factors for their growth and development. Singh (1986) observed that in those plant communities which had a higher percentage of soil organic matter, the water holding capacity of soil was consequently increased due to the colloidal nature of the organic matter. Pakistani soils are extremely low in organic matter (Ladha *et al*., 1996; Aslam *et al*., 2000). The organic matter plays an important role in soil structure, water retention, cation exchange and in the formation of complexes (Alloway & Ayres, 1997). The University Campus soil with low maximum water holding Capacity and high calcium carbonate might be the reason of not supporting the seedling growth performance of *S. saman*. Industrial soils contained appreciable water holding capacity, chloride and sulphur as compared to control which might caused better seedling growth in *S. saman*. pH is one of the factor which influence the bioavailability and the transport of heavy metal in soil and heavy metal mobility decreases with increasing soil pH due to precipitation of hydroxides, carbonates or formation of insoluble organic complexes (Smith, 1996). High pH was recorded for Shafi tannery soil which decreased the translocation of heavy metals in to plants. Chemical balance of inorganic elements in the living organism is a basic condition for their proper growth and development (Markert, 1990). The plants under stress conditions are most likely to be adversely affected by high level of heavy metals. Excessive amount of heavy metals usually caused reduction in plant growth (Prodgers & Inskeep, 1981). Further more, morphology of bean plants was also influenced by the presence of metals; the color of plants was shown to turn yellow, which in turn affected photosynthesis (Azmat *et al*., 2005). The effects of toxic substances on plants are dependent on the amount of toxic substance taken up from the environment. The toxicity of some metals may be so high that plant growth is retarded before large quantities of an element can be translocated (Haghiri, 1973). Root, shoot, leaf dry weight of *S. saman* was recorded significantly lowest in soil of Indus Battery factory. Salemaa & Uotila (2001) found that the number of *Calluna vulgaris* seedlings increased with increasing distance from a copper-nickel smelter. They suggested that the recovery of *C. vulgaris* near the smelter was prevented by low availability of seeds in the soil, unfavourable germination conditions and unsuccessful seedling establishment.

Different industries can affect the plants in some variable ways as Ghimire & Bajracharya (1996) carried out the effects of three different industrial effluents, viz., carpet dyeing, tannery and steel on seed germination and seedling growth of four different vegetables *(Brassica juncea, B. rapa, B. oleracêae* and *Raphanus sativus)*. The degree of toxicity depended both upon the nature and the concentration of chemicals present in the effluents as well as the type of plant species. *B. juncea* and *B. rapa* were comparatively susceptible, whereas, *R. sativus* and *B. oleraceae* were relatively resistant to the toxicants of industrial effluent (Ghimire and Bajracharya, 1996). These studies are in support of our findings that *S. saman* seedling was well adopted in Shafi tannery soil having capability for pollution tolerance.

Soil analysis indicated that industrial soil is sandy in nature while, University Campus soil is clay loam. Bulk density of industrial soil was high with less porosity as compared to University Campus soil. Calcium carbonate was high in University Campus as compared to industrial soil. pH of University Campus was 7.00 while industrial soils pH ranged from acidic to basic with high amount of chlorides in Dalda Ltd. and Pakistan metal industry. Low electrical conductivity and total dissolved salts also increased the growth of *S. saman* in some of the variables in industrial soils as compared to Campus soil.

The conclusion which could be drawn from this study is that the growth of *S. saman* was high in Shafi tannery soil as compared to other industrial and University Campus soils. Therefore this species should be given preference to be planted around the tannery industry due to its tolerance against the tannery pollutants.

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