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EFFECTS OF DIFFERENT SOILS ON SEEDLING GROWTH OF *CASSIA FISTULA* L. UNDER NATURAL FIELD CONDITIONS

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Abstract

The present study reports the effects of different industrial soils on seedling growth of *Cassia fistula* L. as compared to control under natural field conditions. Growth variables *i.e.* seedling length, plant cover, number of leaves, leaf area, seedling fresh weight, total plant dry weight etc were recorded. Seedling length, plant cover, number of leaves, leaf area and seedling fresh weight were significantly ($p<0.05$) high for Shafi tannery soil as compared to control as well as other polluted soils of industrial site. The soils of Indus battery and Dalda Ltd. showed significantly ($p<0.05$) reduction in growth of *C. fistula* as compared to seedlings from other industrial soil as well as Karachi University Campus. The seedlings of *C. fistula* showed tolerance to Shafi tannery and Pakistan metal industrial soils as compared to seedlings grown in Dalda Ltd. and Indus Battery soils.

Introduction

Pollution is an undesirable change in the physical, chemical or biological characteristics of our air, water and land or soil that will harmful to human and other life, industrial processes, living conditions and cultural assets (Spilhaus, 1966 ; Odum 1975). The quality of the environment is a matter of serious concern, especially today that the consequences of human intervention are already evident. Although environment is extremely valuable for people and other organisms living in it, it is also endangered due to human activities that are continuously ruining it (Davis *et al.,* 2006). Air and water accept any kind of pollutants produced mainly from industries, but also naturally, domestic or traffic originated. Modern civilization introduces a wide range of pollutants to the atmosphere through various anthropogenic activities such as industry, mining, transportation, etc. Despite the fact that, it is almost impossible to visualize a soil without pollutants for living organisms, but their excess amounts are generally harmful to plants, animals and human health (Azevedo & Lea, 2005; Jarup, 2003).

Industrialization during 19^{th} century changed mankind's life style. New technology raised man's standard and made life more comfortable but with increasing industrial development, safe disposal of industrial pollutants has become the more ecological challenge. Environmental degradation has now become a global problem and maintaining ecosystem health is a serious issue being confronted by the environmentalists.

All compartments of the biosphere are polluted by a variety of inorganic and organic pollutants as a result of anthropogenic activities and alter the normal biogeochemical cycling. A variety of biological resources have been employed widely both in developed and developing nations for cleanup of the metal polluted sites. These technologies have gained considerable momentum in the last decade and currently in the process of commercialization (Comis, 1995, 1996; Ernst, 2000; Glass, 2000; Prasad & Freitas, 1999; Salt *et al*., 1995, 1998; Watanabe, 1997). The various conventional remediation technologies that are used to clean heavy metal polluted environments are soil *in situ* vitrification, soil incineration, excavation and landfill, soil washing, soil flushing, solidification and stabilization electrokinetic systems. Each of the conventional remediation technology has specific benefits and limitations (EPA, 1997; MADEP, 1993).

Tannery sludge could be an excellent material for soil amendment as it was found to improve the physical properties of soil and contain considerable amounts of plant nutrients (Lewcock, 1994; Tiredstorm, 1997). The sludge derived from the treatment of tannery effluent varies in composition but usually contains water (65-98%), lime, Cr, hydrate oxide, residual sulphides and organic matter (Akan, *et al*., 2009). Common mineral elements such as Al, Fe, Ca, Na, K and Si are present in significant quantities in sludge. It may also contain trace elements and heavy metals such as Cd, Pb, Hg, As, Cr, Cu, Ni, Zn, B, Se, Mo as well as N and P in both organic and inorganic forms (Ogbonna *et al*., 1998). Eventually the effluents and sludge from these operations are discharged onto land and into water bodies. The high sulphide content of tannery sludge, apart from being toxic, poses serious odour problems in the environment. Tanneries have been found to discharge not only Cr which is an inherent product of the tanning process but also significant amounts of Zn, Mn, Cu and Pb have been observed at the main waste disposal points exceeding the toxic range in soils (Imamul Huq, 1998).

Environmental pollution decreases the growth rate of trees and shrubs, and may even result in the decline of whole forest stands. To a large extent this may be due to soil pollution, which has a negative effect on the development of root systems, especially in long-lived organisms, such as trees (Bojarczuk, 2002). At higher pollution levels, root system is extremely lost and at maturity, plants yield are much reduced (Joshi *et al*., 1999;

Mondal *et al*., 2005; Yasir, 2003). Waste water from industries also destroys our productive land by adding pollutants. Delayed germination and earlier leaf senescence are the two most important parameters which cause the yield loss at the end of the season (Bishoni, 1993; Clemente *et al*., 2005).

In Pakistan, though little work is done on this problem, yet the effects of effluents from industries near Nowshera (Ali *et al*., 1976a), Sheikhupura (Ali *et al*., 1976b), Peshawar (Ali *et al*., 1977a,b) Kala Shah Kako (Ali *et al*., 1977c), and Karachi (Ali *et al*., 1979) on the microflora and fauna have been reported. However, handful literature on the effects of pollution is available on higher plants, especially the tree species. Iqbal & Qadir (1973) have reported the effects of effluents, collected from various industries of Karachi, on the germination of various species ranged from inhibitory to stimulatory. The discharge of industrial effluents, besides increasing the dissolved residues which increase the total amount of sediments, also bring about chemical transformation in soils continuously irrigated by polluted waters (Faisal & Husnain, 2004). As a result of this, serious biological and ecological instability may occur as more and more industrial wastes are thrown out into the bodies of water and air which finally come into the soil.

Cassia fistula L. commonly known as golden shower tree belonged to family fabaceae. From early spring through summer, it displays beautiful golden flowers. *Cassia* is a large genus with some 500 species, among which are a number of highly attractive flowering trees. It has great importance for human society as it has a medium size stem which produce durable wood used for construction purposes. Due to its shady nature this species is planted along roadsides and parks. It is successfully established in a wide range of climatic, soil and environmental conditions including pollution sites. The plants are used in folk remedies for tumors of the abdomen, glands, liver, stomach and throat. Sweetish pulp around the seed is used as mild laxative.

Although the industrial pollutants from manufacturing activities in Karachi have been analyzed by some investigators, almost no attempt has been made to evaluate the effects of industrial effluents on soil and vegetation in S.I.T.E. industrial area. In this investigation the effects of industrial pollutants from different industries on seedling growth of *C. fistula* were investigated. The findings will provide a basis for the future extensive study in this field of ecology.

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 *Cassia fistula* L. were collected from the Karachi University Campus. The top ends of seeds were slightly cut with clean scissor to break dormancy and were sown in garden soil in earthen pots and watered regularly. After two weeks of their germination, uniform size seedlings were transplanted in plastic pots of 7.2 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 environmental effects. Climatic data recorded during growth experiment is shown in Appendix 1. 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 seedlings were measured for 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. After air 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). 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.

Table 1 (a). Growth of *Cassia fistula* 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	7.28±0.19c	11.22±0.43bc	16.94±0.52b	33.84±2.39b	11.00±0.45a	4.71±0.37b
B	5.22±0.63b	8.26±0.26a	12.90±0.25a	25.60±1.55a	10.00±0.63a	2.54±0.36a
C	4.08±0.26a	8.84±0.32a	12.92±0.57a	37.42±2.19b	11.66±1.03a	6.40±0.17c
D	5.56±0.28b	10.52±0.48b	16.08±0.70b	44.98±1.59c	16.00±1.52b	9.40±0.67d
E	8.62±0.23d	11.90±0.47c	20.52±0.64c	55.86±2.03d	20.20±0.37c	10.21±0.89d

Table 1 (b). Growth of *Cassia fistula* in soils of different areas.

Treatments	Seedling fresh wt. (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	2.09±0.30b	0.33±0.03c	0.16±0.18ab	0.44±0.06bc	0.93±0.11c	2.07±0.10d	0.47±0.02bc	11.26±1.12a	5.28±0.45a
B	0.92±0.06a	0.12±0.007a	0.12±0.007a	0.17±0.03ab	0.41±0.02a	1.08±0.16bc	0.40±0.04ab	15.48±1.90a	6.12±0.71a
C	1.06±0.03a	0.14±0.03ab	0.23±0.02c	0.19±0.02a	0.56±0.06ab	0.65±0.67a	0.34±0.02a	35.28±4.30ab	11.95±1.38b
D	1.84±0.08b	0.22±0.02b	0.22±0.01c	0.26±0.02a	0.70±0.04ab	1.00±0.05b	0.38±0.02a	36.21±2.97b	13.54±0.66b
E	2.76±0.16c	0.43±0.03d	0.33±0.03d	0.70±0.04c	1.46±0.016bc	1.33±0.07c	0.48±0.01c	14.96±1.71a	7.16±0.84a

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. Soil Analysis of University Campus and Industrial polluted soil samples selected for seed germination and seedling growth of different plant species

S#	Locality	M.W.H. C%	B.D g/cc	Porosity %	$CaCO_3$ %	Cl mg/L	pH	S µg/g	EC dS/cm	TDS mg/L	Ex. Na ppm	Ex. K ppm	Sand %	Silt %	Clay %	Soil texture class
1	University Soil Sample	22.30	1.36	49	21.6	0	6.97	58.75	19.0	13.9	200	160	24.34	44.28	31.42	Clay loam.
2	Indus Battery	28.91	1.27	52	31.65	0	6.54	41.25	33.2	24.5	400	156	29.3	47	23.7	Sandy loam
3	Dalda Ltd.	23.12	1.55	41.5	14.15	400	6.81	40	7.2	5.2	640	192	38.8	30.5	30.7	Sandy loam
4	Pakistan Metal industry	23.88	1.46	45	19.75	710	6.66	45	9.6	7.1	560	200	59.8	13	27.2	Sandy clay loam
5	Shafi Tannery	23.91	1.54	42	19.55	140	7.65	125	0.8	0.6	120	80	69.44	11	19.56	Sandy loam

Abbreviation used:

M.W.H.C. = Maximum Water Holding Capacity
B.D = Bulk Density
$CaCO_3$ = Calcium carbonate
Cl = Chloride
pH = Power of Hydrogen ion
TDS = Total Dissolved Salt
S = Sulphur
EC = Electrical Conductivity
Ex. Na = Exchangeable Sodium
Ex. K = Exchangeable Potassium

Fig. 1. Seedling growth of *C. fistula* in different samples of University Campus and industrial polluted soils

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Appendix 1. Climatic data of Karachi during the growth of *C. fistula* (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

Results

The effects of different industrial pollutants on the seedling growth performance and biomass production of *Cassia fistula* was recorded (Table 1 a & b). Results of the present study revealed that *C. fistula* was adjusted for its different growth parameters in Shafi tannery soil as compared to others soils of industrial areas as well as control (Fig. 1). Root, shoot and seedling length was significantly ($p<0.05$) high and recorded as 8.62, 11.90 and 20.52 cm, respectively for seedlings raised from the soil of Shafi tannery. For control (University Campus) these parameters were measures as 7.28, 11.22 and 16.94 cm respectively, while other soil of industrial site had intermediate root, shoot and seedling lengths.

Plant cover and leaf area were comparatively high in seedlings raised from the soil of industrial areas than the control. Except the seedlings, growing in Indus battery soil all the other had significantly ($p<0.05$) more plant cover and leaf area as compared to control seedlings. Number of leaves were also significantly ($p<0.05$) more in industrial areas seedlings except that of Indus battery soil. Principally, Indus battery soil exhibited great reduction in most of the growth parameters as compared to other industrial soil as well as control.

The effects of industrial pollutants on biomass production of *C. fistula* were also observes. Seedling fresh weight showed that seedlings health were increased in Shafi Tannery soil as compared to seedlings raised from the soil of other industries as well as control. For Shafi tannery fresh weight was recorded as 2.76 g which was reduced to 2.09 g for control while, other industrial soil showed reduction in this parameters. Fresh weight reduction was more prominent for the seedlings raised from Indus battery soil. Total plant dry weight which comprises on the root, shoot and leaf dry weight was comparatively low in industrial areas soil as compared to control. Root/shoot ratio and leaf weight ratios were also significantly ($p<0.05$) reduced in industrial soil as compared to University Campus. Specific leaf area and leaf area ration were significantly ($p<0.05$) reduced in Shafi Tannery, University Campus and Indus battery soil.

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). 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 was determined as 7.65. 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.

Discussion

C. fistula growth was enhanced in tannery effluents but reduced in Indus battery and Dalda Ltd. soils indicating that different industrial pollutants can affect its growth in some variable way. Tannery pollutants are phyto-extracted by the species but Indus battery and Dalda Ltd. soils showed their deleterious effects on its growth. *C. fistula* showed better growth in tannery effluents probably due to mineral elements such as Al, Fe, Ca, Na, K and Si which are generally present in significant quantities in discharged pollutants coming in air, water and soil. These incoming pollutants also resulted in environmental pollution effecting the growth of other plant species. So environmental pollution is an important factor governing seed germination and seedling growth of different plant species. The effects of toxic substances on plants are dependent on the amount of toxic substance taken up from the given environment. Some plants species can act as pollution sink for industrial pollutants as they can tolerate their effects showing great resistance against them. Actually different industries are affecting to different plant species regarding to their morphology as well as productivity. Seed germination and seedlings establishment are vulnerable stages in the plant life cycle (Vange *et al*., 2004). Seedling growth is considered as an indicator of pollution stress on plant ability to survive. The toxicity of some of the pollutants may be large enough that, plant growth is retarded before large quantities of the element can be transferred (Haghiri, 1973).

Plant response varies between species of a given genus and between varieties within a given species. Plants do not necessarily show similar susceptibility to different pollutants. Major variations in response to different species to air pollutants have been documented by Jacobson & Hill (1970). Wang *et al*., (1991) used some higher plants like duck weed (*Lemma minor*), lettuce and rice to assess the toxicity of industrial and municipal effluents. A pre-treated industrial sample of a metal processing plant exhibited 98% inhibitory effect on *L. minor* but was not toxic to lettuce or rice germination, whereas a sample from a dairy plant caused 100% inhibition respectively in lettuce, rice and duck weed. Lakshmanachary (1995) used textile mill effluent on green gram seedling to show the effect on their growth and development. Cargill & Jefferies (1994) observed that the range of substances capable of adversely affecting plant growth is enormous and inevitably the specific effects of these toxins are too numerous.

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 soil 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 salt also increased the growth of *C. fistula* in some of the variables in industrial soils as compared to University Campus soil. The texture of industrial soils is drastically disturbed due to irregular pilling of wastes materials. Particle size distribution is a major factor in governing successful vegetation on polluted soil as it influences water holding capacity, bulk density, soil moisture availability and nutrient contents as well as availability (Dutta & Agrawal, 2002).

Elevated electrical conductivity at higher concentration, than preceding concentration shows the higher salt content. Regarding the effect of higher osmotic pressure on seed germination Rodger *et al*., (1957) reported that higher osmotic pressure causes retardation of germination. The cause of higher osmotic pressure is the higher mineral salt content of the effluent seen in the form of higher electrical conductivity, which reduced the growth in Indus battery soil seedlings. Same type of finding has been reported by Ramana *et al*., (2002), Pandey & Sony (1994). It is anticipated that in this area salt concentration is governing the seed germination, it varies from species to species because each species has its own tolerance to the different salt concentrations.

It was observed that, the industrial polluted soil especially Indus battery and Dalda Ltd. factory soils produced toxic impact on seedling growth of *C. fistula*. Increase in different types of pollutants in soil, brought up changes in most of the growth parameters of *C. fistula*. Therefore, *C. fistula* should be grown in tannery polluted soils and appropriate control measures should be adopted to maintain the toxic content of the soil below the damage threshold level. The pollutants of Dalda limited and Indus battery soil exhibited the lowest percentage of tolerance in seedling growth characteristics of *C. fistula* as compared to other industrial soil indicating that species is not well suited for their pollutants. While, it adjusted itself in soil of Shafi tannery indicating that tannery pollutants which can decrease plant growth of other plant species enhanced the growth of *C. fistula*. The identification of the toxic concentration of pollutants and tolerance indices of plant species, such as *C. fistula*, would be helpful for the establishment of an environment quality standard. The findings can also contribute to better ecological fragility, the potential of *C. fistula* in coordinating species management programmes in industrial polluted areas. Furthermore, research studies with different metal stresses can be helpful in the solution of various problems associated with metal pollution in industrial areas.

This study investigated that physico-chemical parameters of soil such as pH, electrical conductivity, chloride, sodium and potassium, sulphate, electrical conductivity and TDS were relatively high in the industrial area soil and severely affected seed germination and seedling growth in Indus battery and Dalda Ltd. soils. The Indus battery effluent could possibly lead to soil deterioration and low productivity. Terrestrial and aquatic environment pollution could be averted by proper treatment of the effluents using suitable conventional methods.

It may be concluded that the growth of *C. fistula* 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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