Int. J. Biol. Res., 7(2): 111-119, 2019.

EFFECTS OF DIFFERENT INDUSTRIALLY POLLUTED SOILS ON SEEDLING GROWTH OF *BAUHINIA RACEMOSA* LAMK.

MUHAMMAD KABIR[1], M. ZAFAR IQBAL[2], MUHAMMAD SHAFIQ[2*] AND ZIA-UR-REHMAN FAROOQI[2]

[1]*Department of Biological Sciences, University of Sargodha, Sub-campus Bhakkar, Pakistan*
[2]*Department of Botany, University of Karachi, Karachi, 75270, Pakistan*
[*]*Corresponding author email: shafiqeco@yahoo.com*

ABSTRACT

Soil pollution is worldwide problem and polluted soil due to industrial activities affecting seedling growth performance of plants. The results showed variable effects of industrial areas ‘soil treatment on the seedling growth performance of a legume tree, *Bauhinia racemosa* Lamk. The treatment of polluted soils of factories of Indus Battery, Universal Chemicals, Haroon Textile and National Foods Ltd. differentially influenced various growth parameters such as root, shoot, seedling length, plant cover, number of leaves, leaf area, seedling fresh weight, root dry weight, shoot dry weight, leaf dry weight, total plant dry weight, root/shoot ratio, leaf weight ratio, specific leaf area and leaf area ratio. Significant reduction in seedling growth was recorded in soil of Indus Battery factory. However, seedling growth was significantly ($p<0.05$) higher in soil of National Foods Ltd.

KEYWORDS: *Bauhinia racemosa*, Industrially polluted soil, Seedling growth, Soil pollutants, Soil physical and chemical properties.

INTRODUCTION

Karachi is the Pakistan's largest industrial and commercial center, handling much of Pakistan's international trade. Sindh Industrial Trading Estate (S.I.T.E.), Karachi is being conceived as a principal source of environmental pollution due to non-compliance of statuary regulations requiring implementation of proper discharge and effective recycling of industrial solid, liquid and gaseous wastes. Environmental pollution by industries is a major problem today and there is an increasing awareness of the fact that a clean environment is necessary for better health of living organisms. The environmental pollution in and around our surroundings brought up rapidly by the industrial revolution. The development of industrial projects had a profound influenced on society and the environment not only in terms of benefits but also in risks and hazards. This environmental pollution added by different industries is causing a great threat to human, animals as well as to plants. The soil of the industrial area was contaminated by various types of pollutants. The uptake of heavy metal exerts injurious effects on plant growth and developmental stages (Suntonvongsagul *et al.*, 2007), while at the physiological level, it reduces photosynthetic activity (Weis and Weis, 2004).

Different types of toxic pollutants are being deposited directly on the soil as sewage, industrial effluents and chemical fertilizers. Germination is considered an important stage in establishment of trees (Durr *et al.*, 2015). The industrial pollutants after settling on soil surface affects the mineral structure, soil pH, total dissolved salts, soil texture and exchangeable nutrients and thus indirectly affect the plants growth. Various degradable and non-degradable pollutants accumulate in industrial soil up to toxic levels in plants. In highly polluted industrial soils and plants absorb, accumulate and translocate toxic substances in their different parts. Acidic or low pH of soil affects functions of microbes, mainly of decomposers as a result of which decomposition process of organic matter and consequently the nutrient cycles are reduced in the soil. Industry proliferates parallel to urbanization, but increased industrialization produced industrial effluent which is hazardous for the environment if not treated (Ahmad *et al*., 2012).

Species description: *Bauhinia racemosa* Lamk. (vern. Jhinjera, Kosundra, Kanchnal) Eflora, (2019) is a member of the family Caesalpiniaceae and has a widespread occurrence in India, Ceylon, China and Pakistan. *B. racemosa* is a small crooked tree with drooping branches, growing up to 3-5 m tall, distributed in sub-Himalayan tracts from Ravi eastwards also found in Uttar Pradesh, West Bengal, Central and South India. It is highly astringent, anti-inflammatory (used in glandular inflammation, skin diseases, ulcers) and alternative tonic. Furthermore, methanolic extract of *B. racemosa* stem bark exhibited antitumor effect by modulation lipid peroxidation and augmenting antioxidant defense system in Ehrlich ascites carcinoma bearing mice (Gupta *et al*., 2004). The alcoholic and aqueous extract of stem bark of the plant *B. racemosa* showed antipyretic activity in rats (Borikar *et al*., 2009a). It is used in conventional medicine for the cure of various ailments. Stem bark of this plant is conventionally used in the treatment of headache, fever, skin diseases, tumors, dysentery, diarrhoea. Aqueous and alcoholic extract of the dried stem bark are proved to exert significant analgesic activity (Borikar *et al*., 2009b). Phytochemical investigations reported the presence of protein, oil, fats, phenolic compounds, saponins, tannins and carbohydrates. Methanolic and aqueous extracts of the plant are reported to exhibit a broad spectrum of anti-microbial activity (Gaurav *et al*., 2010). *B. racemosa* is a traditional valued plant of anti-ulcer property. The constituents like flavonoids (quercetin, nagingin, silynarin, anthocyanosides and sophoridian derivatives), saponins and tannins produce anti-ulcer effects (Borikar *et al*., 2009c).

In Pakistan, Bauhinia racemosa Lamk. is distributed in Sindh and Punjab. It is a legume of great economic importance. The seeds and pods characteristics and variation in seed size of *B. racemosa* have been examined by Khan and Zaki (2016) and germination and seedling characteristics have been described by Khan *et al.* (2015).

The study of responses of plants' growth to toxic industrial pollutants has become the subject of great interest in recent years. Therefore, the present study was carried out to determine the effects of different soil types collected from unpolluted sites of University of Karachi and polluted industrial areas of Karachi, Pakistan, on seedling growth of this economically important legume tree species, *Bauhinia racemosa.*

MATERIALS AND METHODS

The seed germination and seedling growth experiments were carried out in greenhouse at the Department of Botany, University of Karachi. The vigorous and the same size seeds of *Bauhinia racemosa* Lamk., were collected from the plant 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. After two weeks same size seedlings were transplanted 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. During growth pots were shuffled every week.

Seedling growth parameters such as seedling height, number of leaves, leaf area and plant circumference were noted weekly for eight weeks. After eight weeks, 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). Tables 1-2 showed the physical and chemical characteristics of different soils (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):

$$\% \text{ Promotion / Reduction} = \frac{\text{Control - Treatment}}{\text{Control}} \text{ X } 100$$

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.

RESULTS

The seed germination and early seedling growth are the critical stages of plant development. The seedling growth of selected plant species, *Bauhinia racemosa* Lamk. responded variation in growth variable when treated with different soil samples collected from industrial areas (Tables 3-5; Figs. 1-2). The seedling growth response was found mainly dependent on the soil types collected from the different areas. The seedling growth response also depends on the immediate environmental conditions. A significant ($p<0.05$) variation in seedling growth parameters such as root, shoot and seedling length, plant cover, number of leaves, leaf area (Table 3) and biomass variables as seedling fresh weight, root, shoot, leaf and total plant dry weights, root and shoot ratio, leaf weight ratio, specific leaf area and leaf area ratio ((Table 4) were recorded in soils of Karachi University Campus (Control) and compared with the performance of seedlings in polluted soils of different industries. The seedling length of was significantly ($p<0.05$) reduced in Indus Battery soil as compared to soils of other industries, while in soil of Universal Chemicals, Haroon Textile and National Foods Ltd., it was increased significantly ($p<0.05$). Growth parameters which include such as plant cover, number of leaves, leaf area, seedling fresh weight, total plant dry weight, root/shoot ratio and leaf weight ratio were also reduced in plants grown in the soil of Indus Battery as compared to other industrial soil as well as Karachi University Campus. The growth performance of *B. racemosa* showed that plants are well adopted in National Foods Ltd. soil treatment as compared to soils of other industries and Karachi University Campus. Results have shown that *B. racemosa* plants are well suitable for its growth in industrial areas soil of Textiles and food industries indicating its tolerance against pollutants.

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

Table 2. 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).

Table 3. Seedling growth of *Bauhinia racemosa* 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	5.60 ± 0.45c	7.58 ± 0.34b	13.18 ± 0.39cd	15.70 ± 0.57b	4.80 ± 0.86b	2.87 ± 0.34bc
B	5.10 ± 0.56c	6.96 ± 1.13b	12.06 ± 1.37d	11.88 ± 0.24d	2.80 ± 0.37c	2.18 ± 0.24c
C	8.92 ± 1.61b	7.42 ± 0.69b	16.34 ± 1.73bc	13.88 ± 0.43c	4.20 ± 0.58bc	2.38 ± 0.14c
D	10.02 ± 0.93ab	8.88 ± 0.65b	18.90 ± 1.31b	14.94 ± 0.43bc	6.00 ± 0.70b	3.87 ± 0.38b
E	12.76 ± 0.65a	15.56 ± 0.89a	28.32 ± 1.51a	21.70 ± 0.85a	8.80 ± 0.49a	5.39 ± 0.31a
L.S.D. (p<0.05)	**2.76**	**2.32**	**3.97**	**1.60**	**1.85**	**0.85**

Acronyms: 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. Seedling fresh, dry weights and ratios of different variables of *Bauhinia racemosa* 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	0.39±0.10c	0.04±0.005b	0.04±0.005b	0.07±0.002c	0.15±0.008c	1.00±0.18a	0.48±0.05a	40.96±3.89bc	18.96±1.40b
B	0.22±0.02c	0.02±0.003b	0.03±0.004b	0.4±0.004c	0.09±0.008c	0.67±0.12a	0.45±0.04a	56.17±7.02d	24.13±1.07a
C	0.31±0.04c	0.03±0.003b	0.04±0.003b	0.04±0.00c	0.11±0.005c	0.75±0.35a	0.43±0.02ab	51.11±5.36cd	21.39±0.98ab
D	0.76±0.17b	0.08±0.007b	0.09±0.007b	0.12±0.015b	0.29±0.027b	0.88±0.11a	0.43±0.02ab	30.71±1.75ab	13.17±0.68c
E	2.04±0.10a	0.36±0.046a	0.26±0.34a	0.30±0.037a	0.92±0.085a	1.38±0.16a	0.32±0.02b	19.13±2.89a	6.22±1.06d
L.S.D. (p<0.05)	**0.31**	**0.06**	**0.05**	**0.05**	**0.20**	**0.61**	**0.10**	**13.49**	**3.10**

Symbol used: Sites: A = Karachi University Campus; B = Indus Battery factory; C = Universal Chemicals factory; D = Haroon Textile factory; E = National Foods Ltd. Factory. 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

Table 5. Percentage reduction (-) or promotion (+) in growth of *Bauhinia racemosa* in soils of different factories in comparison with control soil.

Treatments	Root length	Shoot length	Seedling length	Plant cover	Number of leaves	Leaf area	Seedling fresh weight	Root dry weight	Shoot dry weight	Leaf dry weight	Total plant dry weight
A	8.93	8.17	8.49	32.15	41.66	24.04	43.59	50	25	42.86	40
B	59.28+	2.11+	23.98+	11.59	12.5	17.07	20.51	25	00	42.86	26.67
C	78.93+	17.15+	43.40+	4.84	25+	34.84+	94.87+	100+	125+	71.43	93.33
D	7.83+	105.27+	114.87+	38.22+	83.33+	87.80+	423.08+	800+	550+	328.57	513.33

Acronyms: Sites: A = Indus Battery factory; B = Universal Chemicals factory; C = Haroon Textile factory; D = National Foods Ltd. Factory. + = Percentage increase

Fig. 1. Growth of *Bauhinia racemosa* in different soils (in pots and after harvest) at the age of ten weeks. Acronyms: 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

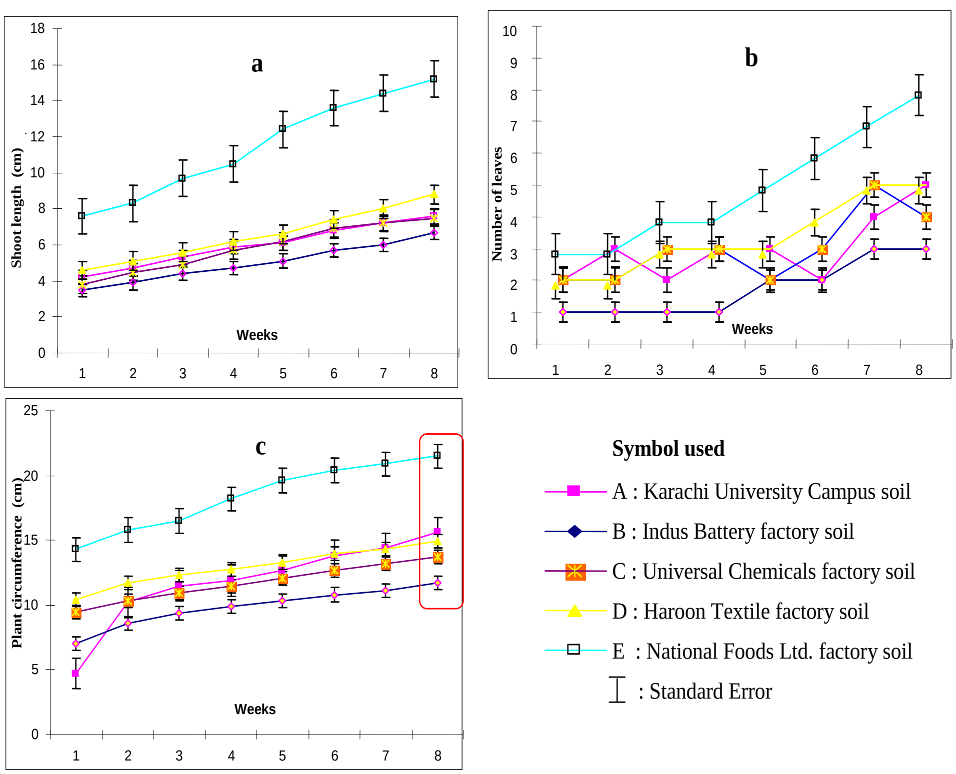

Fig. 2. Seedling size (a), number of leaves (b) and plant circumference (c) of *Bauhinia racemosa* periodically in soils of different industrially polluted and control area.

The percentage reduction in different growth parameters of *B. racemosa* as compared to control showed that all the growth variables were increased in the soils of Haroon Textile and National Foods Ltd., while in Indus Battery the percentage was decreased (Table 5). The seedling growth of *B. racemosa* in Karachi University Campus under pot conditions and after harvest at the age of ten week is shown in (Fig. 1). In soils of different areas under field conditions its growth before and after harvest responded differently. The periodic growth of *B. racemosa* was also recorded (Fig. 2). The seedling size, number of leaves and plant circumference of *B. racemosa* were recorded weekly. The increase in periodical growth parameters were more prominent for seedlings grown in the soil of National Foods Ltd., factory while reduction was recorded for seedling raised from the soil of Universal Chemicals factory. The seedling size and number of leaves increased in National Foods Ltd., during 1st week and maintained it for rest of the growth period (Fig. 2).

DISCUSSION

Plants directly depend on the soil characteristics and environmental conditions necessary for the growth. In the present study, the seedling growth performance of *B. racemosa* was found significantly decreased and was associated with soil properties of polluted and less polluted industrial areas. *B. racemosa* prefer to grow on light (sandy), medium (loamy) and heavy (clay) soils (PFAF, 2019). The changes in physical and chemical properties values of coarse sand, water holding capacity of soil, pH, organic matter, calcium carbonate, total dissolved salts and soil sulphur in industrial area an important factor in producing harmful impact on the plant growth. Soil texture and water holding capacity showed marked correlation and influenced the growth of *B. racemosa* in Indus Battery factory soil. A high percentage of silt particles and water holding capacity in soil of Indus Battery caused reduction in the growth of *B. racemosa*. Soil organic matter content was high in soil of control area (Karachi University Campus soil). The seedlings of *B. racemosa* showed better was found significantly associated with soil properties of polluted and less polluted industrial areas. High organic matter caused improved growth in plants as determined by Singh (1986). He observed that in those plant communities (group of plants) 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; Zia *et al.*, 1998; Bhatti, 1999). The concentration of Calcium carbonate was higher in Indus Battery soils relative to the control soil. An appreciable amount of Calcium carbonate (9.8 - 17.1%) is the characteristic features of arid zone soils (Aubert, 1960). Exchangeable sodium and potassium were low in soil of National Foods Ltd. while their concentrations were high in all other industrial soils as compared to control. Salinity is a major yield–limiting factor for crops in all the arid and semiarid regions of the world (Flores *et al.*, 2004). High amount of available sulfate reduces the plant growth and absorbed sulphur in the form of sulfate which is obtained from industrial emission of SO_2 in excessive amount. Exposure to constant concentration of SO_2 caused notable and significant reductions in the dry matter accumulation and yield of *Lolium perenne* L. cv. S23 (Bell *et al.*, 1979). Soils of industrial areas particularly Indus Battery factory soil mostly affected the growth of *Bauhinia racemosa* Lamk., as compared to control area soil of Karachi University Campus.

The present studies would suggest that the soil of the most industries areas is not good for growth of *B. racemosa*. However, National Foods Ltd. factory soils increased most of the growth variables in *B. racemosa*. Similar results were also observed by Atiq-ur-Rehman (2006) in One Tech Ply Board factory soil. He examined that different variables of *Thespesia populnea*, *Peltophorum pterocarpum*, *Azadirachta indica* and *Prosopis juliflora* (Korangi and Landhi industrial areas population) were increased in growth in One Tech Ply Board factory soil than other factories soils. The success of better seedling growth performance of *B. racemose* and adaptation may be due to its ability to respond to abiotic stress. The seedling growth of *Cassia fistula* was significantly decreased for soils of industrial areas (Kabir and Iqbal, 2011).

Thus, *B. racemosa* was sensitive for soils of industrial areas particularly with respect to Indus Battery factory soil. Therefore, *B. racemosa* should not be grown in the vicinity of Indus Battery factory due to its low tolerance for industrial pollutants. Iqbal and Shafiq (1999) reported that *Ricinus communisis* is a tolerant plant and should be planted around the industrial areas of Karachi. The establishment of favorable habitat for native plants species is recommended in the disturbed industrial sites. Encourage the plantation of native plants whenever possible as they have evolved to tolerate the local climatic condition. The reclamation and phytoremediation struggle have attained the world's large importance and improvement procedures are immediately required (Buscann *et al*., 2008). In other industrial area, tolerant tree species should be chosen according to the level of industrial pollution (Shafiq *et al.*, 2019).

ACKNOWLEDGEMENTS

The authors are thankful to Chairman, Department of Botany, University of Karachi for providing experimental support to this study. The critical review on manuscript by Dr. D. Khan is also sincerely acknowledged.

REFERENCES

Ahmad, I., M.J. Akhtar., Z.A. Zahir, and A. Jamil. (2012). Effect of cadmium on seed germination and seedling growth of four wheat (*Triticum aestivum* L.) Cultivars. *Pak. J. Bot.,* 44: 1569-1574.

Atiq-ur-Rehman, S. and M.Z. Iqbal. (2006). Seed germination and seedling growth of trees in soil extracts from Korangi and Landhi Industrial Areas of Karachi, *Journal of New Seeds*, 8(4): 33-45.

Aubert, L. (1960). Arid Zones Soils; study of their formation, characteristics utilizations and conservations. In: The Problem of Arid zone. UNESCO Publications, Paris, pp. 115-137

Bell, J.N.B., A.J. Rutter and J. Relton. (1979). Studies on the effects of low levels of sulphur dioxide on the growth of Lolium perenne L. *New Phytologist*, 83: 1-7.

Bhatti, M.A.R. (1999). Self-sufficiency in food through soil improvement -use of bio-fertilizers. *Pakistan Food and Agriculture Review*, 5: 12-14.

Borikar, V.I., C.R. Jangde, P. Philip, D.S. Rekhe and S.K. Atole. (2009a). Study of antipyretic activity of *Bauhinia racemosa* Lam., in rats. *Journal of Veterinary World,* 2: 217-218.

Borikar, V.I., C.R. Jangde, P. Preety and D.S. Rekhe. (2009c). Study of anti-ulcer activity of *Bauhinia racemosa* Lam. in rats. *Journal of Veterinary World,* 2: 215-216.

Borikar, V.I., C.R. Jangde, D.S. Rekhe and P. Preety. (2009b). Study of analgesic activity of *Bauhinia racemosa* Lam*.*, in rats. *Journal of Veterinary World,* 2: 135-136.

Buscann, J., M. Berg, C. Stengel, L. Winkel, M.L. Sampson, P.T.K. Trang and P.H. Viet. (2008). Contamination of drinking water resources in the Mekong delta floodplains: Arsenic and other trace metals pose serious health risks to population. *Environment International*, 34: 756-764.

Dürr, C., B.C. Dickje, X.Y. Yang and H.W. Pritchard. (2015) Ranges of critical temperature and water potential values for the germination of species worldwide: Contribution to a seed trait database. *Agricultural and Forest Meteorology,* 200: 222-232.

E-flora. (2019). Flora of Pakistan. *Bauhinia racemosa* Lamk. http://www.efloras.org/ florataxon. aspx? floraid=5&taxon_id=200011956. Accessed on November 01, 2019.

Flores, P., M.A. Botella, A. Cerda and M. Vicente. (2004). Influence of nitrate level on nitrate assimilation in tomato (*Lycopersicon esculentum*) plants under saline stress. *Canadian Journal of Botany*, 82: 207-213.

Gaurav, K.L., L. Karthik and K.V. Bhaskara. (2010). Phytochemical composition and *In vitro* antimicrobial activity of *Bauhinia racemosa* Lamk. (Caesalpiniaceae). *International Journal of Pharmaceutical Sciences and Research*, 1: 51-58.

Grigalaviciene, I., V. Rutkovience and V. Marozas. (2005). The accumulation of heavy metals lead, copper and cadmium at roadside forest soil. *Polish Journal of Environmental Study*, 14: 109-115.

Gupta, M., U.K. Mazumdar, R.S. Kumar and T.S.S. Kumar. (2004). Antitumor and antioxidant role of *Bauhinia racemosa* against *Ehrlich ascites* carcinoma in Swiss albino mice. *Acta pharmacological Sinica*, 25: 1070-1076.

Iqbal, M.Z. and M. Shafiq. (1999). Effects of chromium on germination and growth of *Ricinus communis* and *Leucaena leucocephala* Herb, Medicines and Therapeutics. Proceedings of the first National symposium on Pharmacy, Pharmaceuticals and Health, Karachi, Pakistan 29th March 1997(Eds.): M. Ahmad and G.H. Rizwani, pp. 126-137.

Kabir, M. (2014). Effects of industrial pollution on tolerance and distribution of plants. Ph. D thesis. University of Karachi, Karachi, Pakistan.

Kabir, M. and M.Z. Iqbal. (2011). Effects of different soils on seedling growth of *Cassia fistula* L. under natural field conditions. *FUUAST. J. Biol.*, 1(2):115-122.

Khan, D. and M.J. Zaki. (2016). Size variation and surface structure of pods and seeds of *Bauhinia racemosa*. *FUUAST J. Biol*., 6(1): 73-80.

Khan, D., M.J. Zaki and M. Anis. (2015). Seedling characteristics of Jhinjera (*Bauhinia racemosa* Lamk.). *Int. J. Biol. Biotech*., 12(1): 143-154.

Ladha, J.K., M.G. Kundu, A. Coppenolle, M.B. Peoples and P.J. Dart. (1996). Legume productivity on the growth of *Lolium perenne* L. *New Phytologist,* 83: 1-7.

P.F.A.F. Plants For A Future. (2019). Physical characteristics. https://pfaf.org/user/Plant.aspx? Latin Name =Bauhinia+racemose. Accessed on 2nd January, 2019.

Rehman, S.A. and M.Z. Iqbal. (2009). Growth of *Leucaena leucocephala* (Lam.) De-wit in different soil compositions of Korangi and Landhi industrial areas of Karachi, Pakistan. *Pak. J. Bot.,* 41: 3125-3138.

Shafiq, M., M.Z. Iqbal., M. Kabir and Z.R. Farooqi. (2019). Poison Land. "Vegetation of disturbed and polluted areas in Pakistan". Strategic book publishing & rights agency, U.S.A. 173 pp.

Singh, A.P. (1986). Seasonal fluctuation of organic matter with relation to moisture retention characteristics and availability of water in salt affected soil (India). *Acta Botanica Indica*, 14: 73-76.

Suntornvongsagul, K., D.J. Burke, E.P. Hamerlynck and D. Hahn. (2007). Fate and effects of heavy metals in salt marsh sediments. *Environ. Pollut*., 149: 79-91.

Weis, J.S. and P. Weis. (2004). Metal uptake, transport and release by wetland plants: Implications for phytoremediation and restoration. *Environ. Int*., 30: 685-700.

Zia, M.S., M.B. Baig and M.B. Tahir. (1998). Soil environment issues and their impact on agricultural productivity of high-potential area of Pakistan. *Science Vision*, 4: 56-61.

(Received September 2019; Accepted November 2019)