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Influence of Locomotive Activities Polluted Soil on Seedling Growth Performance of an Evergreen False Rosewood Coastal Tree Species (*Thespesia populnea* (L.) Soland ex Correa)

Zia-ur-Rehman Farooqi[1], Muhammad Zafar Iqbal[1], Muhammad Shafiq[1]✉, Mohammad Athar[2], Muhammad Kabir[3]

[1]Department of Botany, University of Karachi, Karachi, 75270, Pakistan. E-mail : farooqi_bot@yahoo.com
[1]Department of Botany, University of Karachi, Karachi, 75270, Pakistan. E-mail: mziqbalbotuokpk@yahoo.com
[1]Department of Botany, University of Karachi, Karachi, 75270, Pakistan. E-mail: shafiqeco@yahoo.com
[2]California Department of Food and Agriculture, 1220 N Street, Sacramento, CA 95814, USA. E-mail: atariq@cdfa.ca.gov
[3]Department of Biological Sciences, University of Sargodha, Sub-campus Bhakkar, Pakistan. E-mail: muhammad.kabir@uos.edu.pk
Corresponding Author, Department of Botany, University of Karachi, Karachi, 75270, Pakistan. E-mail: shafiqeco@yahoo.com

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Abstract

Objective: Rail transportation is an economic mode of transportation for goods and public movement. In recent years, railway activities are also becoming an important cause of deterioration of environment and also negatively affecting growth of plant. The discharge of different types of pollutants from railway activities changes the soil qualities and growth performance of plants. The effects of locomotive activities on edaphic characteristics and seedling performance of economically and medicinally evergreen Portia tree species were recorded.

Material and Methods: The seedling growth of *Thespesia populnea* was tested in soil of nearby railway track side in pot of 20.0 x 9.80 cm in size was evaluated. The pots were reshuffled on weekly basis with five replicates to avoid any light or shade effect. The plant circumference, seedling height, and leave numbers were noted. The plant material was uprooted from pots carefully and kept in oven get constant dry weights.

Results: The treatments of different soil types close to the railway track areas reduced significantly ($p<0.05$) in terms of plant growth and total yield of *T. populnea*. The periodical growth study for *T. populnea* seedlings showed a wide difference in number of leaves, plant circumference, and seedling height raised in soils of University Campus as compared to treatment of soil of different railway side.

Conclusion: Results showed that seedling growth performances of *T. populnea* in Cantonment Station soil was highly decreased which might be due to the ongoing railway vehicles repairing activities in servicing workshop, release of toxic pollutant, and accumulation in soil from locomotives diesel engines and exploitation of fuel oils by railway transport.

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Introduction

The transportation of goods and passenger by railways is a popular and safe mode of movement from one place to another. In recent years railway activities are considered as an important cause of air, water, and soil pollution problems at

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regional and global level. The common toxic compounds viz. CO_2, hydrocarbon, heavy metals, and PAHs normally released in environment due to exhaust emission from locomotive engines [1-8]. Railway activities also brought up disturbances on ecology, soil quality, oil derived product and soil pollution [9]. Zhang, *et al.*, [10] reported the highest enrichment of metal in Delingha soil of Qinghai-Tibet railway.

Thespesia populnea (L.) Soland ex Correa is shrub or medium size ever green tree species and commonly distributed in tropical areas and planted in parks [11-12]. *T. populnea* reaches maximum of 18 meters in height and fruits extract help for treatment of antifungal and antibacterial infections [13-14]. *T. populnea* is confined to coastal region particularly in Karachi (Pakistan), cultivated along road side as a shade tree [15], timber, and is found in and around mangrove. *T. populnea* belongs to family Malvaceae (Mallow family) and having cup shaped yellow flower.

The Pakistan railway consists of 500 diesel locomotives and shares in transportation sector is expected to increase from 4 to 25% in the year 2025 according to Pakistan Railway vision, 2025 [16-18]. The scientific research report on plant soil relationship for *T. populnea* in railway transport affected soil is not available in Pakistan. The aim of this work was to find the impact of five different types of soil affected by locomotive activities on the growth performance of an economic multipurpose plant species, *T. populnea.*

Material and methods

Study site and soil collection

The surface (0-30 cm) soil samples were collected from five predetermined railway sites comprised on A= University of Karachi University to serve as control; B= Karachi Cantonment Railway Station, C= Drigh Road Junction, D= Malir Station and E= Landhi Junction for treatment.

These air-dried soil samples were passed through 2.0 mm mesh in the laboratory to remove large soil particles, stone and boulders for treatment of seedlings. A sufficient quantities of *T. populnea* seeds were collected from the species growing in Karachi University Campus and sown in a pot in garden loam soil at 1 cm depth. Seeds were allowed to germinate for two weeks and regularly irrigated with tap water. The germinated seedlings with uniform size were transferred in 20.0 x 9.80 cm size pot at green house of the Department of Botany, University of Karachi for different types of soil treatment. The design of the experiment was completely randomized along with five replicates. The positions of pots were rearranged on weekly basis to avoid the impact of shade or light for eight weeks. The plant circumference, seedling height measured, and number of leaves were recorded on weekly basis. Finally, seedlings were removed carefully from pots and washed with distilled water for the measurement of different growth characteristics. The seedlings were divided in root, shoot, and leaves placed in an oven at 80 °C for 24 hours to get dry weights.

Statistical analysis

The experimental data of growth parameters statistically performed through one-way ANOVA techniques and Duncan's Multiple Range Test at $p< 0.05$ level through (SPSS 20) software.

Results

The seedlings growth development characteristics of *T. populnea* raised in soil of site C reduced significantly ($p<0.05$) as compared to control (Table 1).

Table 1: Effects of different soils on seedling growth of *Thespesia populnea*

Sites	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Leaf area (cm^2)
A	11.62±1.01a	16.44±0.55ab	28.06±1.48ab	8.43±0.42a
B	10.26±0.62a	14.24±0.58a	24.50±0.61a	6.92±0.16a
C	12.70±0.82ab	18.90±0.71b	31.60±0.65b	12.79±1.06b
D	16.18±2.24bc	22.26±1.35c	38.44±3.22c	12.65±0.98b
E	19.36±1.59c	23.46±1.34c	42.82±2.78c	15.92±0.66c
LSD P<0.05	4.09	2.89	6.60	2.18

Symbol used: Sites = **A** = University Campus; **B** = Cantonment Station; **C** = Drighroad Junction; **D** = Malir Station; **E** = Landhi Junction. 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

The results also indicated the remarkable influence of B site polluted soil on shoot growth of *T. populnea.* The soil of site C and D mostly favored the production of root, shoot and leaf size of *T. populnea.*

The results of this study also indicated that the soil treatment strongly influenced root, shoot, leaves, and seedling dry weight of *T. populnea* (Table 2).

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Table 2: Effects of different soils on seedling dry weight of *Thespesia populnea*

Soil sample Sites	Root dry weight (g)	Shoot dry weight (g)	Leaf dry weight (g)	Seedling dry weight (g)
A	0.13±0.08a	0.29±0.08a	0.23±0.09a	0.65±0.01a
B	0.10±0.04a	0.24±0.01a	0.19±0.01a	0.53±0.02a
C	0.17±0.07a	0.57±0.05b	0.46±0.02b	1.20±0.06b
D	0.31±0.05b	0.69±0.03c	0.50±0.02b	1.51±0.09c
E	0.47±0.03c	0.82±0.03d	0.61±0.03c	1.90±0.10d
LSD (p<0.05)	**0.08**	**0.09**	**0.06**	**0.21**

The seedling of *T. populnea* before and after showed a wide range of difference in seedling dry weight values when raised in different railway site soils. The harvested seedling of *T. populnea* showed a wide range of difference in dry weight of seedlings when raised in different soils. The treatment of railway soil showed different response in plant circumference values of *T. populnea* on weekly basis (Fig. 1).

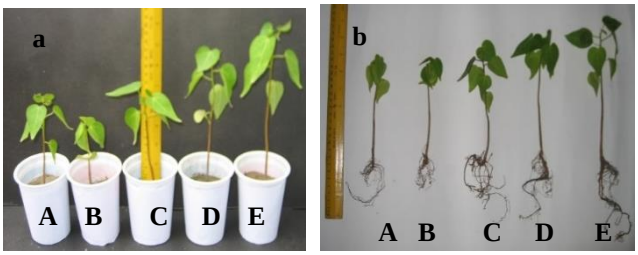

Fig. 1. Seedling treatment of *T. populnea* before (a) and after harvest (b).

The results of the periodical studies showed different response on the seedling height, circumference and number of leaves of *T. populnea* (Fig. 2).

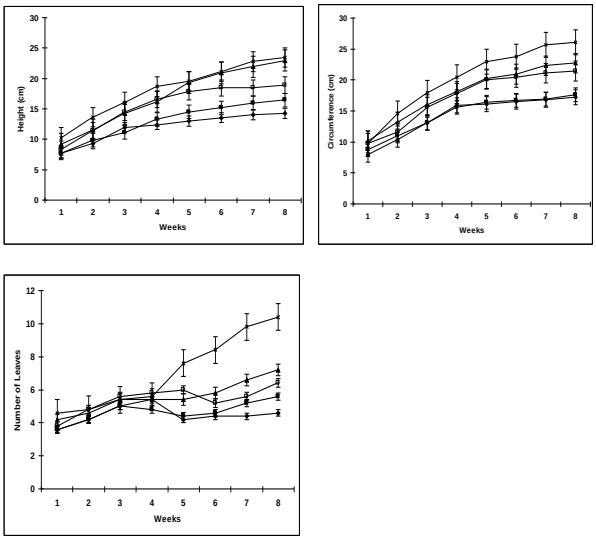

Fig. 2. Seedling height, circumference and number of leaves of *T. populnea* growth periodically in soils of different areas.

Symbol Used:

KU. Campusa; Drigh Road Junction
Malir Station
Landhi Junction
Standard Error

The results of Pearson's correlation between soil physical and chemical properties of soil with some growth parameters of *T. populnea* collectively showed different responses (Table 3). The root, shoot, plant height, number of leaves, leaf area, circumference, and leaf weight ratio of *T. populnea* showed different Pearson's correlation between maximum water holding capacity of soil.

Table 3: Pearson's correlation between soil physical properties and growth variables of *T. populnea*.

GP	M.W.H.C	B.D.	Porosity	Sand	Silt	Clay
RL	-0.531**	0.013	0.019	0.497*	-0.637**	0.041
SL	-0.734**	-.018	0.054	0.648**	-0.696**	-0.142
PH	-0.663**	-.002	0.038	0.601**	-0.702**	-0.049
N	-0.611**	0.226	-0.185	0.537**	-0.682**	0.036
LA	-0.761**	0.269	-0.238	0.708**	-0.658**	-0.307
CI	-0.689**	0.172	-0.145	0.732**	-0.767**	-0.189
SD	-0.763**	0.232	-0.202	0.758**	-0.750**	-0.261
RS	-0.018	-0.106	0.131	0.054	-0.436*	0.540*
LD	0.480*	0.015	-0.060	-0.337	0.587**	-0.255
SL	0.635**	0.000	-0.009	-0.750**	0.666**	0.371
LA	0.640**	0.083	-0.103	-0.716**	0.742**	0.199

GP= Growth Parameter; RL=Root Length; SL=Shoot Length; PH=Plant Height; N=Number of Leaves; LA= Leaf Area; CI= Circumference; SD= Seedling Dry Weight; RS= Root/Shoot ratio; LD= Leaf Weight Ratio; SL= Specific Leaf Area; LA= Leaf Area Ratio; M.W.H.C.= Maximum Water Holding Capacity; BD= Bulk Density

Discussion

Transport activities in daily life are responsible for environment degradation. *T. populnea*, a large flowering tree prefers to grow in tropical and coastal areas. Trees provide shade and are long lived as compared with most of the other plants and differ by virtue of their height [19]. This study provides the information about the influence of different types of soil collected from close to railway track on seedling growth performance of *T. populnea*. Seedlings of *T. populnea* raised in soil of D and E site railway station showed higher growth. The repairing railway workshop of Karachi Cantonment Station is a busy place for maintenance of locomotives [20]. The discharge of waste products and engine oil on soil of Karachi Cantonment Station was considered as the main cause of a significant decrease in root and shoot growth of *T. populnea*. Similarly, the plant communities near the railway servicing workshops were found severely affected in Kumasi city, Ghana [21]. It is widely accepted that polluted soil due to toxic compounds affect plant growth. The significant reduction in leaf size of *T. populnea* in same side

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soil treatment also might be due to the loss in the quality of soil. The used oil polluted soil inhibited the growth of soybean [22]. Railway engines emission adversely produced abnormalities in stomata of *Croton bonplandianum* [23]. Ezio, *et al.,* [24] stated that soil pollutants have a damaging effect on physicochemical and biological properties of soil. The workshop of Karachi Cantonment Station is a busy place for maintenance of locomotives. It is widely accepted that uptake of toxic materials from polluted soil affects plant growth. According to their results, Rehman and Iqbal [25] also noted variation in number of leaves of *Prosopis juliflora* in polluted soils due to industrial activities. Landhi station soil treatment proved favorable and most suitable medium for seedlings of *T. populnea*. *T. populnea* seedlings can be used for soil pollution stress studies. Various tree species have been suggested for stabilization and removal of contaminants from contaminated soils [26]. The seedling growth of *T. populnea* differed in their sensitivity to locomotive polluted soil treatments. The seedlings of *T. populnea* tree species were found resistant to soil of Landhi Junction as compared to control. The soil treatment of Karachi Cantonment Station increased the toxicity and lowered the tolerance in seedling growth performance of *T. populnea.* The cause of low tolerance in seedlings of *T. populnea* to Karachi Cantonment Station soil treatment could be due to accumulation of toxic substances and disturbance in physiological processes. The tolerance indices of *T. populnea* progressively decreased with the increasing concentration of lead and cadmium treatment [27]. Rehman *et al.* [28] suggested that the changes in physico-chemical soil properties of industrial site affected the plants growth.

There are available evidences that railway emission affects the terrestrial vertebrate, aquatic fauna, insects, amphibian, vegetation, and soil of the area [29]. The release and settling of toxic chemicals from locomotive activities on soil can be considered as an important reason for noticeable decrease in seedling growth characteristics *T. populnea.*

Conclusion

The data on the toxic effects of polluted soil for the native flora in Pakistan is insufficient to locomotive pollution stress. There is a need to create awareness of high level of interest in selection of plant species for plantation near railway track. It was concluded that the significant reduction in seedling growth and yield of *T. populnea* in soil of Karachi Cantonment Station was recorded.

Recommendations

It is recommended that the indiscriminate discharge of pollutants from railway activities in immediate environment should be avoided. Landhi station soil treatment proved favorable and most suitable medium for seedlings of *T. populnea*. *T. populnea* seedlings can be used for soil pollution stress studies. More efforts are required to increase vegetation cover near railway track. There is a dire need of locomotive emission monitoring program. There is also a need for using improved fuel and alternatively electric engines for lowering environmental pollution issues.

List of abbreviations

ANOVA= Analysis of variance; BD= Bulk density; CO_2 ,= Carbon dioxide; L.S.D. = Least Significant Difference; M.W.H.C. = Maximum Water Holding Capacity

Conflicts of Interest

The authors declare that there exists no conflict of interest on publication of this manuscript

Author's contribution

Muhammad Zafar Iqbal designed and supervised the experiment. Zia-ur-Rehman Farooqui conducted the experiment and collected the data. Muhammad Shafiq surveyed the literature and prepared the manuscript. Mohammad Athar and Muhammad Kabir critically reviewed the manuscript. All authors approved the final version.

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