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# Effects of Different Industrial Soils on Seedling Growth of Leguminous Tree *Acacia nilotica* (L.) Willd. ex Delile

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## Abstract

The edaphic and climatic factors affect growth of plants. The fast growth of industrial activities and technological advancement are found responsible for the change in environmental conditions of the major urban center of the world and importantly influencing on the growth of living organism. The soil pollution is a regional and global problem. The indiscriminate discharge of the pollutants from the industries also altering the physical and chemical properties of soil. The results of the present studies showed that the treatment of soil of different industrial area affected the seed germination and seedling growth performance of *Acacia nilotica* (L.) Willd. ex Delile depending upon the soil types and availability of pollutants. The seedlings of *A. nilotica* were found flourished well in soils of Haroon Textile Factory as compared to Karachi University Campus (control). A significant ($p < 0.05$) reduction in root, shoot and seedling length of *A. nilotica* was recorded for seedlings grown in soil of Universal Chemicals factory as compared to other industrial soil treatment. The biomass production of *A. nilotica* showed variation in different industrial areas soil samples treatment. The correlation coefficient between growth parameters and soil characteristics for *A. nilotica* was calculated. The periodic growth of *A. nilotica* for root, shoot and seedling length, plant cover, number of leaves, leaf area 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 were responded differently in soils of different industries (polluted) as compared to Karachi University Campus (Control). The seedlings of *A. nilotica* showed high percentage of tolerance indices in soil of Haroon Textile factory while, lowest tolerance was shown in soil of Universal Chemicals factory. A better seedling growth of this species could be obtained if it is given the favorable environmental conditions likewise Haroon Textile factory soil. It is suggested that *A. nilotica* should be grown around the Haroon textile industry as it can well adapted to pollutants discharges from the textiles industries.

***Keywords:*** *Industrial Pollution; Seedling Dry Weight; Soil Pollutions; Soil Physical and Chemical Properties*

## Introduction

Soil pollution is a major problem all around the world. Industrial projects have a profound influence on the plant growth due to discharge of different types of organic and inorganic substances, heavy metals and particulate matter in the environment. The accumulation of the toxic pollutants in soil can affect the seedling growth and metabolic reactions of plants, however, they affect according to soil properties. The pollutants also can affect the mineral structure, soil pH, total dissolved salts, soil texture and exchangeable nutrients of soil and thus indirectly affect the plants. Soil environment issues and their impact on agricultural productivity of high-potential area of Pakistan [1-3]. As environmental factors also determine the pattern of seed germination and early seedling growth depending on the interaction between the internal factors of the seed and the environment [4]. Root growth reduction caused by trace elements pollution could reduce their resistance to drought and hence increase their death rate. Growth of different plants may also be reduced, due to the cost of tolerance to the environmental stress [5]. Air, water and land degradation are common reported effect of industrial activities [6-8]. Addition of heavy metal involves disruption in metabolic and enzyme activities and decrease plant growth [9].

*Acacia nilotica* (L.) Willd. ex Delile is a perennial legume shrub or tree and usually 2.5 - 15 meters high and the bark or trunk is whitish when young, rough, black to gray or brown when mature. The crown in India and Pakistan is hemispherical or narrow and erect. The native distribution of *A. nilotica* includes much of Africa and the Indian subcontinent [10]. In Pakistan, *A. nilotica* planted along field borders as windbreaks and shelterbelts. *A. nilotica* has been planted widely for generations in arid and semi-arid regions of India and Pakistan. Consistent increase in organic matter promotes soil aggregation which in turn provides stability to soil against erosion [11] and improves soil texture, structure and microbial biomass [12,13]. The fruit of *A. nilotica* is an indehiscent leathery pod [14]. The pod is variable, dark brown to gray or gray-green, straight or curved, glabrous to velvety, compressed but rather thick, usually strongly constricted between seeds. Seeds are long lived (more than five years) in the soil [15]. Most seeds are "hard" due to impermeable seed coats and can remain dormant in soil for long periods [16]. The growth rates are variable and may mature in eight months under ideal conditions, or not for up to 12 years under harsh conditions, drought and arid environments [17]. The tree plays an important role in the rural economy by providing fuel, fodder, timber, gum and local medicines [18].

Tree plantation considered an important tool for regulation of climate [19]. The response of plant growth in soil of industrial area has become an important subject of great interest in recent years because of their nature of toxicity to plants. Attention has been given in developed countries about the effects of industrial area soil on tree species and little has been done on this aspect in the country on tree species. Therefore, the present study was carried out with the aim to determine the effects of five different soil types collected from industrial areas on seedling growth performance of an economic important legume tree species, *A. nilotica* of Pakistan.

## Materials and Methods

The seed germination and seedling growth experiments were carried out in greenhouse at the Department of Botany, University of Karachi, Karachi, Pakistan. The vigorous and the same size seeds of *Acacia nilotica* were collected from the species growing in the University of Karachi Campus, Karachi, Pakistan. The micropyle ends of seeds were cut to some extent with hygienic scissor 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. Later than after two weeks of seed germination, same size seedlings were transplanted in plastic pots of 20 cm in diameter and 9.8 cm in depth having the one soil type of Karachi University Campus as control and four different industrially polluted soils of Indus Battery factory, Universal Chemicals factory, Haroon Textile factory and National Foods Ltd. factory, respectively. There were five replicates for each treatment and the experiments were completely randomized. One seedling was planted in each pot and the plants were watered regularly. During growth after every week reshuffling of pots were also carried out to avoid light or shade or any other greenhouse effects.

Seedling growth parameters such as seedling height, number of leaves, leaf area and plant circumference were noted for eight weeks. After this period, 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 [20]. Table 1 and 2 showed the physical and chemical analysis of soil samples collected from industrial polluted areas namely Indus Battery factory, Universal Chemicals factory, Haroon Textile factory and National Foods Ltd. factory and Karachi University campus (non-polluted) areas [21].

Percentage reduction of different growth parameters of plants grown in industrial soils of polluted site was determined in comparison with a control site using the following formula [22]:

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

| 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 | |

***Table 1:*** *Physical characteristics of different soils.*

*Means followed by the same letter in the column 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.*

| Locality | $CaCO_3$ (%) | Cl ($mgL^{-1}$) | pH | O.M. (%) | T.O.C. (g) | S ($\mu gg^{-1}$) | 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 |

***Table 2:*** *Chemical characteristics of different soils.*

*Means followed by the same letter in the column are not significantly different according to Duncan Multiple Range Test at p < 0.05 level.*

*± Standard Error, L.S.D: Least Significant Difference (Source; Kabir, 2014). Sites: A: Karachi University Campus; B: Indus Battery Factory; C: Universal Chemicals Factory; D: Haroon Textile Factory; E: National Foods Ltd. Factory. Acronyms, symbols and formulae: $CaCO_3$: Calcium Carbonate; Cl: Chloride; pH: Power of Hydrogen ion; O.M.: Organic Matter; T.O.C.: Total Organic Carbon; S: Sulphur; E.C.: Electrical Conductivity; T.D.S.: Total Dissolved Salts; Na: Sodium; K: Potassium (Source: Kabir, 2014).*

### Statistical analysis

Data of different growth parameters were statistically analyzed by Analysis of Variance (ANOVA) and Duncan Multiple Range Test (DMRT) on personal computer at $p < 0.05$ level using SPSS version 14.

## Results

The effect of soils of different Industrial area (polluted) and Karachi University Campus (non-polluted) on seedling growth and seedling dry weight of *Acacia nilotica* (L.) Willd. ex Delile was recorded (Table 3-8 and figure 1 and 2). Results showed a significant difference in seedling growth of *A. nilotica* grown in different industrial area soil. The soils of Indus Battery, Universal Chemicals, and National Foods Ltd. Factories affected seedling growth of *A. nilotica* as compared to non-polluted soils. The seedlings growth of *A. nilotica* were best in Haroon Textile factory while, significant ($p < 0.05$) reduction in seedling height, plant cover, number of leaves and plant cover was recorded for seedlings grown in soil of Universal Chemicals factory (Table 3). The 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 of *A. nilotica* were highly affected in soils of industries (Table 4). A high percentage reduction in root (39.51%), shoot (37.92%), seedling length (38.35%), number of leaves (51.72%) and leaf size (56.22%) of *A. nilotica* was recorded in soil of Universal Chemical Factory as compared to National Foods Ltd. and Indus Battery. The lowest percentage of reduction for root (14.802%), shoot (14.30%), seedlings length (14.44%) and seedling dry weigh (16.67%), of *A. nilotica* was recorded in soil of National Food Factory (Table 5).

| Treatments | Root length (cm) | Shoot length (cm) | Seedling length (cm) | Plant cover (cm) | Number of leaves | Leaf area (Sq cm) |
|---|---|---|---|---|---|---|
| A | 12.30 ± 0.23b | 33.28 ± 0.94a | 45.58 ± 1.15b | 16.00 ± 0.71b | 29.00 ± 1.14a | 5.71 ± 0.29b |
| B | 9.30 ± 0.33d | 23.56 ± 0.85c | 32.86 ± 1.17d | 13.20 ± 1.17c | 22.80 ± 1.16b | 2.72 ± 0.24c |
| C | 7.44 ± 0.20e | 20.66 ± 0.51d | 28.10 ± 0.68e | 11.60 ± 0.68c | 14.00 ± 1.22c | 2.50 ± 0.24c |
| D | 17.26 ± 0.35a | 35.62 ± 1.21a | 52.88 ± 1.55a | 20.00 ± 1.00a | 31.80 ± 1.43a | 6.45 ± 0.21a |
| E | 10.48 ± 0.27c | 28.52 ± 0.76b | 39.00 ± 1.04c | 16.40 ± 0.51b | 24.00 ± 1.64b | 5.06 ± 0.22b |
| L.S.D. (p < 0.05) | 0.84 | 2.61 | 3.39 | 2.19 | 3.93 | 0.72 |

***Table 3:*** *Growth of Acacia nilotica in soils of different areas.*

*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.*

| 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 | 0.30 ± 0.007c | 0.03 ± 0.004ab | 0.06 ± 0.007ab | 0.06 ± 0.005a | 0.15 ± 0.015a | 0.50 ± 0.05bc | 0.41 ± 0.009a | 90.59 ± 11.96bc | 39.79 ± 5.27ab |
| B | 0.19 ± 0.013a | 0.02 ± 0.002b | 0.04 ± 0.004cd | 0.04 ± 0.005b | 0.10 ± 0.01b | 0.50 ± 0.03b | 0.41 ± 0.013a | 67.18 ± 7.17c | 27.98 ± 2.82b |
| C | 0.26 ± 0.006b | 0.02 ± 0.002b | 0.03 ± 0.002d | 0.02 ± 0.002c | 0.07 ± 0.006b | 0.67 ± 0.08a | 0.32 ± 0.019b | 107.73 ± 14.58ab | 35.16 ± 5.42ab |
| D | 0.31 ± 0.017c | 0.03 ± 0.005a | 0.07 ± 0.009a | 0.08 ± 0.009a | 0.18 ± 0.023a | 0.43 ± 0.04bc | 0.42 ± 0.009a | 89.70 ± 9.93bc | 37.82 ± 4.83ab |
| E | 0.24 ± 0.01b | 0.02 ± 0.000b | 0.05 ± 0.004bc | 0.04 ± 0.004bc | 0.11 ± 0.005b | 0.41 ± 0.04c | 0.35 ± 0.029b | 139.27 ± 16.10a | 47.26 ± 2.96a |
| L.S.D (p < 0.05) | 0.03 | 0.009 | 0.018 | 0.016 | 0.04 | 0.15 | 0.05 | 36.48 | 13.01 |

***Table 4:*** *Fresh, dry weights and ratios of different variables of Acacia nilotica in soils of different areas.*

*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.*

| 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 | -24.39 | -29.21 | -27.91 | -17.50 | -21.38 | -52.36 | -36.67 | -33.33 | -33.33 | -33.33 | -33.33 |
| B | -39.51 | -37.92 | -38.35 | -27.50 | -51.72 | -56.22 | -86.36 | -33.33 | -50.00 | -66.67 | -53.33 |
| C | +40.33 | +7.03 | +16.02 | +25.00 | +9.65 | +12.96 | +3.33 | 00.00 | +16.67 | +33.33 | +20.00 |
| D | -14.80 | -14.30 | -14.44 | +2.50 | -17.24 | -11.38 | -20.00 | -33.33 | -16.67 | -33.33 | -26.67 |

***Table 5:*** *Percentage reduction in growth of Acacia nilotica in soils of different factories in comparison with control soil.Symbol: +: Percentage increase; -: Percentage decreased.*
*Sites: A: Indus Battery Factory; B: Universal Chemicals Factory; C: Haroon Textile Factory; D: National Foods Ltd. Factory.*

| Growth parameters | M.W.H.C. | B.D. | Porosity | Sand | Silt | Clay |
|---|---|---|---|---|---|---|
| Root length | -0.226 | -0.069 | 0.083 | 0.347 | -0.418* | 0.055 |
| Shoot length | -0.379 | -0.083 | 0.106 | 0.257 | -0.318 | 0.071 |
| Seedling size | -0.329 | -0.080 | 0.099 | 0.296 | -0.361 | 0.066 |
| Plant cover | -0.244 | 0.058 | -0.044 | 0.487* | -0.521** | -0.147 |
| Number of leaves | -0.093 | -0.316 | 0.334 | 0.161 | -0.169 | -0.058 |
| Leaf area | -0.480* | 0.089 | -0.066 | 0.397* | -0.459* | 0.00 |
| Seedling fresh weight | -0.686** | -0.260 | -0.241 | 0.122 | -0.292 | 0.517** |
| Root dry weight | -0.686** | 0.260 | -0.241 | 0.122 | -0.292 | 0.517** |
| Shoot dry weight | -0.224 | -0.034 | 0.042 | 0.006 | -0.106 | 0.336 |
| Leaf dry weight | -0.273 | -0.059 | 0.076 | 0.271 | -0.315 | 0.007 |
| Total plant dry weight | -0.142 | -0.275 | 0.290 | 0.067 | -0.122 | 0.155 |

***Table 6:*** *Pearson's correlation of soil physical characteristics and growth parameters of Acacia nilotica.*
**, ** Correlation is significant at the $p < 0.05$ and $p < 0.01$ levels, respectively (2-tailed).*
*Abbreviation: M.W.H.C.: Maximum Water Holding Capacity; B.D.: Bulk Density (Source: Kabir, 2014).*

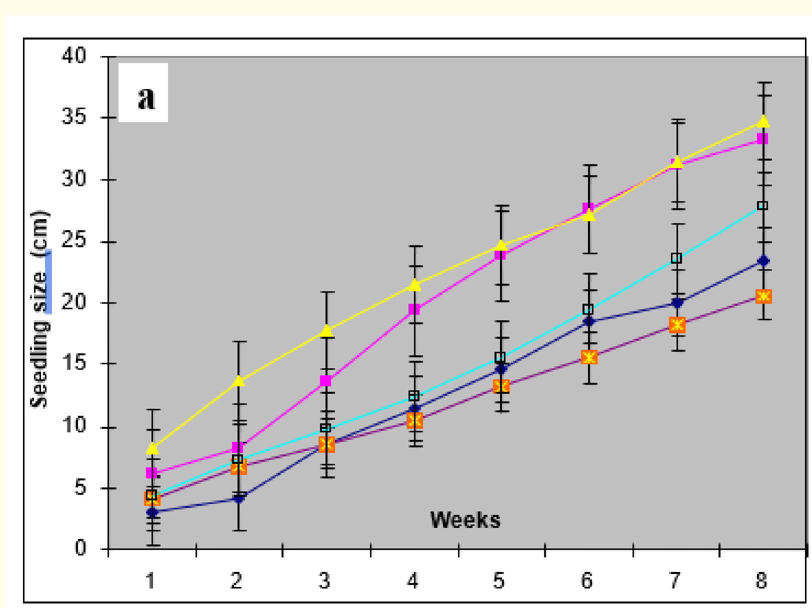
| Growth parameters | $CaCO_3$ | Cl | pH | O.M. | T.O.C. | S | E.C. | T.D.S. | Na | K |
|---|---|---|---|---|---|---|---|---|---|---|
| Root length | -0.006 | 0.541** | -0.138 | -0.274 | -0.273 | -0.055 | -0.118 | -0.115 | 0.018 | 0.262 |
| Shoot length | -0.028 | 0.265 | 0.100 | -0.289 | -0.288 | 0.147 | -0.148 | -0.146 | -0.290 | 0.040 |
| Seedling size | -0.020 | 0.373 | 0.013 | -0.289 | -0.288 | 0.075 | -0.140 | -0.138 | -0.181 | 0.123 |
| Plant cover | -0.046 | 0.415* | 0.129 | -0.323 | -0.322 | 0.214 | -0.256 | -0.253 | -0.176 | -0.012 |
| Number of leaves | 0.254 | 0.125 | -0.018 | -0.009 | -0.007 | 0.089 | 0.095 | 0.098 | -0.319 | 0.000 |
| Leaf area | -0.162 | 0.298 | 0.264 | -0.430* | -0.429* | 0.295 | -0.324 | -0.323 | -0.340 | -0.068 |
| Seedling fresh weight | -0.503* | 0.524** | -0.047 | -0.600** | -0.599** | -0.145 | -0.363 | -0.365 | 0.157 | 0.414* |
| Root dry weight | -0.123 | 0.414* | -0.294 | -0.201 | -0.200 | -0.304 | -0.021 | -0.021 | 0.255 | 0.438* |
| Shoot dry weight | -0.007 | 0.270 | 0.070 | -0.239 | -0.238 | 0.125 | -0.133 | -0.131 | -0.212 | 0.035 |
| Leaf dry weight | 0.143 | 0.286 | -0.214 | -0.065 | -0.064 | -0.144 | 0.105 | 0.107 | -0.058 | 0.259 |
| Total plant dry weight | 0.041 | 0.320 | -0.118 | -0.168 | -0.167 | -0.064 | -0.013 | -0.012 | -0.075 | 0.209 |

***Table 7:*** *Pearson's correlation of soil chemical characteristics and growth parameters of Acacia nilotica.*
**, ** Correlation is significant at the $p < 0.05$ and $p < 0.01$ levels, respectively (2-tailed).*
*Abbreviation: $CaCO_3$: 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).*

| Haroon Textile Factory | National Foods Ltd. Factory | Indus Battery Factory | Universal Chemicals Factory |
|---|---|---|---|
| 140.32 | 85.20 | 75.60 | 60.48 |

***Table 8:*** *Percentage of tolerance in seedlings of Acacia nilotica against different industrial soil as compared to control.*


***Figure 1:*** *Growth of Acacia nilotica in different soils (a) and after harvest (b).*
*Sites: A: Karachi University Campus Soil; B: Indus Battery Factory Soil; C: Universal Chemicals Factory Soil;*
*D: Haroon Textile Factory Soil; E: National Foods Ltd. Factory Soil.*



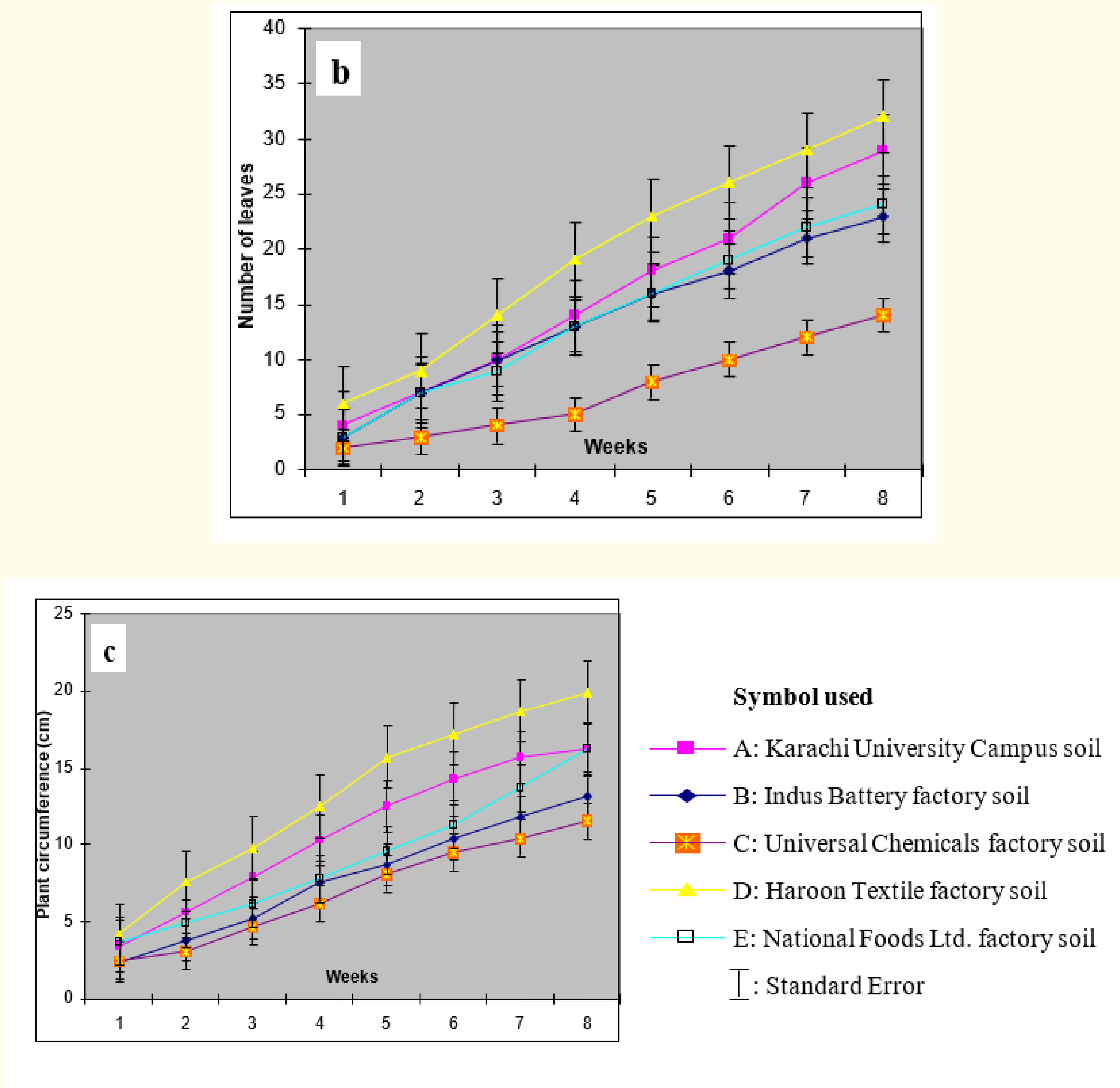



***Figure 2:*** *Seedling size (a), number of leaves (b) and plant circumference (c) of Acacia nilotica growing in soils of five different areas.*

The correlation coefficient between growth parameters and soil characteristics was calculated (Table 6). A positive and negative correlation found in soil physical characteristics and growth parameters of *A. nilotica*. Seedling fresh weight and root dry weight were significantly ($p < 0.01$) positive correlated with clay particles. In soil chemical characteristics, chloride contents showed positive correlation with root length, clay particles and root dry weight at significance level ($p < 0.01$). At same significance level of negative correlation was found for maximum water holding capacity and silt with root dry weight and plant cover, respectively. Others growth and soil characteristics doesn't show any correlation at the significance level. Cross correlation among growth parameters showed that all parameters were significantly ($p < 0.01$) positive correlated except root dry weight which has non-significant cross correlation with plant cover, number of leaf and leaf area (Table 7).

The seedling height, number of leaves and plant circumference were slightly increased from 2nd week to 8th week but this increment was more prominent for seedlings raised from soil of Haroon Textile factory. In soil of Universal Chemicals all these periodical growth parameters were reduced indicating that species cannot flourish well in chemical polluted soils. In Karachi University Campus soil, Indus Battery factory soil and National Foods Ltd., factory soil these periodical growth parameters have their range between that were recorded for Haroon Textile and Universal Chemicals factory soils.

The seedlings of *A. nilotica* were tested for tolerance indices to soil of industrial and control areas. Tolerance indices of *A. nilotica* showed highest tolerance index in soil of Haroon Textile factory while, the lowest tolerance index was shown in soil of Universal Chemicals factory (Table 8). The seedling of *A. nilotica* showed tolerance index in response to polluted soil treatment of Haroon Textile (140.32%), National Foods Ltd (85.20%), Indus Battery (75.60%) and Universal Chemicals factory (60.48%), as compared to control, respectively.

## Discussion

*Acacia nilotica* (L.) Willd. ex Delile well is adapted to varieties of soil. Seed germination and seedling growth performance influenced by soils types. The industrial area soils collected from Indus Battery, Universal Chemicals, Haroon Textile and National Foods Ltd. factories affected seedling growth, leaf area, number of leaves and seedling biomass production of *Acacia nilotica* (L.) Willd. ex Delile as compared to non-industrial area treated soil. The failure after germination to elongate under higher application of the functional inhibitors may be an effect of retarded water absorption, retarded cell divisions and cell elongation in the embryo. Such changes lead to overall reduction in catabolic and anabolic activities related to these processes. Thus, blockage of any one of the activities leading to germination may entirely reduce the phenomenon of germination and can lead to inhibition of seedling growth. For different woody plant species, seedling establishment is the vital phase in their life cycle [23,24]. The seedlings of *A. nilotica* were flourished well in soils of Haroon Textile factory while, significant reduction in growth was recorded for seedlings grown in soil of Universal Chemicals factory. Our findings clarify that soil of Universal chemical factory doesn't support the growth of *A. nilotica* as chemical pollutants have toxic effects on growth of living organisms. The result of the present studies showed that the treatment of polluted soil decreased high percentage of seedling dry weight of *A. nilotica* as compared to control. It was reported that a decrease in leaf fresh as well as dry weight is concerned with diverse forms of contaminants which are discharged into the surroundings by an industrial estate. The leaf area leaf fresh and dry weight of polluted sites species were significantly reduced when compared with leaved of non-polluted sites. These investigations are in agreement with those of Sibak and Gulyas [25]. He found air polluting substances from industrial region of Hungary responsible for leaf anatomical changes in *Perishing acaluous* oak. The condensed leaf size, vegetation disturbances, due to different air born pollutants observed [26,27]. The yield of a plant is mainly dependent on its metabolic activities which include the rate of photosynthesis and respiration but both these processes may be affected in industrial areas as a result of different types of industrial pollutants. In the present study seedlings growth of *A. nilotica* affected which might be due to disturbance in the rate of photosynthesis and respiration activities. A high percentage of inhibition in root, shoot and seedling length of *A. nilotica* was found with the treatment of polluted soil of Universal Chemicals factory. The seedling growth of selected plants specie (*Acacia nilotica*) was found retarded by increasing level of industrial pollutants in the field conditions. The effects of toxic substances are dependent on the quantity of toxic substances absorb from the particular environment. The toxic effects of some pollutants may be large sufficient and are pronounced that plant growth is inhibited before a large amount of that pollutants could be translocated [28]. Mathur., *et al*. [29] reported that high contents of cadmium and chromium (100 - 250 ppm) affected early seedling growth behaviour of *Allium cepa*. The cause of inhibition in seedling length due to metal toxicity may be the decline in meristematic cells exists in this growing region and some enzymes enclosed in the cotyledon and endosperms. In normal conditions cells remain active and initiate to assimilate and store food which is changed into soluble type and translocated to the plumule and radical tips for enzymatic action of amylase which transfer starch into sugar and other enzyme proteases which act on protein. So, when actions of hydrolytic enzyme are affected, the food substances could not reach to the radical and plumule finally affect the seedling length. The seedling of *A. nilotica* showed lowest tolerance index in response to polluted soil treatment of Indus Battery followed by Universal Chemicals factory, Haroon Textile and National Foods Ltd as compared to control, respectively. As soil act as basic medium for plant growth and development. The control (non-polluted) soil is best one for proper seed germination and seedling growth of different plant species but some affected soils can also promote the seedling growth of some species as in present study soil of Haroon Textile factory promoted growth of *A. nilotica*. Such investigations were also carried out by some other workers that seed germinations and seedling growth of seeds of *Albizia lebbeck* and *Dalbergia sissoo* collected from polluted regions of the city demonstrated considerable decline in germination rate as compared to the seeds collected from the less infected areas [30]. The growth of *Pongamia pinnata* and *Albizia lebbeck* was significantly decreased in seedling developed from the pollution infected seeds than to control area seeds. Seedling growth of *Cassia fistula* L. was found significantly decreased with the treatment of Indus Battery, Dalda Limited and Shafi tannery area soils [32]. The soil is the main reservoir of mineral and nutrients. The addition of toxic materials in soil due to industrial activities disturbed the physical and chemical characteristics of the soil and plant growth [33]. The positive and negative correlation between soil properties and seedling growth parameters of *A. nilotica* was observed. The Pearson analysis showed that maximum water holding capacity of soil, silt particles, Total dissolved salts, sodium and calcium carbonate contents of industrial areas soil were negatively correlated to root, shoot, seedling length, plant cover, leaf area and total plant dry weight of *A. nilotica*.

## Conclusion

Soil pollution is a worldwide problem and has an important concern for environment and plants growth. It was concluded from present study that the treatment of Universal Chemicals Factory soil induced significant ($p < 0.05$) reduction in root, shoot, seedling length, plant cover, number of leaves, leaf area and biomass production of *A. nilotica* over the soil of the control area. *A. nilotica* should not plant around such types of chemical industries due to low tolerance to pollutants. A strict inspection, monitoring and implementation of environmental laws by Environmental Protection Authority team is recommended against the industries polluting the environment of the industrial sites of the Karachi, Pakistan.

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## Conflict of Interest

There is no conflict of interest among all authors.

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