Effect Of Polluted Soil On Germination And Seedling Growth Of Lens Culinaris

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Abstract: Industrial, anthropogenic and modern civilization caused soil pollution problem all around the world. The shoot length and root length decreased with the increase in percentage of polluted soil. The overall fresh weight of the seedling showed decline in weight as percentage of polluted soil increase, except for the sample with 25% polluted soil which showed comparatively less weight than other treated samples. The dry weight of the seedling also showed similar descending results with the increase in percentage of polluted soil. The treatment with 25% polluted soil showed low dry weight as compared to rest of the treated samples. The result of the present studies showed high percentage of rate of seed germination, shoot length, root length and total seedling length of lentil in control sample as compared to polluted soil treated seedling. The treatment of polluted soil decreased shoot, root, total seedling weight, shoot, root, and total seedling dry weight of lentil as compared to control. With the increase in polluted soil concentration further decrease root/shoot ratio, leaf area, leaf fresh weight, dry leaf weight, leaf specific area, leaf weight ratio and leaf area weight ratio of lentil as compared to control treatment. According to tolerance test increase in concentration of polluted soil treatment decreased tolerance percentage in seedlings of lentil as compared to control. The seedling vigor index in response to polluted soil treatment (T1), (T2), (T3), (T4), (T5) was recorded 752.40, 300, 161.50, 294 and 120, respectively.

Key Words: Lens culinaris, seedling growth, soil pollution, tolerance, toxicity.

Introduction

The ever increase in addition of the pollutants in the environment producing air, water and soil pollution problem. The environmental degradation is an alarming issue of the developed and particularly for under developed countries. Environmental pollution formed an adverse effects on land and water and has health hazards to human, animals and plants (Al-Dulaimi et al., 2012). Soil pollution is an important concern for germination and plant growth. Soil is one of the most important natural resources for food production globally (Biggelaar et al., 2003). The physical and chemical characteristics of soil are recognized as possible key factors in affecting plant species coexistence (Bonanomi & Mazzoleni, 2005). Industrial and anthropogenic activities adversely affected the soil’s productivity (Jagadamma et al., 2008). Soil type, sunlight, nutrients and fresh water are essential and can govern plant life (Martonas, 2012).

High rate of increase in population density and industrial growth are adversely affecting the plant growth due to changes in physical, chemical and biological properties of soil. Interest in the quality and productivity of soil and its effects on crop has been increased since last couple of decade by researchers. Such types of studies on the impact on growth of lentil on this aspect are few in the country. The farmer of the area gets assistance for the cultivation of crops from the two main river Lyari and Malir of the Karachi, city. The present study was carried out with the aim to find out the effects of polluted soil using different concentration of polluted soil on seedling growth and biomass production of lentil, L. culinaris. The objective of the present study was also to investigate the tolerance indices and seedling vigor index of lentil in response to soil pollution.

Materials And Methods

A research was carried out to find out the effects of different concentration of polluted soil on germination and seedling growth of lentil (Lens culinaris L.).

Site description

The soil samples were collected from two different sites. One from garden of Karachi University Main Campus and other from Lyari River. The Lyari River flows from north East of Karachi to the central districts and drains into the Arabian Sea at Manora Channel. Until the 1950’s the river had clean water with farming activities on its bank. With rapid growth of the city, industries and population the river was transformed to discharge waste water, sewage and industrial effluents. Approximately 2,200 industrial units are situated around the Lyari River. The Lyari River is a key contributor and an estimated amount of 200 million imperial gallons of raw sewage that enter Arabian Sea. Major wastage is dumped from leather tanning, pharmaceutical, petrochemical, chemical and textile industries. Healthy and viable seeds of lentil were collected from the market and their viability and percentage of germination was pre-tested in a petri dish to obtain an uniform germination and growth in soil samples. After the collection of soil sample
from above mentioned sites, the soil was air dried for 48 hours, grounded and then after removing pebbles and twigs the soil sample s were passed through a 2.0 mm iron sieve.

The ratios were as follows.

T1= 0% polluted soil + 100% garden soil
T2=25% polluted soil + 75% garden soil
T3=50% polluted soil + 50% garden soil
T4=75% polluted soil + 25% garden soil
T5=100% polluted soil + 0% garden soil

The experiment was conducted in a green house under uniform natural conditions at the Department of Botany, University of Karachi. The range of maximum temperature and minimum temperature was 22-31°C and 11-18°C, respectively during the experiment. Atmospheric humidity during the experiment was in the range of 14 - 88%. The weather outlook was mostly sunny with a range of 10:30 to 11:41 hour’s sun shine. Healthy seeds of Lens culinaris (Lentil) were taken from local market. The seeds of lentil were sterilized with aqueous mercuric chloride (0.1%) for 5 minutes to avoid fungal contamination and thoroughly washed with distilled water. The seeds were sown at 1 cm depth in plastic pots of 7.3 cm diameter and 9.6 cm in depth in different concentration of polluted soil. The pots were irrigated daily with tap water until the soil is completely soaked. Each pot prepared by filling the soil by 2/3 in pot and punching of one hole in the bottom. A total of 25 pots were randomly divided into five groups for polluted and unpolluted soil composition and marked on pot as (T1), (T2), (T3), (T4), (T5). There were five replicates for each treatment and the experiment was completely randomized. Every week, pots were reshuffled to avoid light / shade or any other green house effects.

After five weeks, seedling were carefully removed from the pots and washed thoroughly to measure root, shoot and seedling length (cm). Leaf area, root / shoot ratio, leaf weight ratio, leaf area weight ratio were also recorded. Root, shoot and leaves were separated for drying in an oven at 80 ° C. The effects of polluted soil on biomass production (leaf fresh weight (g), root dry weight (g), shoot dry weight (g), leaves dry weight (g) and total seedling dry weight (g) of lentil seedlings were also noted. The data collected from various growth indices were statistically analyzed by standard statistical technique on personal computer.

Leaf weight ratio was determined according to following formulae.

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\text{Leaf weight ratio = Leaf dry weight / Root dry weight} \\
\text{Leaf area weight ratio = Leaf area / Root fresh weight} \\
\text{Leaf / shoot ratio = Leaf dry weight / Shoot dry weight} \\
\text{Leaf area specific area = Leaf area / Root length} \\
\text{Leaf weight ratio = Leaf dry weight / Root fresh weight} \\
\text{Leaf area weight ratio = Leaf area / Root fresh weight}
\]

Percentage reduction in seed germination and seedling growth parameter was calculated as per following formulae.

C-T \times 100

| Table 1. Seedling growth performance of Lens culinaris in response to polluted soil |
|-----------------------------------|---------|---------|---------|---------|---------|
| Parameter                         | Soil Types | T1      | T2      | T3      | T4      | T5      |
| Seed germination (%)              |          | 40.00   | 20.00   | 20.00   | 10.00   | 10.00   |
| Shoot length (cm)                 |          | 9.71    | 7.0     | 8.50    | 8.80    | 6.75    |
| Root length (cm)                  |          | 9.10    | 9.50    | 7.65    | 6.75    | 5.50    |
| Leaf length (cm)                  |          | 1.5(Mx) | 0.44(Mx) | 1.4(Mx) | 1.12(Mx) | 0.70(Mx) |
| Leaf breadth (cm)                 |          | 0.40(Mx) | 0.30(Mx) | 0.25(Mx) | 0.60(Mx) | 0.32(Mx) |
| Leaf area (sq.cm)                 |          | 0.13(Mn) | 0.10(Mn) | 0.10(Mn) | (Mn)    | 0.10(Mn) |
| Root area (sq.cm)                 |          | 0.60(Mx) | 0.42(Mx) | 0.35(Mx) | 0.672(Mx) | 0.21(Mx) |
| Total seedling length (cm)        |          | 0.05(Mn) | 0.05(Mn) | 0.075(Mn) | 0.104(Mn) | 0.03(Mn) |
| Shoot fresh weight (g)            |          | 0.30    | 0.07    | 0.25    | 0.21    | 0.20    |
| Root fresh weight (g)             |          | 0.08    | 0.05    | 0.065   | 0.006   | 0.007   |
| Total seedling fresh weight (g)   |          | 0.38    | 0.12    | 0.32    | 0.305   | 0.23    |
| Root dry weight (g)               |          | 0.05    | 0.011   | 0.03    | 0.025   | 0.020   |
| Shoot dry weight (g)              |          | 0.06    | 0.019   | 0.05    | 0.05    | 0.04    |
| Leaf dry weight (g)               |          | 0.002   | 0.0018  | 0.0012  | 0.001   | 0.0007  |
| Total seedling dry weight (g)     |          | 0.151   | 0.03    | 0.08    | 0.075   | 0.06    |
| Root – Shoot ratio                |          | 0.80    | 0.58    | 0.60    | 0.50    | 0.50    |
| Leaf weight ratio                 |          | 0.025   | 0.017   | 0.01    | 0.002   | 0.0017  |
| Leaf specific area                |          | 163.00  | 127.70  | 175.0   | 380.0   | 166.66  |
| Leaf weight ratio                 |          | 0.06    | 0.14    | 0.03    | 0.006   | 0.007   |
| Leaf area weight ratio            |          | 0.85    | 1.91    | 0.65    | 1.24    | 0.52    |

Symbol used. Soil Treatment:
T1= 0% polluted soil + 100% garden soil, T2=25% polluted soil + 75% garden soil
T3=50% polluted soil + 50% garden soil, T4=75% polluted soil + 25% garden soil
T5=100% polluted soil + 0% garden soil
Mx= Maximum, Mn= Minimum
The result of the present studies showed negative impact on seed germination, seedling growth and biomass production of lentil (Lens culinaris) when treated with different level of polluted soil (Table 1; Fig. 1-5). The highest percentage of germination and growth of lentil seedlings was recorded in control. While the lowest was recorded in rest of treated seedlings. A pronounced variation in average shoot length (9.71 – 6.75 cm), root length (9.10 – 5.50 cm), total seedling length (18.81 – 12.0 cm) and leaf area (0.38 – 0.12 cm²) was recorded (Table 1). Similar trend in shoot fresh weight (0.30 – 0.255 g), root fresh weight (0.08 – 0.065 g), total seedling fresh weight (0.38 – 0.120 g), was observed. The treatment of different concentration of polluted soil at 25, 50, 75 and 100 % decreased shoot dry weight (0.06 – 0.04 g), root dry weight (0.05 – 0.020 g), total seedling dry weight (0.11 – 0.03 g), root / shoot ratio (0.80 – 0.50) was observed. A gradual decrease in leaf weight, dry leaf weight, leaf specific area, leaf weight ratio and leaf area weight ratio of lentil seedling in soil of polluted treated soil was recorded.

Soil treatment (T2) produced lowest percentage of decrease in seed germination (50%), shoot length (27.90%), seedling length (20.20%) and increased root length (4.39%) of lentil seedling as compared with control soil treatment. Soil treatment (T3) produced further decrease in shoot length (12.46%), seedling length (14.14%) and leaf area (34.37%) of lentil seedling as compared with control soil treatment. Which, the polluted soil treatment (T5) produced highest percentage of decrease in seed germination (75%), shoot length (30.48%), root length (39.56%), seedling length (36.20%) and leaf area (62.50%) of lentil seedling as compared with control.

![Seed germination](image1)
![Shoot length](image2)
![Root length](image3)
![Seedling length](image4)

Figure 1. Percentage decrease in seed germination, shoot, root and seedling length of lentil in response to different concentration T1, T2, T3 and T4 of polluted soil (soil contaminated by 25, 50, 75 and 100%) as compared control. T1= 25% polluted soil + 75% garden soil, T2=50% polluted soil + 50% garden soil, T3=75% polluted soil + 25% garden soil, T4=100% polluted soil + 0% garden soil.
Figure 2. Percentage reduction root, total seedling dry weight (g) and root / shoot ratio of lentil in response to different concentration (T1 (25%) T2 (50%) T3 (75%) T4 (100%) of polluted soil as compared control.

T1= 25% polluted soil + 75% garden soil, T2=50% polluted soil + 50% garden soil, T3=75% polluted soil + 25% garden soil,
T4=100% polluted soil + 0% garden soil
Leaf area weight ratio

Leaf area

Figure 3. Percentage reduction in leaf fresh weight, leaf dry weight, leaf weight ratio and leaf area weight ratio of lentil in response to different concentration T1, T2, T3 and T4 of polluted soil as compared control.

T1 = 25% polluted soil + 75% garden soil, T2 = 50% polluted soil + 50% garden soil, T3 = 75% polluted soil + 25% garden soil, T4 = 100% polluted soil + 0% garden soil

Leaf area (cm²)

Leaf specific area

Figure 4. Percentage decrease in Leaf area (cm²) and leaf specific area of lentil in response to different concentration T1, T2, T3, and T4 of polluted soil as compared control.

T1 = 25% polluted soil + 75% garden soil, T2 = 50% polluted soil + 50% garden soil, T3 = 75% polluted soil + 25% garden soil, T4 = 100% polluted soil + 0% garden soil

According to tolerance test, the seedlings growth of lentil seedling showed high percentage of tolerance index (104.39%) at 25% concentration of polluted soil treatment as compared to control (Fig. 5). The seedlings of lentil showed the lowest percentage of tolerance index (60.435%) at 100% of polluted soil treatment as compared to control. The highest value of seedlings vigor index (752) of lentil was recorded in control soil treatment while, the lowest seedling vigor index (120.0) for lentil seedlings was recorded with the treatment of polluted soil at 100% concentration (Fig. 6).
Some researchers have done experiments in soil due to human activities and dumping of wastes in Lentil (Lens culinaris), which could modify the edaphic characteristics of the soil. Variation in seedling growth performance of lentil seedlings could be attributed with the treatment of different concentration of soil. Lentil seeds are tolerant to a wide range of conditions. However, the possibility of developing environmental stress has increased due to industrial activities and dumping of waste in Lyari River. This type of waste is hazardous to marine ecology and spillage because of tidal action also continues to impact the mangrove. Polluted soil treatment (%)

The depressive effect of polluted soil on plants response can be considered an important cause of variation in seedling growth performance of Lentil. The result of the present studies showed that the seedlings of lentil seedlings raised in polluted soil at T5 (100% polluted soil) were considerably smaller in root, shoot, total seedling height and leaf area than those treated with less polluted soil T2 (25%), T3 (50%), and T4 (75% polluted soil), respectively. The growth in terms of seedling length and root length of Lentil culinaris were higher in T1 (0% polluted soil).

Discussion

The soil is the main reservoir of the mineral and nutrients. The addition of toxic materials in soil due to human and industrial activities influenced on the physical and chemical characteristics of the soil and affect plant growth. In present studies, the effects of different concentration of polluted soil showed variation in seed germination, seedling growth and productivity performance of Lentil (Lens culinaris) as compared to control. Variation in seedling growth performance of lentil seedlings could be attributed with the treatment of different concentration of soil. Lentil seedlings showed some adaptability indicating with the increase in specific leaf area. The availability of toxic pollutants in soil and uptake through root can be considered an important cause of variation in seedling growth performance of lentil seedlings when treated with different concentration of polluted soil. Some researchers had been demonstrated the relationship of different soil characters with the performance of plant growth (Bonanomi and Mazzoleni, 2005; Aziz et al., 2008; Martonas, 2012). The result of the present studies showed that the seedlings of lentil seedlings raised in polluted soil at T5 (100% polluted soil) were considerably smaller in root, shoot, total seedling height and leaf area than those treated with less polluted soil T2 (25%), T3 (50%), and T4 (75% polluted soil), respectively. The growth in terms of seedling length and root length of Lentil culinaris were higher in T1 (0% polluted soil).

The above studies suggest that the variation in seedling growth performance of lentil seedling depend on the physical and chemical nature of soil used for treatment. The response of decrease in root growth of lentil to polluted soil treatment is of particular importance because it affects subsequent plant growth and ability to withstand environmental stresses. The treatment of different concentration of polluted soil highly affected biomass production of lentil seedlings. In an investigation, the exposure of different types of abiotic and biotic stresses adversely affected the productivity of Vigna mungo (Kundu, et al., 2011). Accumulation of toxic pollutants in soil imposes a major environmental threat to soil quality and limit crop yield. The depressive effect of polluted soil stress (T2-T5) treatments on dry weight of lentil seedlings which could be related to decline in root, shoot and seedling growth. The lowest seedling dry weight of lentil was observed in the T4 and T5 treatment of soil and indicating the strong influence of soil characteristics. The plants responded differently to adapt the environment (Climate or soil) in differing patterns of vegetative and reproductive growth (Silvertown & Rabinowitz, 1985).

Conclusion

This type of waste is hazardous to marine ecology and spillage because of tidal action also continues to impact the mangrove. Pollutants such as these are dangerous for biodiversity of this regions. It was concluded that the contamination or degradation of soils impacts heavily on growth of plants. The soil pollution could modify plant metabolism and lower crop productivity. The soil becomes unsuitable for crop survival or any other form of vegetation. In present study, these results might prove the toxic effects of polluted soil on plants. An intense industrial, anthropogenic activities and dumping of waste in Lyari River has polluted the soil. The accumulation of toxic chemical and pollutants are responsible for changing the edaphic characteristics of the soil collected from Lyari River. It is evident from our results...
that the treatment of different concentration of polluted soil proved to be highly responsive and sensitive for the seedling growth of L. culinaris and could be used as indicator of soil quality. It was found that the seedling growth performance of L. culinaris was poor in polluted soil treatment as compared to control soil treatment. The other discouraged factors were the low seedling tolerance and vigor indices to soil pollution as compared to control.

References