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# Comparison of Seed Germination, Root and Shoot Length of Maize and Wheat Crops with Compost Leachate and Commercial Fertilizer

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## Abstract

The increasing public concern about municipal solid waste (MSW) due to its impact on health and environment induces people to think about more ways of recycling this waste. These days, people strive to find more appropriate methods and processes to treat MSW for its proper management and disposal. Composting process is the most appropriate method of recycling used to get rid of organic fractions. The most important concern is the production of compost leachate. This study was designed to check the potential of compost leachate as a chemical fertilizer and to compare it with commercial fertilizer. Different dilutions of compost leachate and commercial fertilizer were used to check their effects on seed germination of wheat and maize crop and the initial root and shoot length measurement of these crops. Germination index, germination inhibition and germination rate were also evaluated in different experimental trials with variation in leachate dilution. The results showed best root, shoot length and seed germination at low quantity of leachate sample. The obtained results showed that leachate has better fertilizer qualities as compared to commercial fertilizer. Moreover, it is more economical and environment friendly. It also helps in maintaining the structure of soil and conditions the soil.

**Keywords:** compost, fertilizer, municipal solid waste (MSW), soil

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## 1. Introduction

A huge amount of municipal solid waste (MSW) is produced by all countries and its amount is increasing day by day. MSW, mostly termed as “trash” or “garbage”, is the by-product of human activities [1]. During the past few decades, due to a drastic increment in the amount of MSW, its handling and management has become and continues to be a major environmental challenge around the world [2]. The disposal of this waste in an open space and its burning are old practices. Increasing public concern regarding the environmental and health impacts of MSW led to the banning of waste dumping on open sites in many countries [3]. Now,

people are striving to find different methods and processes for its proper management, treatment and disposal. The main purpose of proper solid waste management is to divert the greatest amount of solid waste from landfills through source reduction, material reuse, recycling, business development, and composting [4]. Indeed, recycling, composting, incineration, and sanitary landfills are some common techniques to deal with MSW [5].

The benefits of using compost leachate as fertilizer are obvious. Its utilization as fertilizer would lower the consumption of

commercial fertilizers for which a huge amount of energy is required and they incur incredible production cost. Fertilizer production is also responsible for massive greenhouse gas (GHG) emission [6]. Leachate, being a waste product, has no directly affiliated production costs, energy consumption and GHG emission. The utilization of leachate in agriculture would also reduce the cost of waste treatment plants needed for the removal of excessive substances such as nitrogen and phosphorous [7].

## 2. Material and Methods

Lahore Compost Company under an agreement with the City District Government Lahore (CDGL) at Mahmood Booti set up the first composting plant. The rationale for selecting this site was that it is the only certified company in Lahore which is converting a portion of Lahore's waste organic matter into compost (organic fertilizer) through aerobic windrow composting.

Samples of commercial fertilizer were obtained from a certified shop. They were stored in air tight transparent polyethylene bags. They were transported to the laboratory for further analysis.

Samples of leachate and fertilizer were digested and analyzed in duplicates. The samples were analyzed for metals including Ni, Cr, Zn, and Cu using the atomic absorption technique with flame photometer system.

### 2.1. Seed Collection

Punjab Seed Corporation (Lahore office) was visited for the purpose of collecting seeds. Seeds of two common crops of Punjab, that is, wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.) were collected from there.

### 2.2. Seed Germination Experiment

Seed germination experiments were performed in SDSC labs, GCU Lahore. These experiments were performed using 8.5cm thick glass petri dishes. The seeds of both crops were surface sterilized with 0.1% mercuric chloride solution for 5 minutes and they were rinsed thoroughly with distilled water [8].

The samples of waste compost leachate and chemical fertilizers were diluted with distilled water in series 25%, 15%, 10%, 5%, 3%, 1%, 0.5%, and 0.1%. Petri dishes of 8.5cm were lined with Whatsman No. 1 filter paper. In case of control, seeds were placed on two Whatsman No.1 filter discs moistened with water instead of samples. The petri dishes were incubated at 25.5°C in the incubator.

## 3. Calculations

### 3.1. Initial Root and Shoot Length Measurement

Seed germination was counted after an interval of 24 hours for 7 days. The initial root length and shoot length of seeds were measured after 7 days. Seeds were measured to be germinated when the radicle protruded more than 2/2.5mm from the seed coat [8].

### 3.2. Measurement of Germination Rate %, Germination Inhibition Rate % and Germination Index

Germinated seeds were calculated after an interval of 24 hours for 7 days. Germination Rate (GR), Germination Index (GI) and Germination Inhibition Rate (GIR) were calculated using the following formulae.

$$GI = [(Seed\ Germination\ (\%) \times Average\ Root\ Length\ of\ Treatment) / (Seed\ Germination\ (\%) \times Average\ Root\ Length\ of\ Control)] \times 100 [7].$$

$$Average\ Germination\ Rate\ (\%) = (Number$$

of Seeds Germinated / Total Number of Seeds) × 100.

Germination Inhibition Rate (%) = 100 – GR [9].

### 3.3. Effect of Leachate on Seedling Growth of Wheat and Maize

The effects of different leachate concentrations were calculated on the shoot, root and seedling growth of wheat and maize seeds.

Data related to average root, shoot and seedling length described in Table 1 showed that high levels of leachate concentration were phytotoxic for plant growth. Leachate treatments of 0.5% to 5% concentration produced positive effects on seed germination and seedling length as compared to control. A further increase in the concentration of leachate up to 25% reduced seed germination, root, shoot and seedling length as compared to control. In case of wheat, in 0.1% leachate solution average root and shoot lengths were noticed of approximately 5.3cm and 4.7cm respectively, which were less as compared to control. This might be due to nutrients' imbalance and deficiency. Minimum root and shoot length of approximately 0.7cm and 0.2cm were noted in 25% leachate solution.

Most of the roots grown in 15% to 25% leachate concentration samples withered partly as can be seen in the picture. Dimitriou described that when short-rotation willow (*Salix*.sp.) coppice, a crop grown commercially for energy purposes, was irrigated with higher concentrations of leachate it resulted in reduced relative growth rates [10]. Zhou, Wang and Zhang also described that an increased concentration of leachate resulted in wilted growth of plant [11]. The survival of impatient became impossible because the plants withered either partly or completely when irrigated with undiluted

and untreated leachate. This was mainly due to high levels of organic compounds, heavy metals and a low pH value. Quaik and others documented that the higher concentration of leachate might cause the burning of a leaf's surface [12]. The dilution of leachate was strongly recommended by Quaik when vermicomposting leachate is utilized as foliar sprays [13].

**Table 1.** Effect of Leachate on Root, Shoot and Seedling Length of Wheat and Maize

Treatment	Average Root Length (cm)	Average Shoot Length (cm)	Seedling Length (cm)
Leachate			
Wheat			
0.1%	5.2±1.97	4.3±1.15	11.2±1.20
0.5%	11.8±2.87	6.3±1.10	17.6±1.02
1%	9.8±1.11	4.1±0.71	15.2±0.61
3%	10.1±1.77	6.4±1.18	17.1±1.22
5%	9.1±1.59	5.1±1.35	14.5±0.94
10%	4.4±1.34	1.1±1.01	6.0±1.01
15%	2.3±0.64	0.6±0.75	2.7±0.66
25%	0.6±0.19	0.2±0.07	0.9±0.06
Control	8.7±2.71	5.5±2.16	15.1±2.02
Maize			
0.1%	8.8±3.54	3.3±1.21	12.9±2.00
0.5%	12.6±3.81	5.2±1.14	19.1±2.03
1%	10.5±2.98	5.1±1.11	16.2±1.99
3%	14.7±2.71	6.5±0.88	22.4±2.12
5%	8.8±1.54	3.3±0.79	13.0±1.24
10%	8.09±1.86	2.8±1.6	12.2±1.70
15%	6.5±2.39	2.1±0.92	8.8±1.88
25%	4.5±1.02	0.3±0.31	4.8±1.02
Control	9.4±1.58	4.0±1.20	13.8±1.37

### 3.4. Effect of Fertilizer on Seedling Growth of Wheat and Maize

The effects of different fertilizer concentrations were noted on the root, shoot and seedling growth of wheat and maize seeds.

The effect of fertilizer on root, shoot and seedling length of wheat and maize is shown in Table 2. It is very surprising. Even in the lowest concentration of fertilizer, the seedling growth of both

crops was less than control. In case of wheat germination, it was observed only in 0.1%, 0.5% and 1% treatments and in higher concentrations there were no germination. Maximum root, shoot and seedling lengths were observed and noted as 6.3cm, 4cm and 10.5cm, respectively in 0.1% fertilizer treatment. In case of maize, germination was observed in four treatments including 0.1%, 0.5%, 1% and 3%. The lower root, shoot and seedling length indicated the presence of phytotoxic substances and their adverse influence. Savage and Tyrrel documented that reduced growth in case of fertilizer may result because of excessively large amounts of ammonia and nitrogen [13]. Another reason might be the high amount of heavy metals (Zn, Cr, Cu & Ni) present in the fertilizer. Negative effects of heavy metals on seed germination and seedling growth are well documented in literature.

**Table 2.** Effect of Fertilizer on Root, Shoot and Seedling Length of Wheat and Maize

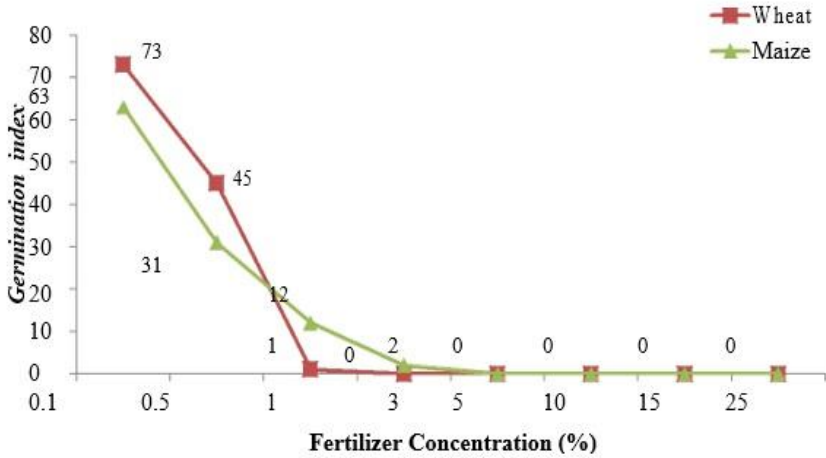
Treatment	Average Root Length	Average Shoot Length	Average Seedling Length
Fertilizer	(cm)	(cm)	(cm)
<b>Wheat</b>			
0.1%	6.3±1.87	4.3±1.42	11.5±1.01
0.5%	4.2±0.97	3.0±1.08	8.0±1.00
1 %	0.3±0.07	0.3±0.07	0.8±0.05
Control	8.6±2.71	5.5±2.17	15.1±2.01
<b>Maize</b>			
0.1%	6.3±1.89	4.0±0.67	10.5±1.78
0.5%	3.5±0.51	2.3±0.46	5.9±0.89
1 %	1.7±0.61	0.4±0.33	2.3±0.57
3%	0.3±0.24	0.1±0.10	0.4±0.10
Control	9.3±1.58	4.0±1.21	13.8±1.38

### 3.5. Comparison of Fertilizer on the Germination Index of Wheat and Maize

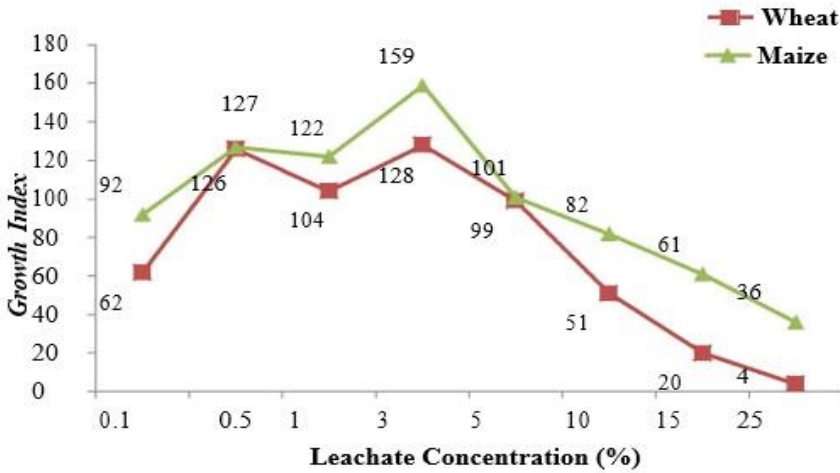
According to Figure 1, the germination index (GI) of both maize and wheat is reduced in higher concentrations of leachate. GI for commercial fertilizer in both cases was always low as compared to the control GI and in higher concentrations it became zero. This indicates the adverse influence of phytotoxic substances present in the fertilizer. In case of wheat, maximum GI observed was 73 and in case of maize it was 63. The Pearson p value for both maize and wheat (-0.546 and -0.492, respectively) supported the hypothesis that there existed a significant relation between GI and fertilizer concentration. One of the major reasons for the reduction of GI might be the presence of excessively large amounts of ammonia and nitrogen and in the fertilizer; these may affect the seed germination and growth index [7, 13]. Surprisingly, adverse effects on GI were observed even for dilutions recommended by the suppliers. According to Datta and others, reduction in GI is due to the greater amounts of heavy metals, especially Cr (VI) [14]. However, trace amount of them can promote seed germination and growth index.

### 3.6. Comparison of Leachate in the Germination Index of Wheat and Maize

Data regarding root length and germination rate were combined to calculate the growth index (Gi) [15]. Figure 2 represents the relationship between leachate concentrations and Gi. The Gi for both crops was higher for lower concentrations (below 5%) as compared to control (only water). The Pearson p values for both wheat and maize (-0.847 and -0.833, respectively) showed that there was



**Figure 1.** Comparison of fertilizer concentrations on the germination index of wheat and maize



**Figure 2.** Comparison of leachate concentrations in the germination index of wheat and maize

a strong relationship between leachate concentration and Gi. The Pearson values supported the hypothesis that higher concentration leachate had phytotoxic effects and reduced Gi, while lower concentration leachate promoted growth and had no or less phytotoxic effects. Quaik and others, and Zhou, Wang and Zhang also stated that higher concentration leachate has phytotoxic

effects due to higher amounts of substances [11, 12]. Phytotoxic effects of leachate were lesser in its higher dilutions because these dilutions resulted in lower levels of toxic substances [7]. It means that an adequate dosage of leachate is required to minimize the damage to plants.

In case of wheat, in 1% leachate sample Gi was lower than control. However, for

concentrations of 0.5%, 1% and 3% Gi was greater as compared to control (only water) and the highest Gi was noted in 3% leachate treatment. For 5% leachate sample treatment, Gi was almost equal to the control but in higher concentrations (10%, 15%) Gi reduced gradually and remained 4% in 25% leachate treatment. The same trend of Gi was observed in the case of maize. The highest GI was noted in 3% leachate treatment and the lowest was noted in 25% leachate treatment. Reduction in Gi was higher in wheat than maize and this showed that wheat was more sensitive to phytotoxic effects of leachate as compared to maize.

In lower concentrations, leachate promoted Gi. This supports our hypothesis that leachate can be utilized as liquid fertilizer. According to Cheng, the increase in Gi was probably due to longer root length as compared to the control. This promotion in growth could be the result of a higher concentration of nutrients present in leachate, such as  $\text{NH}_4^+$ ,  $\text{K}^+$  and P [15, 16]. However, in higher concentration it resulted in reduced Gi. So, care is needed while utilizing leachate as fertilizer. Dilution of leachate lowered the negative impact produced due to leachate irrigation [11].

The results of the experimental comparison of leachate and commercial fertilizer showed that leachate had better fertilizing qualities than the fertilizer despite the fact that the latter was a marketed product. Dimitriou and others stated that compost and landfill leachate can promote the development of plant because of the high nutrient content [10]. Leachate promoted the seedling growth and growth index but its higher concentration resulted in germination inhibition and wilted growth. Therefore, an optimization of dose is required according to the crop needs for better

results [11].

According to Romero, leachate production cost as fertilizer includes the following operational costs [7].

**3.6.1. Raw material cost.** Leachate is a by-product of the composting process and requires treatment. Using leachate as liquid fertilizer is a better alternative to bearing the cost of its treatment. Therefore, no cost will be charged for its supply.

**3.6.2. Bottles required for liquid fertilizer.** For the delivery of liquid fertilizer bottles are an essential requirement.

**3.6.3. Equipment cost.** A liquid fertilizer filling machine which fills 1000 to 4500 bottles of 1.5 L in an hour is required.

**3.6.4. Labour cost.** A worker is required to manage the liquid fertilizer filling machine.

**3.6.5. Storage and energy costs.** Low storage and energy costs are associated with this process as compared to the treatment cost before discharge.

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