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# Growth behavior studies of bread wheat plant exposed to municipal landfill leachate

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**Abstract**

Pot experiments were carried out to study the effect of different dilutions of leachate generated from municipal solid waste (MSW) landfill on bread wheat (*Triticum aestivum*). Eight treatment groups with different concentrations (0-100%) of leachate were prepared and treatments were given to the plants till they reached complete vegetative phase (45 days). The growth performances of wheat plants were assessed in terms of various parameters such as shoot and root length, dry biomass and chlorophyll content. Plants treated with higher concentrations of leachate (75% and 100%) showed higher growth (2.5 and 6%) and 100% survival rate as compared to control. However, high shoot weight (0.028 and 0.030 gm) and high chlorophyll content (213 and 230%) was reported in 30 and 40% leachate treatment as compared to control. Some symptoms of stress (discoloration of leaf blade, wilting and yellowing of plants) were also observed in plants, which could be related to the presence of high concentration of salts in the leachate. The current study suggests that MSW landfill leachate is rich in nutrients and can be used as fertilizer but before its application, the salinity level and concentration of toxic metals present in leachate should be considered in accordance with the tolerance ability of any plant.

**Key words**

Landfill leachate, Phytotoxicity, *Triticum aestivum*

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## Introduction

Unscientific disposal of solid waste is the most common method for dumping the waste. Majority of dumping sites are located on the outskirts of city, mainly near the agricultural fields, thereby, posing a great threat to the environment. The open dumps pollute the environment mainly by adding greenhouse gases and by release of leachates into the immediate surroundings (Mor *et al.*, 2006a). Landfill leachate comprises of waste byproducts containing innumerable organic and inorganic compounds like humic acids, ammonical nitrogen, heavy metals and various other salts (Wiszniowski *et al.*, 2006). The contaminated leachate can pass to the nearby water resources or enter the food chain through the vegetation around the site. Several studies have reported that the leachate percolation contaminates the ground water resources (Tricys, 2002; Mor *et al.*, 2006b).

However, landfill leachate can also be used as a fertilizer as they contain a substantially high concentration of ammonical nitrogen which can be regarded as an alternate source for plants. Chan *et al*. (1999) suggested that the use of landfill leachate in irrigation water during dry seasons can enhance the growth, survival and stomatal conductance of *Acacia confusa, Leucaena leuocephala and Eucalyptus torelliana.* In another study, it has been reported that irrigated plants can be benefited by leachate as it leads to increase in foliage and growth of plant (Cheng *et al.,* 2007). However, several other studies highlight that leachate can induce both positive and negative responses in the plants (Wong and Leung, 1989; Bakare *et al*., 2000). Sang *et al.* (2010) reported inhibition of growth and chlorophyll, along with oxidative stress in *Zea mays.* Popular plants also show phytotoxicity symptoms such as brown leaves and necrotic spots (Zalesny *et al*., 2008). In contrast, Haarstad and Maehlum, (1999) conducted a study using untreated

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leachate in the vegetated land and reported that leachate helps in providing good nutrient cycling loop to the vegetation as well as remediation option for leachate.

There are several studies, which report the toxicity of different wastewater, effluents or sludge on wheat (Pandey *et al*., 2009; Dash *et al*., 2012) and other plants (Malaviya *et al.,* 2012; Marwari and Khan, 2012). However, to the best of our knowledge, there was no study available regarding the effect of landfill leachate on bread wheat plant (*Triticum aestivem* L.em Thell.). Hence, in the current study growth behavior of bread wheat plant was investigated under different concentration of landfill leachate.

## Materials and Methods

**Leachate collection :** Landfill leachate was collected from three different locations of the Dadumajra municipal solid waste (MSW) dumping site and mixed thoroughly to make a representative sample as reported in several studies (Sang and Li, 2004; Mor *et al*., 2006b). This representative leachate sample was analyzed for various physico-chemical parameters such as pH, COD, EC, TDS, $NO_3^-$, $Na^+$, $K^+$ and $Cl^-$ ions following standard methods (APHA, 2005). After the analysis representative leachate sample was stored in a plastic container and subsequently used for the preparation of different dilutions (6, 10, 20, 30, 40, 75 and 100%; marked as $S_1$ to $S_7$) using double distilled water. These seven dilutions ($S_1$ to $S_7$) along with negative control (double distilled water) were used for treatment.

**Plant material and growing conditions**: Experiments were carried out in the month of October - November, 2011. Seeds of wheat (*Triticum aestivum*) were obtained from the local seed store and soaked in distilled water for 24 hrs before use. Uniform sized seeds were sowed in pots containing garden soil collected from Mehra Botanical Garden of Panjab University, Chandigarh. Ten seedlings of bread wheat were used in each pot. Each set of the experiment was performed using four replications. Plants were grown under natural conditions with natural daylight of 12-15 hours. Pots were irrigated with dilutions of different leachate concentrations and distilled water was used for control pots. Morphological observations like root and shoot length and wiltage were made after an interval of ten days. Plants were up-rooted after 45 days well before the onset of reproductive phase and shifted to laboratory for analysis of various parameters. Dry biomass was determined after drying the plants in an oven at 80 ºC for a period of 4-5 days till the weight became stable. Chlorophyll content of leaves was determined by the method of Arnon (1949) and the results were expressed as mg $g^{-1}$ f.wt.

**Statistical analysis:** Parameters were expressed as mean ± SD and the data was analyzed using one-way ANOVA with the help of SPSS software. Statistical significance was accepted at $p < 0.05$, 0.01 and 0.001.

## Results and Discussion

Representative leachate sample used in the present study at 100% concentration showed pH value of 8.5 and have COD value of 5,340mgl$^{-1}$.The COD values of different dilutions ($S_6$-$S_1$) were reduced in the range of 4005mg $l^{-1}$ - 320mg $l^{-1}$. The concentration of other physico-chemical parameters (EC, TDS, $NO_3^-$, $Na^+$, $K^+$ and $Cl^-$) in representative leachate sample are listed in Table 1, which indicates high levels of the organic and inorganic fraction in leachate.

There was noticeable difference in the emergence and initial growth of bread wheat under different leachate concentrations. Initially, on third day the germination percent in $S_7$ and $S_6$ treatment group was high as compared to control. However, after 5 days, it was observed that the emergence of plants in $S_6$ was much higher followed by control as compared to other leachate concentrations as shown in Fig. 1. In case of treatment groups with lower concentration of leachate ($S_1$ and $S_2$), the rate of germination was very low compared to other treatments. Girisha and Raju (2008) reported that the germination percentage of groundnut showed positive response when treated with 25% of sewage water having high COD value (348 mgl$^{-1}$).

Growth responses varied significantly between the control and leachate concentration throughout the study. After 7 days, the growth of plants treated with higher concentration of leachate shows reduced growth as compared to control. This may be due to the stress caused by the high salt content in the leachate, which may lead to the suppressed growth (Stephens *et al*., 2000). After 15 days, significant increase in the growth in $S_7$ and $S_6$ treatment groups were observed as compared to control. Finally, after 45 days, the plants showed 6% and 2.5% increase in growth in $S_7$ and $S_6$ treatment respectively in comparison to control. As suggested by Bojovic and Markovic (2009) during cold season wheat consumes relatively large amounts of minerals

**Table 1 :** Physico-chemical characteristics of leachate sample collected from Dadumajra dumping site, Chandigarh

| Parameters | Concentration* |
|---|---|
| pH | 8.5 |
| COD | 5340 |
| EC | 48200 |
| TDS | 34692 |
| $NO_3^-$ | 110 |
| $Na^+$ | 5210 |
| $K^+$ | 3260 |
| $Cl^-$ | 1387 |

*All values are in mg $l^{-1}$ except pH and EC (µScm$^{-1}$)

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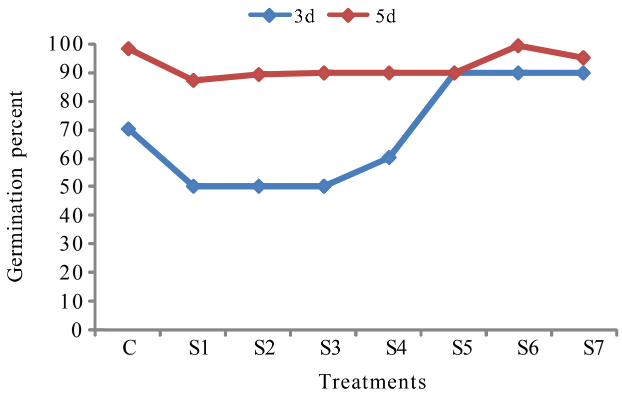


**Fig. 1 :** Percentage seed germination in wheat after 3 and 5 days of leachates treatments ($S_1$-$S_7$ and control)

for its vegetative growth, as soils generally lack main nutrients required for the growth of plants. Hence, it could be suggested that application of leachate to the plants might have responded positively due to excess nutrients. Further, the shoot length showed no significant change after 45 days of plants growth in different treatment groups. Lowest growth was reported in $S_1$ and $S_2$ treatment groups which could be co-related to the availability of fewer nutrients. Table 2 shows the growth response of wheat in terms of shoot length after 7, 15, 25, 35 and 45 days to different treatment groups. Chiemchaisri *et al.* (2005) reported that plants could not be grown well when exposed to higher concentration of leachate (>8,850 $mgl^{-1}$ COD) , however diluted leachate having medium concentrations (1,770-3,540 $mgl^{-1}$ COD) stimulate the growth in plant species. In the present study the COD values of higher concentration of leachate was 5,340 $mgl^{-1}$ .

Lowest dry shoot weight was reported in $S_1$ and $S_2$ group. As given in Table 3, the highest shoot weight was reported in $S_4$ and $S_5$ treatment. Negligible differences were observed for root dry mass for all treatment groups. The increase in shoot weight in leachate groups might be attributed to more accumulation of nutrients present in the leachate into the plants (Roghanian *et al., 2012*).

Length of roots increased by 58 and 61% in $S_7$ and $S_6$ plants as compared to control (Fig. 2). However, other treatment groups showed a linear trend towards the reduced root length of test plants. Similar trend was also reported by Kausar *et al.* (2012) where increase in root length was observed in plants of *E. crassipes* treated with sewage water having high COD value.

Leaf necrosis, yellowing and drying of leaves are the simple indicator of stress on plants. Morphological symptoms like leaf necrosis, discoloration of leaf blade, yellowing of leaves were visible after 30-35 days that can be co-related to salt stress. It was observed that at the end of experiment all the plants grown in $S_7$ and $S_6$ survived and were healthy. Further, no major toxicity symptoms were noted except for slight wiltage whereas, 16.6% plants in $S_1$ treatment group, 7% in $S_3$ and 2.7% in $S_4$ could not survive. Stress symptoms can be attributed to the presence of high salt content or some contaminants in the leachate. Common symptoms of leaf necrosis and scorching were also reported by Dimitriou *et al.* (2011) in willows and poplars treated with wastewater and sewage sludge. Nagajypthi *et al.* (2009) reported toxic effects of industrial effluent having high level COD and heavy metals like Pb, Zn, and Cd on green gram.

The effects of landfill leachate on chlorophyll content in leaf tissue are shown in Fig. 3. It was observed that, there was an increase of 213% and 230% in total chlorophyll content of $S_4$ and $S_5$ treatment groups in comparison to control. However, this increase in total chlorophyll content was only 165% and 146% in $S_6$, $S_7$ treatment as compared to control. Comparatively lower chlorophyll content was reported in $S_1$ treatment group as compared to the control. The increase in chlorophyll content in samples might be the cause of hormetic effect (Cargnelutti

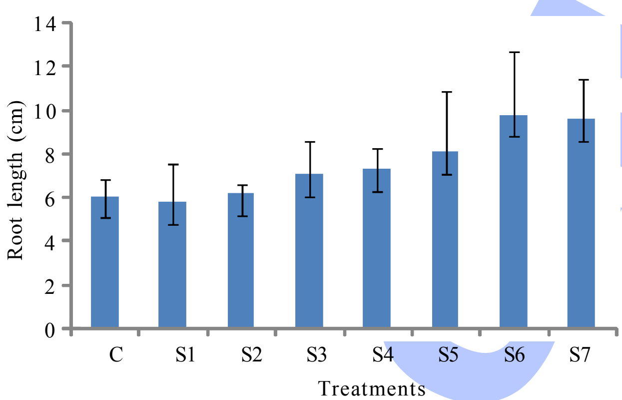


**Fig. 2 :** Root length of wheat plants treated with different concentrations of leachates after 45 days Error bars show the standard deviation of three replicates

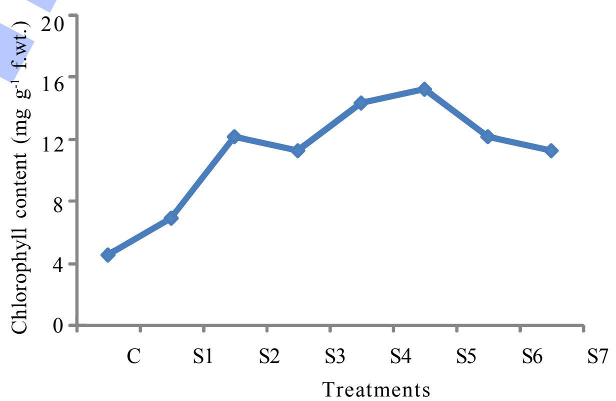


**Fig. 3 :** Total chlorophyll content (mg $g^{-1}$) of wheat plants treated with different concentrations of leachates after 45 days.

**Table 2 :** Shoot length (cm) of wheat plant treated with different concentrations of leachates ($S_1$-$S_7$ and control)

| Days | C | $S_1$ | $S_2$ | $S_3$ | $S_4$ | $S_5$ | $S_6$ | $S_7$ |
|---|---|---|---|---|---|---|---|---|
| 7 | 2.4±0.46 | 2.2±0.53 | 2.3±0.13 | 2.4±0.12 | 2.5±0.29 | 2.5±0.33 | 1.9 ± 0.64* | 1.9 ± 0.16 |
| 15 | 6.6 ± 0.44** | 6.9± 0.59** | 6.6 ± 0.37 | 7.6 ± 0.17 | 8.1±1.13 | 8.07±0.15 | 8.1±1.13** | 8.3±1.32** |
| 25 | 20.7±1.71 | 18.5±0.71*** | 18.9±1.75*** | 17.9±2.02*** | 16.9±0.48*** | 17.9±1.03*** | 23.0±3.5 | 22.3±2.05 |
| 35 | 23.1±1.5 | 21.2±2.21 | 22.1±2.39 | 23.6±1.89 | 23.5±0.58 | 23.8±1.43* | 23.7±3.74 | 24±2.04 |
| 45 | 23.6±2.7 | 21.5±1.57 | 22.9±2.63 | 23.8±3.31 | 23.9±1.08 | 24.4±2.04* | 24.6±3.41** | 25±1.68** |

Values are mean of four replicates ± SD; significant at P<0.05*, P<0.01**, P< 0.001***

**Table 3 :** Dry root and shoot weight (gm) of wheat plant treated with different concentrations of leachates ($S_1$-$S_7$ and control)

| | **C** | $S_1$ | $S_2$ | $S_3$ | $S_4$ | $S_5$ | $S_6$ | $S_7$ |
|---|---|---|---|---|---|---|---|---|
| Dry shoot weight | 0.01±0.005 | 0.01±0.029 | 0.012±0.008 | 0.015±0.006 | 0.028±0.005 | 0.03±0.006 | 0.021±0.0025 | 0.023±0.005 |
| Dry root weight | 0.007±0.003 | 0.007±0.0025 | 0.006±0.003 | 0.007±0.0025 | 0.007±0.005 | 0.008±0.007 | 0.008±0.0025 | 0.07±0.043 |

Values are mean of four replicates ± SD

*et al.,* 2006; Calabreseci, 1999). Hormetic effect could lead to increase in the chlorophyll content at medium leachate concentrations as these plants also report increase in shoot weight. The reduced chlorophyll content may be due to inhibition of particular enzymes that are responsible for the synthesis of the green pigments (Kiani *et al*., 2005). Mishra *et al*. (2006) reported that this effect depends on the types and concentration of salts present in the medium and also on different growth stages of the plant.

Based on the current study, it is suggested that leachates are rich in nutrients and can be used as fertilizer. However, before its application, the salinity level and concentration of toxic metals present in leachate should be considered in accordance with the tolerance ability of any plant.

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