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Comparison of crop production efficiency of compost leachate with chemical fertilizer and evaluating its effect on germination and growth of wheat crop

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Increasing public concern in relation to health and environmental issues of organic waste leads to many solutions of waste management. Many different methods are discovered for proper waste management and disposal. Organic fractions of solid waste are treated with aerobic composting. It is one of the better treatments for organic waste. The important issue of concern here is the production of compost leachate with organic waste. In this study, to evaluate the competency of produced leachate as fertilizer and making the composting process more cost effective and environmentally friendly, liquid fertilizer prepared by Lahore Compost Company was used. Different percentages of leachate (0.2, 0.5, 1.5, 3.5, 5.5, 10.5, 15.5, and 25.5%) were prepared and germination rate of wheat was checked by evaluating its fertilizing quality compared to fertilizer. Results showed high germination and growth rate at lower concentration of leachate as compared with control and commercial fertilizer due to the presence of many suitable nutrients. This study was designed to compare the crop production efficiency of compost leachate with commercial fertilizer. It was revealed in this study that low leachate percentage give better crop production in case of wheat.

Key words: Compost, leachate, recycling, organic waste.

INTRODUCTION

Solid waste management has become a core issue in under-developing countries. International recommendations implement the strategy to recycle waste in these countries. Main emphasis was provided on aerobic composting. Composting is a natural process but can be altered by changing various physical and chemical parameters (Turjillo e al., 2006). In this method, the organic content of municipal solid waste is converted into humus-like material called compost. To increase food production in modern agriculture, the use of agricultural chemicals such as fertilizers, herbicides, and insecticides has become an integral part and will continue in future (Azizullah et al., 2011). Most farmers wrongly believe that applying more fertilizer will lead to higher production but this result comes with contamination of natural resources (Zia et al., 2008). Many fertilizers have very slow degradation rate, complicates the calculation of nutrient availability and may have properties that magnify their

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pollution potential. In addition, some chemical fertilizers contain substances which are toxic to living organisms such as inorganic acids, heavy metals and organic pollutants. Worldwide, there are sufficient evidences of harmful effects of long term application of these chemicals on aquatic and forest ecosystems (Howarth et al., 2002). 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 and production cost is required. Use of leachate in agriculture would also reduce the waste treatment plants cost which is needed for the removal of excessive substances such as nitrogen and phosphorous (Romero, 2013). Leachate includes a number of considerable potential pollutants for contaminating the environment such as high and variable concentrations of oxidizable organic substances, inorganic salts, ammonia, metals and toxic compounds (Brown et al., 2013). Leachate can be defined as a potentially polluting liquid that may lead to harmful effects on the public health, surrounding aquatic ecosystems and ground water resources. Solid waste compost leachate is a liquid that percolates through the organic solid waste and brings out a complex variety of dissolved and suspended organic compounds and materials such as heavy metals, fatty acids, humic substances and many hazardous chemicals (Zazouil and Yousefi, 2008). Many parameters effect on leachate e.g. seasonal weather variations, pilling and compacting method used during its production. If compost leachate is not properly managed it can place local and public ecosystems at risk by contaminating the surface and ground water resources (Cumar and Nagaraja, 2011). Since leachate is potentially harmful, leachate management system is required by the composting facility municipalities. A well-managed system is required for the collection, monitoring, control and treatment of leachate before its disposal to the environment (Brown et al., 2013). Municipal Waste Compost Leachate (MWCL) is considered in compost production, as it may be utilized as a source of water and nutrients (Romero et al., 2013). MWCL composition is characterized by several parameters in high concentrations such as boron, carbon, phosphorous, potassium, zinc, calcium, magnesium and nitrogen. These elements are important micro- and macronutrients required by the plant, thus leachate may be useful as fertilizer for the growth of plants (Dimitriou, 2006). Leachate obtained from vermicomposting comprises of larger amounts of plant nutrients so it can be utilized as liquid fertilizer. As leachate usually contains higher amounts of plant nutrients, it should be diluted to prevent plant damage (Gutierrez-Miceli et al., 2008). In addition to these nutrients, leachate also contains sufficient amount of organic matter which helps in the maintenance of soil structure and fertility. Soil organic matter (SOM) is taken as a key indicator for assessing soil quality (Riley et al., 2008).

The potential of using municipal solid waste compost as a fertilizer was evaluated by observing the effect of different concentrations of leachate on the germination and growth rate of wheat.

MATERIALS AND METHODS

This study was designed to check the efficiency of municipal solid waste compost leachate as fertilizer. Lahore Compost Company was selected as the basic site for the collection of municipal solid waste compost leachate. Lahore Compost Company at Mahmood Booti has their composting plant in Pakistan.

Leachate preparation

Samples were collected from the leachate collection tank of Lahore Compost Company during fall season for one week and stored in 1.5 L labelled glass bottles. After collecting 5 samples from different windrows, the samples were transported from composting plant to the laboratory and preserved at 3°C for further analysis. Samples of commercial fertilizer were obtained from a certified shop. They were stored in air tight transparent polyethylene bags and transported to the laboratory for further analysis. Municipal solid waste compost leachate and commercial fertilizer were analysed for chemical parameters. Some important parameters were selected to increase the fertility and quality of leachate. Leachate sample (100-ml) digestion was poured into the beaker and heated using hotplate without boiling it until the sample volume was reduced to 50 mL. 15 mL of concentrated nitric acid and HCl was added and then heated for 30 min. Thereafter solution was filtered to remove any insoluble material. After filtration, the sample was transferred to 200 mL flask and volume was raised up to 150 mL by adding distilled water (Abu Dabees et al., 2013). Compost sample was digested as follows: 10 g compost was dissolved in 20 ml HCl and heated for 30 min. Samples of different percentage of leachate (0.2, 0.5, 1.5, 3.5, 5.5, 10.5, 15.5, and 25.5%) were prepared in duplicates by using 10 g compost per sample for different leachate percentage preparation. The prepared leachate was diluted further to make different percentages (0.2, 0.5, 1.5, 3.5, 5.5, 10.5, 15.5, and 25.5%). Commercial fertilizer was used in its original form as purchased from the company.

Seed collection

The seeds of wheat (*Triticum aestivum L.*) were collected from Seed Corporation in Lahore. Proper morphology of seeds was examined and healthy seeds were screened out for further analysis.

Seed germination experiment

Seed germination experiments were conducted by using 10 cm glass Petri dishes. The seeds of wheat species were surface sterilized with 0.4% mercuric chloride solution for 8 min and washed with distilled water (Zhou et al., 2012). Samples of municipal solid waste compost leachate and commercial fertilizer (Urea) were diluted to concentration series with distilled water. Petri dishes (10 cm diameter) were lined with filter paper which was moistened with 4 mL of sample. In case of control, the seeds were placed on two filter discs moistened with water instead of samples. Throughout the experiment filter papers were moistened whenever needed with the respective solutions. In the experiment, 10 seeds of each species were placed in a Petri dish, using three replicates for each treatment. The Petri dishes were incubated at 26°C in an oven.

Measurement of primary root and shoot length

The seeds with germination effect were examined after 2 days interval in a week. Initial root and shoot length of the germinated seeds were measured after one week. Proper radicle protruded more than 1.92 mm from the seed coat (Zhou et al., 2011). Data was analyzed and interpreted by using SPSS. The descriptive analysis was done to express the percentage of germination rate. Standard error of mean was fined by using SPSS (Nath et al., 2005; Hema and Subramani, 2013).

RESULTS AND DISCUSSION

This study deals with the effect of different leachate and fertilizer concentrations on seeds of wheat crop. The purpose of the study was to check the potential of leachate as a liquid fertilizer. For this purpose, germination rate, primary root and shoot lengths were calculated.

Effect of leachate and fertilizer on seed germination of crops

There are many factors which contribute to the yield of the crop, and one of them is seed germination (Buriro et al., 2011). Seed germination is a sensitive stage of plant's life. It is affected by the variations in internal conditions and environmental parameters. Seed germination and vigorous seedlings are important characteristics for any crop which could provide advantages for its establishment. For the achievement of better growth and high yield of crop, rapid and steady field emergence is necessary. In this study, potential of MSW compost leachate as liquid fertilizer is checked by noticing its effect on wheat seed germination and comparing it with a commercial chemical fertilizer. Wheat seeds were used for bioassay test because they show a more sensitivity to low concentration of phototoxic substances and salts. Salinity is one of the major abiotic stresses. It has many negative effects on morphology, physiology and biochemical activities of crop. High salt concentrations cause slow germination rate. Osmotic pressure causes imbalance in enzyme activities and the results also showed that wheat seeds were more sensitive towards different concentrations of leachate (Hasanuzzaman et al., 2017). By comparing with control results, significant difference between leachate and fertilizer was observed. Maximum seedling length was observed in 0.5% leachate sample and lowest was observed in 25.5% leachate sample.

Effect of leachate on germination rate of crops

Both leachate and fertilizer had affected the growth of wheat. Results indicated that on lower concentrations, leachate promoted the seed germination and seedling growth but on higher concentrations it resulted in reduced seed germination rate and seedling growth. Analysis of data regarding germinated wheat seeds in different leachate concentrations collected is shown in the Tables 1 and 2.

The results from the study provide evidence of micro and macro nutrients present in compost leachate (Quaik et al., 2012; Dimitriou, 2006). This indicated that retarded growth of wheat exist with decreased and increased dilution. Excessive amount of nutrients are present in sample for crop benefits (Savage and Tyrrel, 2005). Dosage of leachate should be balanced according to the need of crop.

Effect of commercial fertilizer on germination rate of crop

In Table 2, low concentration leachate has promoted the growth. This might be due to dilution of leachate which resulted in the dilution of toxic substances too, thus reducing their adverse effects and the negative impacts which were produced due to leachate irrigation.

On higher concentration, leachate caused wilted root to grow due to higher amounts of salt and toxic substances. High levels of leachate concentration were toxic for plant growth because leachate also contains some toxic substances and high amount of heavy metals. Leachate treatment from 0.5 to 5.5% concentration has an impact on seed germination and length when compared with control (Table 1). Maximum increase in concentration of leachate up to 25.5% is responsible for the reduction in the seed germination, root, and shoot length as compared to control. In wheat, 0.2% leachate solution showed average root and shoot lengths were noticed about 6.4 and 5.7 cm which were less compared to control. Maximum root, shoot seedling length 11.8, 6.2 and 16.5 cm were observed in 1.5 and 5.5% leachate concentration and almost these same results were observed in 3.5% leachate concentration (Table 3). Minimum root and shoot length about 0.7 and 0.2 cm were noted in 25.5% leachate solution. The results from these studies revealed that at low concentration of leachate, maximum growth was observed. Dilution of leachate up to maximum value also decreases the amount of toxic substances (Zhou and Wang, 2010; Romero et al., 2013). The results confirmed the hypothesis that due to the presence of essential plant macro and micro nutrients such as nitrogen, carbon, potassium, phosphorous and other trace elements like zinc, calcium, boron, magnesium (Zhou and Wang, 2010), leachate could be used as liquid fertilizer (Miceli et al., 2008; Dimitriou, 2006). Higher concentration of leachate up to 5.5% and above showed minimum growth of the crop and the growth of both primary shoot and root were stopped (Table 3). On higher concentration, leachate caused wilted root to grow due to higher amounts of salt and toxic substances.

Table 1. Weekly analysis of germination rate of wheat seed in leachate.

Leachate (%)	Wheat seed germination						
	Day 1	Day 2	Day 3	Day4	Day 5	Day 6	Day 7
0.2	62±1.2	76±0.5	82±0.5	91±0.5	92±0.5	91±0.5	92±0.5
0.5	31±1.0	58±0.5	83±0.6	90±0.5	90±0.5	90±0.5	90±0.5
1.5	30±1.0	45±0.5	53±0.53	83±0.5	83±0.5	83±0.5	83±0.5
3.5	61±1.2	78±2.5	90±0.5	97±0.7	97±0.7	97±0.5	97±0.5
5.5	21±1.0	56±0.5	69±0.6	80±0.5	80±0.5	80±0.5	81±0.5
10.5	32±1.0	66±0.5	79±0.6	82±0.5	83±0.5	83±0.5	83±0.5
15.5	09±1.1	30±1.5	52±0.5	63±0.5	63±0.5	63±0.5	63±0.5
25.5	00±0.0	20±0.5	37±0.5	40±0.5	40±0.5	40±0.5	40±0.5
Control	**40±0.5**	**63±0.5**	**77±0.5**	**87±0.5**	**87±0.5**	**87±0.5**	**87±0.5**

The standard error of mean value is shown in the above table. Mean difference is significant at the level of ($p \leq 0.05$) by Duncan's new multiple range test.

Table 2. Weekly analysis of germination rate of wheat seed in commercial fertilizer.

Fertilizer (%)	Wheat seed germination						
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
0.2	23±1.2	56±0.5	82±0.5	90±0.5	90±0.5	91±0.5	91±0.5
0.5	43±1.0	63±0.5	80±0.6	84±0.5	84±0.5	84±0.5	84±0.5
1.5	03±1.0	10±0.5	13±0.53	13±0.5	13±0.5	13±0.5	13±0.5
3.5	NG	NG	NG	NG	NG	NG	NG
5.5	NG	NG	NG	NG	NG	NG	NG
10.5	NG	NG	NG	NG	NG	NG	NG
15.5	NG	NG	NG	NG	NG	NG	NG
25.5	NG	NG	NG	NG	NG	NG	NG
Control	**40±0.5**	**63±0.5**	**77±0.5**	**87±0.5**	**87±0.5**	**87±0.5**	**87±0.5**

The standard error of mean value is shown in the above table. Mean difference is significant at the level of ($p \leq 0.05$) by Duncan's new multiple range test. *NG = Not germinated.

Table 3. Effect of low and high percentage of leachate on root, shoot and seedling length of wheat on 1st week.

Leachate treatment	Root length (cm)	Shoot length (cm)	Seedling length (cm)
Low % of leachate			
0.2	6.4±1.9	5.7±1.1	12.1±1.2
0.5	11.8±2.8	6.2±1.1	16.0±1.0
High % of leachate			
1.5	9.7±1.1	4.1±0.7	15.2±0.6
3.5	10.2±1.7	6.4±1.1	17.1±1.2
5.5	9.2±1.5	5.1±1.3	14.5±0.9
10.5	4.8±1.3	1.1±1.0	6.0±1.0
15.5	2.4±0.6	0.6±0.7	2.7±0.6
25.5	0.7±0.1	0.2±0.0	0.9±0.0
Control	**8.7±2.4**	**5.9±2.3**	**16.1±2.1**

The standard error of mean value is shown in the above table. Mean difference is significant at the level of ($p \leq 0.05$) by Duncan's new multiple range test.

In leachate concentration of 0.2 and 0.5%, wheat crop germination rate was less than control. Concentrations of leachate up to 1.5 and 3.5% of the germination rate were better. 3.5% leachate treatment showed highest growth. The concentration of 5.5% leachate sample showed germination rate that was approximately equal to the control trial. Larger quantity of leachate 10.5 and15.5% retarded the growth. In this study, highest germination rate was noted in less (3.5%) leachate treatments and lowest was noted in high (25.5%) leachate treatment.

Conclusion

The results from this study revealed that the leachate produced from solid waste processing have fertilizer efficiency. It provides better results at low concentrations when compared to commercial fertilizer. Leachate promoted the growth due to the high basic nutrient content e.g. nitrogen, phosphorous, humid acid and organic matter etc.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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