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Utilization of Municipal Solid Waste Compost for the Improvement of Microbial Biomass, N-Mineralization and Fertility of Soil under Maize Crop

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ABSTRACT

The experiment was conducted to assess the influence of municipal solid waste compost on microbial activity of soil after harvesting of maize crop and to determine the effect of municipal solid waste compost on N mineralization. A field experiment to test the effect of solid waste compost on fertility, microbial biomass and nitrogen (N) mineralization was conducted at Agriculture Research Institute Tarnab, Peshawar during spring 2017. A maize crop was selected as test crop for this experiment. The experiment was carried out in a Randomized Complete Block (RCBD) design with three replications. Maize variety (Azam) was sown in March 2017. Plot size was 5 × 3 m. Municipal solid waste compost was applied as treatment in each plot with different rates. The data showed maximum N mineralization (7.6 µg g^{-1} soil**)** at the treatment T_2 where only NPK dose was applied while minimum N was mineralized at treatment T_1 control where no NPK and MSW compost was applied, Then the application of MSW compost influenced N mineralization at large extent (6.4 µg g^{-1} soil) in treatment T_4 where MSW compost was applied at 12 t ha^{-1} followed by the treatment T_6 (6.1 µg g^{-1} soil) where MSW compost was applied at 24 t ha^{-1}. Applying MSW compost influence microbial activities and increase soil organic carbon.

1. Introduction

The municipal solid wastes (MSW) of the provincial capital Peshawar city are dumped on open ground at three locations close to the residential areas. The open dumps not only cause unpleasant odor and nuisance but also pose a potential risk of spreading infectious diseases in the nearby areas. There is also a great risk of site contamination with heavy metals such as Zn, Cu, Fe, Mn, Cr, Pb, Cd and Ni and leaching of toxic materials to surface and ground waters. Similarly, heavy metals from MSW may enter into the food chain through fish and pose a significant health risk to humans. It is estimated that 500 tons of municipal solid wastes are produced per day in Peshawar valley of which only 350 tons are picked up **(Director General, City, Municipal and Dev. Depit., 2002, Personal Communication)**. It has been found that MSW of Peshawar city contains considerable amounts of N and K, and a small amount of P **(Shah & Anwar, 2003; Shah et al. 2005)**. Land application of MSW may be the best choice as most organic wastes are valuable resource of plant nutrients especially N, P, K, S, Ca, Mg, organic C and improve physical, chemical and biological properties of a soil **(Cameron et al. 1997; Zaman et al. 1999; Zaman et al. 2002a; Shah & Anwar, 2003)**. Both under laboratory and field conditions, N mineralization rates, and microbial biomass have been shown to increase after a single application of organic wastes **(Paul & Beauchamp, 1996; Zaman et al. 1999a and b, Zaman et al. 2002b)**. Municipal solid waste compost is increasingly used in agriculture as a soil conditioner but also as a fertilizer. Municipal solid waste is mostly made up of household waste and its composting has been accommodated by many municipalities **(Otten, 2001)**.

Composting is the way of conversion of organic waste materials to a useful product at a very low cost which can be used for agriculture purposes **(Eriksenet et al., 1999)**. Composting of solid waste demotes the volume of waste, kills the pathogen available, reduces germination of weeds in agricultural fields and destroy the hazardous compounds **(Jakobsen, 1995)**.

Microbial activity is of first-rate significance for biological and biochemical soil processes as it once influences the transformation of nutrients and natural compost. It is also qualitatively and quantitatively associated with the presence of extracellular hydrolytic enzymes which might be vital in the system of decomposition and mineralization of organic matter **(Eldor, 2007)**. Incorporation of organic materials, such as municipal solid waste (MSW) compost, into the soil improves microbiological activity and soil fertility by the mineralization of the important organic elements such as C, N, P, and S **(Frankenberger and Dick, 1983)**. Nitrogen mineralization is the process by which organic N is converted to plant-available inorganic forms. Soils regularly amended with organic wastes will accumulate organic N until they reach a steady-state condition, a concept useful for planning N management strategies. Several factors affect mineralization rates, particularly temperature, so that release varies amount throughout the year in a predictable pattern. An understanding of these patterns is necessary to match crop N demands with the plant-available N in the soil. Manure nitrogen (N) comes in both organic and inorganic forms. Inorganic N, mostly ammonium (NH^4) and nitrate (NO_3), is readily available to plants. Before organic N can be taken up, however, it must first be converted to inorganic forms. This process, which is completed by soil microbes as a by-product of organic matter decomposition, is called mineralization. The mineralizationrateis, therefore, the rate at which organic N is made plant available. In manured forage systems, mineralization accounts for much or most of the crop needs. An understanding of the mineralization rate concept can help improve manure management to meet crop N demands **(Crohn and Solano, 2003)**. This the experiment was conducted to assess the influence of municipal solid waste compost on microbial activity of soil after harvesting of maize crop and to determine the effect of municipal solid waste compost on N mineralization.

2. Methodology

A field experiment to test the effect of solid waste compost on fertility, microbial biomass and nitrogen (N) mineralization was conducted at Agriculture Research Institute Tarnab, Peshawar during spring 2017. Maize crop was selected as test crop for this experiment. This experimentation was carried out in a Randomized Complete Block (RCBD) design with three replications. Maize variety

(Azam) was sown in March 2017. Plot size was 5 × 3 m^2. Municipal solid waste compost was applied as a treatment in each plot with different rates.

Table 1. Treatments t used the experiment

Treatments	**Municipal solid waste compost (ton ha^{-1})**
T1	Control
T2	Only recommended NPK
T3	6
T4	12
T5	18
T6	24

All the required NPK and MSW compost were applied before sowing of the crop. All the cultural practices were carried out during the growth of the crop. After complete maturity the crop was harvested, and fresh soil samples were collected for fertility analysis. The soil samples were collected at field capacity condition from each subplot after the harvesting, the samples were sieved and kept in plastic bags in their frigerator under control environment for further microbial analysis. A 50 g of moist soil sample was taken in a 500 mL conical flask and 10 mL of 0.3 M NaOH solution was added into a vial and suspended in the flask containing the soil sample with the help of a string. The flask was sealed with rubber bung (airtight) and incubated at 25°C for one week. The blank was also incubated with NaOH with no soil. After the incubation period the flak was taken out from incubator and the rubber bung was removed. Then the vail was taken out and its contents was transferred quantitatively to a clean 250 mL flask. 10 mL 0.1 M $BaCl_2$ solution and few drops of phenolphthalein was added and stirred (note: pink color will appear; if not appeared that means all the NaOH has been neutralized by CO_2) and repeated incubation needed). The sample was titrated against 0.1 N HCl until pink color disappears. Then the amount of CO_2 produced was calculated. Mineral N was determined by the methods as described by **Mulvaney (1996)**. While of percent organic matter was calculated using the method of **Nelson and Sommer (1982)**. The data obtained were analyzed using analysis of variance technique suitable for randomized complete block design. Data were compared with LSD when P- values were less than 0.05.

3. Result and Discussions

The utilization of municipal solid waste compost on fertility, microbial activity and nitrogen mineralization of soil under maize crop was carried out at Agriculture Research Institute Tarnab, Peshawar during spring 2017. Maize crop was sown as test crop for this experiment. This experimentwas carried out in RCB design having three replications. Maize variety (Azam) was sown in a plot size of 5 × 3 m. Municipal solid waste compost was applied at the rate of 6, 12, 18 and 24 t ha^{-1} to the each plot. Data on microbial activity, N mineralization, and organic matter was recorded. The physiochemical characteristics of experimental soil before sowing and application of treatments doses are given in Table 2.

Table 2. Physico-chemical characteristics of experimental soil

Property	**Unit**	**Concentration**
Texture	-	Silty Clay Loam
pH	-	7.95
EC	dS m^{-1}	0.18
OM	%	0.274
N	%	0.014
Extractable P	mg kg^{-1}	5.92
Extractable K	mg kg^{-1}	233

The soil was clay loam in texture with low organic matter content. The pH of the soil was slightly alkaline with low phosphorous (P) level while the potassium content was adequate.

Data regarding N-mineralized of soil as affected by the application of municipal solid waste compost under spring maize is presented in Table 3. The data further showed maximum N mineralization (7.6 µg g^{-1} soil**)** at the treatment T_2 where only NPK dose was applied, while minimum N was mineralized at treatment T_1 control where no NPK and MSW compost was applied, then the application of MSW compost influenced N mineralization at large extent (6.4 µg g^{-1} soil) in treatment T_4 where MSW compost was applied at 12 t ha^{-1} followed by the treatment T_6 (6.1 µg g^{-1} soil) where MSW compost was applied at 24 t ha^{-1}. These findings providing similar information as of **Shah et al. (2007)** in which it was reported that net N mineralization rates in municipal solid waste were either negative (immobilization) or very low as evident from their low mineral N production. Immobilization could be attributed to the lack of readily mineralizable organic substrates in MSW at the time of their application or due to the fact that added MSW was fresh and was not stabilized.

Table 3. Influence of municipal solid waste compost on N-mineralized (µg g^{-1} soil)

Treatment (MSW compost t ha^{-1})	Mean N-mineralized (µg g^{-1} soil)
T1= Control	5.3
T2= Only recommended NPK	7.6
T3= 6 t ha^{-1}	5.3
T4= 12 t ha^{-1}	6.4
T5= 18 t ha^{-1}	5.8
T6= 24 t ha^{-1}	6.1
LSD ($p \leq 0.05$)	2.13

Data regarding the microbial activity of soil as affected by the application of municipal solid waste compost under maize is presented in Table 4. The data showed that on 2-day of incubation of soil, the microbial activity was recorded higher in treatment T_6 where MSW compost was applied at 24 t ha^{-1} while microbial activity was recorded lower in control plot. Where no MSW compost was applied. On 5-day incubation of soil, higher microbial activity was noticedin treatment T_6 where MSW compost was applied at 24 t ha^{-1} while lower microbial activity was recorded in control plot. On 10-days of incubation, higher microbial activity was also recorded in treatment T_6 where MSW compost was applied at 24 t ha^{-1} while lower microbial activity was recorded in control plot.

Microbial activity was recorded higher in all treatments on 2 days of incubation where MSW compost was applied at different rates, while lower microbial activity was recorded on 10 days of incubation. These results are in association with **Crecchioet al (2001)** as the addition of organic materials to the soil increased the values of biomass carbon, basal respiration, biomass C/total organic C ratio and metabolic quotient (qCO_2), indicating the activation of soil microorganisms.

Table 4. Influence of municipal solid waste compost on microbial activity in soil (µg g^{-1}soil)

Treatment (MSW compost)	Mean CO_2 Evolved (µg g^{-1}soil day^{-1})		
	2 days	5 days	10 days
T1= Control	54.2e	43.1f	18.2d
T2= Only recommended NPK	60.9e	53.1e	21.1d
T3=6 t ha^{-1}	74.1d	62.2d	25.7c
T4=12 t ha^{-1}	82.8c	72.1c	27.7c
T5=18 t ha^{-1}	97.5b	79.2b	31.7b
T6=24 t ha^{-1}	125.4a	92.7a	37.5a
LSD ($p \leq 0.05$)	7.70	4.9	3.9

Data regarding soil organic matter as affected by the application of municipal solid waste compost under maize crop is presented in Table 5. The findings revealed that organic matter (1.7 %**)** was maximum in a treatment T_6 whereMSW compost was applied at 24 t ha^{-1},while organic matter (0.5

%) was minimum treatment T_1(control) where no NPK and MSW compost was applied. These results are in association with **Pascual et al. (1999)** in which it was reported that the organic matter fractions were higher in the soil amended with MSW compost than in the control soil.

Table 5. Influence of municipal solid waste compost on soil organic matter (%)

Treatment	Mean
T1	0.5f
T2	0.7e
T3	0.8d
T4	0.8c
T5	1.5b
T6	1.7a
LSD ($p \leq 0.05$)	0.1

4. Conclusion

Based on the findings it was concluded that the application of MSW compost has no significant effect on N mineralization. Microbial activity was significantly influenced by incorporation of MSW compost in the soil before sowing of the crop. The addition of MSW compost increased the soil organic matter content significantly. Application of MSW compost to the soil before sowing of the crop should be preferred to increase soil microbial activity and organic matter content.

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