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RESEARCH ARTICLE

# INFLUENCE OF MUNICIPAL SOLID WASTE COMPOST ON YIELD OF TOMATO-APPLIED SOLELY AND IN COMBINATION WITH INORGANIC FERTILIZER WHERE NITROGEN IS THE ONLY VARIABLE FACTOR

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## ABSTRACT

Municipal solid waste compost (MSWC) is considered as one of the prominent fertilizers that improve soil health and productivity. To evaluate the effects of MSWC on plant growth, an experiment was conducted by using sole MSWC and with a combination of inorganic fertilizer. The sole MSWC was applied at the rate of 0, 5, 10, 15 t ha$^{-1}$. In case of MSWC with inorganic fertilizer, MSWC was applied equally (5 t ha$^{-1}$) and phosphorus and potassium fertilizers were applied at 100 and 50 kg ha$^{-1}$, respectively. Nitrogen was the only variable nutrient. Nitrogen was applied three different doses (25, 50 and 100 kg ha$^{-1}$) along with control. Tomato (*Solanum lycopersicum L.*) was grown as experimental plant and maximum yield (72.7±6.3 t ha$^{-1}$) of tomato was found when sole MSWC was applied at 15 t ha$^{-1}$ and was significantly higher than other treatments. When MSWC was applied in combination with inorganic fertilizer, the combination 5 t ha$^{-1}$ MSWC +100 kg N ha$^{-1}$ +100 kg TSP ha$^{-1}$ +50 kg MoP ha$^{-1}$ produced maximum yield (79.0±3.2 t ha$^{-1}$). So, application of sole MSWC in soil enhanced the productivity of soil and side by side, MSWC in combination with inorganic fertilizer reduced the volume of MSWC application.

**KEYWORDS**

Garbage composting, Organic fertilizer, Chemical fertilizer, Yield, Management.

## 1. INTRODUCTION

Management of the growing amount of MSW, produced with the development of urbanization and industrialization, is a challenging problem throughout the world. Improper management and disposal of the waste led to pollution and serious health hazards that can be considered as a threat to the ecosystem and environmental sustainability (Adani et al., 2000; Sharma and Shah, 2005; Srivastava et al., 2016). Current global average generation of MSW is approximately 1.2 kg per person per day which will reach to 1.42 kg per person per day by 2025, reaching 2.2 billion ton of waste per year, includes both domestic and commercial waste (White et al., 1995; Hoornweg and Bhada-Tata, 2012).

MSW is largely incinerated or openly landfilled but the major fraction (> 50%) of MSW constitutes organic wastes which is biodegradable under anaerobic conditions. Thus, the application of MSW in soil has become a good choice for waste management and recycling (Barlaz et al., 2010; Lee et al., 2018). Composting of MSW is gaining popularity to apply them as soil amendments which represents an acceptable solution of landfill disposal, volume reduction of MSW and at the same time increasing its value as it contributes soil organic matter restoration (Hargreaves et al., 2008; Zhao et al., 2012).

Composting is a widely accepted way of stabilizing solid organic wastes by biological degradation of organic matter under aerobic conditions to produce a safer and stable humus-like product (Baran et al., 2009; Fernández et al., 2014). At the time of composting of MSW, separation of the waste into organic and inorganic fractions is the most important step to make high quality compost. Otherwise, inadequate separation of biodegradable fractions from non-degradable materials results in high values of trace elements and heavy metals in compost (Barth and Kroeger, 1998; Jodar et al., 2017).

Applications of MSWC increase soil fertility by adding soil organic matter and plant nutrients. It also helps in enhancing water holding capacity, infiltration, soil aeration, soil microbial response; reduce erosion; improve soil structure (Bouzaiane et al., 2014; Weber et al., 2014; Lim et al., 2015). Thus results in positive influence on plant growth (Rajaie and Tavakoly, 2016). However, in some cases, the only MSWC application provide the nutrients for crops may not sufficient, hence, co-application of inorganic fertilizers with MSWC is helpful to improve soil nutrients and crops productivity (Ramadass and Palaniyandi, 2007; Ghaly and Alkoaik, 2010; Nigussie et al., 2015).

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Moreover, N addition with MSWC enhanced positive effect of nutrients uptake because, the nitrogen contents in compost are generally low (0.5 to 2%) and the stock of mineralized N is not enough to meet the crop requirements for maximum yield (Rajaie and Tavakoly, 2016; Karlen et al., 1995). The purpose of the study was to assess the effects of MSWC on tomato yield and to enhance the popularity of MSWC as organic fertilizer which will indirectly serve as a promising way for controlling the pollution of MSW by an effective and sustainable management approach. Side by side, it will be helpful to supply organic matter in soil and reduced the increasing sole dependency on inorganic fertilizer by increasing the co-application of MSWC and inorganic fertilizer.

## 2. MATERIALS AND METHODS

### 2.1 Site description

The experiment was conducted at the experimental field of Soil, Water and Environment Discipline, Khulna University, Bangladesh (N-22$^0$80.33´/E-89$^0$53.24´). The field was medium high land. The region is under hot humid subtropical climate with plentiful rainfall during monsoon.

### 2.2 Selection of experimental plant

The experimental plant was tomato (*Solanum lycopersicum L.*) which is an important commercial vegetable in Bangladesh due to its high production, consumption and nutritional values (BARI, 2010). Tomato ranks seventh in worldwide production and in Bangladesh, among the winter vegetable crops, tomato ranks second in respect of production and third in respect of area cultivated (FAOSTAT, 2011). Tomato covered 17037 ha of land and the total production was approximately 131 thousand metric tons (BBS, 2004, 2006). Tomato crop requires balanced fertilizer and water for obtaining economical yield. For proper growth of tomato organic and inorganic fertilizer both are needed. In this case, co-application of organic compost and inorganic fertilizers (mainly N, P and K) play a significant role in tomato production rather than using separately (Ghaly and Alkoaik, 2010; Kumar et al., 2013; Ogundare et al., 2015). Among the nutrients, N is very important for better quality and yield of tomato as it stimulates vegetative growth and flowering of tomato plant (Pascale et al., 2006; Rashid et al., 2016). Different studies revealed that, the combined application of MSWC and N fertilizer plays a significant role on the growth of tomato (Rajaie and Tavakoly, 2016; Abate et al., 2017).

### 2.3 Growing season

The experiment was conducted in winter season. Tomato is usually cultivated in Bangladesh around the year but in this season tomato is cultivated intensively because this season is suitable for tomato.

### 2.4 Collection of MSWC

Trucks of Khulna City Corporation (KCC), Bangladesh collects wastes for final disposal into Rajbandh landfill area which is located at a distance of 9 kilometers from Khulna city center. About 70% of the total MSW in Khulna city is organic in nature and advantageous for preparation of compost fertilizer. A popular NGO in Khulna named 'RUSTIC' is producing about 30 tons MSWC per month using 46 tons (0.53%) solid waste (Roy et al., 2013). The MSWC was collected from RUSTIC (a NGO) for our experiment.

### 2.5 Experimental setup and treatments combination

The experiment was carried out to assess the effects of sole MSWC and in combination with inorganic fertilizers on tomato production. The whole experiment was divided into two parts. In one part, MSWC was applied three different doses (5, 10 and 15 t ha$^{-1}$) along with control. In another part of the experiment, MSWC was also applied equally (5 t ha$^{-1}$); P and K fertilizers were applied as recommended doses (100 and 50 kg ha$^{-1}$, respectively) to all plots at the beginning of the experiment. Nitrogen was the only variable nutrient. Nitrogen was applied three different doses (25, 50 and 100 kg ha$^{-1}$) along with control. Urea, triple super phosphate (TSP) and muriate of potash (MoP) fertilizer were applied as the source of N, P and K where N is 46%, $P_2O_5$ is 52% and K is 60%.

### 2.6 Experimental design

A completely randomized design (CRD) was followed for the experiment and the plot size was 0.7m×0.7m.

### 2.7 Experimental plot preparation

Total 24 experimental plots were prepared. Traditional spade was used to plough the land. Weeds, stubble, and crop residues were removed manually. The MSWC was mixed properly in every plot according to required amounts. In case of inorganic fertilizer, one-third of urea, total TSP and MoP were applied during field preparation. Another one-third of the urea was applied at growth stage and rest of the urea was applied at flowering stage.

### 2.8 Tomato seedling collection

Seedlings were collected from Gollamari bazar, Khulna, Bangladesh. The age of seedlings was 20 days. It was collected from the dealer in the afternoon to avoid the risk of dehydration.

### 2.9 Choice of varieties

We selected BARI tomato 3-variety that performs best under the local conditions.

### 2.10 Seedling transplantation

After collection, 20 days aged seedlings were transplanted in the experimental field. There were 5 plants in each plot. An extensive care was taken to keep enough moisture for the seedlings until the seedlings were stable.

### 2.11 Irrigation

Same volume of normal tap water was used in every plot for irrigation when needed.

### 2.12 Weeding and controlling pest

Weeding was done regularly by manually uprooting. *Early blight* of tomato disease was observed and fungicide (mancozeb group) was sprayed two times.

### 2.13 Sampling and harvesting

Matured tomato fruits were collected at three different times. The fresh weight of tomato was recorded for each collection time. Tomato yield was calculated in t ha$^{-1}$ considering the area of the plot.

### 2.14 Soil sample analysis

Organic carbon, pH, electrical conductivity (EC) and all other nutrients were determined into laboratory of Soil, Water and Environment Discipline, Khulna University by following the procedures described (Imamul Huq and Alam, 2005).

### 2.15 Statistical analysis

Statistical analysis was done by following ANOVA technique using MINITAB 17.0 and DMRT test was applied to assess the differences between treatments (n=3). Graphs were prepared by using MS Excel 2010.

## 3. RESULTS AND DISCUSSION

### 3.1 Soil properties

Analytical results of important soil properties are given in Table 1. Soil sample was mildly alkaline, non-saline in nature (Soil survey manual, 1993). Nitrogen content was medium and OC, P, K and S contents were very low, with regarding to the range of soil nutrients mentioned in (Imamul Huq and Alam, 2005).

| **Table 1:** Some basic properties of soil sample | |
|---|---|
| Soil Properties | Results |
| pH | 7.44 |
| Electric Conductivity (EC) | 1.98 (dS/m) |
| Organic Carbon (OC) | 0.56 (%) |
| Nitrogen (N) | 0.25 (%) |
| Phosphorus (P) | 0.021 (%) |
| Potassium (K) | 0.11 (%) |
| Sulfur (S) | 0.003 (%) |

### 3.2 Properties of MSWC

The MSWC used in this experiment was prepared by RUSTIC (a NGO) and declared some properties of prepared compost are presented in Table 2. The pH of MSWC was neutral in nature (Soil survey manual, 1993) and the nutrient contents were low to medium according to the experimental result of (NEERI, 2005, 2009).

| **Table 2:** Some properties of MSWC | |
|---|---|
| Properties | Results |
| Moisture content | 17.0 (%) |
| pH | 7.0 |
| Organic Carbon | 10.65 (%) |
| Nitrogen (N) | 0.95 (%) |
| Phosphorous (P) | 0.70 (%) |
| Potassium (K) | 1.25 (%) |
| Sulfur (S) | 0.29 (%) |
| Zink (Zn) | 0.04 (%) |
| Copper (Cu) | 0.016 (%) |
| Chromium (Cr) | 18.28 (mg kg$^{-1}$) |
| Cadmium (Cd) | 0.18 (mg kg$^{-1}$) |

Presence of heavy metal in MSWC is a common problem because of the presence of plastics, electronic appliances, paint chips, batteries, motor oils etc. (Hamdi et al., 2003). The result of heavy metal can be compared with Spanish standard where the concentration of heavy metal in MSWC are categorized into three categories (Quality A, B and C) and quality C is considered as last permissive level of heavy metal (Real Decreto, 2013). The contents of Zn and Cu in this MSWC were in B category, and Cr and Cd were in A category. So, the heavy metal concentration in this compost, which is a big concern in case of MSWC application, is very low and there was no risk of heavy metal contamination into soil as well as plant growth. Side by side, after comparing with the Indian standard threshold limit values of heavy metals in compost and soils also revealed that the heavy metal content of this MSWC is under tolerance limit (Awashthi, 2000; ECN, 2008).

### 3.3 Yield of tomato

#### *3.3.1 Experiment-1*

The average fresh weight of tomato is presented in Table 3. The yield of tomato was significantly increased ($p < 0.001$) with increasing rate of sole MSWC application. The maximum yield (72.7±6.3 t ha$^{-1}$) was found where 15 t ha$^{-1}$ MSWC was applied whereas the minimum yield was observed in control (33.6±5.8 t ha$^{-1}$). The results showed that the yield was significantly ($p < 0.001$) higher at the highest amount of MSWC application (15 t ha$^{-1}$) but the production of tomato under control and 5 t ha$^{-1}$ was statistically same although tomato yield was significantly higher at 10 t ha$^{-1}$ MSWC application as compared to control and 5 t ha$^{-1}$. Similar findings were reported on tomato plant (Rajaie and Tavakoly, 2016; Maynard, 2013). Other studied on potato, corn, wheat and poa revealed the similar results that MSWC is an efficient source of available nutrients for promoting plant growth (Ghaly and Alkoaik, 2010; Horrocks et al., 2016; Civeira, 2010). The addition of MSWC increases the total N, OC, available P, pH, other microelements and improve soil physical status can be considered as the reasons of growth enhancement of plant (Amlinger et al., 2003; Bouzaiane et al., 2014; Weber et al., 2014). On the other hand, application rate of MSWC is a very important factor because over application results in a reduction of plant growth. Increased amount of MSWC application in lettuce and tomato inhibited plant growth and the reasons for growth inhibition were N immobilization or decreased N mineralization (Giannakis et al., 2014).

<table>
<tr><th colspan="6">Table 3: Response of MSWC with or without inorganic fertilizer on tomato yield</th></tr>
<tr><td colspan="3">Experiment-1</td><td colspan="3">Experiment-2</td></tr>
<tr><td colspan="2">Treatment</td><td>Tomato yield (t ha$^{-1}$)</td><td colspan="2">Treatment</td><td>Tomato yield (t ha$^{-1}$)</td></tr>
<tr><td></td><td>Control</td><td>$33.6\pm5.8^{c}$</td><td colspan="2">Control</td><td>$33.6\pm5.8^{c}$</td></tr>
<tr><td rowspan="4">MSWC</td><td>5 t ha$^{-1}$</td><td>$40.0\pm3.5^{c}$</td><td rowspan="4">5 t ha$^{-1}$ MSWC + 100 kg TSP ha$^{-1}$ + 50 kg MoP ha$^{-1}$ +</td><td>0 kg N ha$^{-1}$</td><td>$39.7\pm6.9^{c}$</td></tr>
<tr><td>10 t ha$^{-1}$</td><td>$55.2\pm3.1^{b}$</td><td>25 kg N ha$^{-1}$</td><td>$45.6\pm6.8^{bc}$</td></tr>
<tr><td>15 t ha$^{-1}$</td><td>$72.7\pm6.3^{a}$</td><td>50 kg N ha$^{-1}$</td><td>$50.9\pm1.0^{b}$</td></tr>
<tr><td></td><td></td><td>100 kg N ha$^{-1}$</td><td>$79.0\pm3.2^{a}$</td></tr>
</table>

Data represent the average ± the standard deviation ($n = 3$)

#### *3.3.2 Experiment-2*

Results of the average fresh weigh of tomato under different treatments from *Experiment-2* where MSWC was applied in combination with inorganic fertilizer are also presented in Table 3. The maximum yield (79.0±3.2 t ha$^{-1}$) was observed under the combination of 100 kg N ha$^{-1}$ + 100 kg TSP ha$^{-1}$ + 50 kg MoP ha$^{-1}$ + 5 t ha$^{-1}$ MSWC whereas the minimum yield was observed under control (33.6±5.8 t ha$^{-1}$). Statistical analysis of the results showed that the maximum yield at treatment combination 100 kg N ha$^{-1}$ + 100 kg TSP ha$^{-1}$ + 50 kg MoP ha$^{-1}$ + 5 t ha$^{-1}$ MSWC was significantly ($p < 0.001$) higher as compared to the other combinations (50 kg N ha$^{-1}$ + 100 kg TSP ha$^{-1}$ + 50 kg MoP ha$^{-1}$ + 5 t ha$^{-1}$ MSWC; 25 kg N ha$^{-1}$ + 100 kg TSP ha$^{-1}$ + 50 kg MoP ha$^{-1}$ + 5 t ha$^{-1}$ MSWC; 0 kg N ha$^{-1}$ + 100 kg TSP ha$^{-1}$ + 50 kg MoP ha$^{-1}$ + 5 t ha$^{-1}$ MSWC and control).

Integrated use of MSWC and inorganic fertilizer especially N performed best in tomato production (Ghaly and Alkoaik, 2010; Kumar et al., 2013). Rajaie and Tavakoly also reported that combined application of MSWC and N results improved growth of tomato than application of either MSWC or N fertilizer only because with N addition, the positive effect of MSWC on nutrients uptake become more prominent (Rajaie and Tavakoly, 2016). However, in our experiment, tomato yield significantly increased at 100 and 50 kg N ha$^{-1}$. So, increased doses of N-fertilizer applications increased the tomato yield. The total yield was not up to the maximum level this might be due to pest attack. But the main point is that determination of proper application doses of fertilizer is the prerequisite to control the adverse effects on soil and plant growth (Hossain et al., 2017).

It was also found that the application of sole MSWC and combined application of inorganic fertilizer (Urea, TSP, MoP) and MSWC with variation of urea application, both the application of MSWC alone and in combination with N-fertilizer increased tomato yield. The application of sole MSWC at 15 t ha$^{-1}$ showed the maximum tomato production (72.7±6.3 t ha$^{-1}$) and approximately similar to (79.0±3.2 t ha$^{-1}$) the result obtained at treatment combination 100 kg N ha$^{-1}$ + 100 kg TSP ha$^{-1}$ + 50 kg MoP ha$^{-1}$ + 5 t ha$^{-1}$ MSWC. In some cases, mineralized N from compost is insufficient to meet the requirements for highest yield especially at the first growing season (Eriksen et al., 1999). So, in that case, application of supplementary inorganic fertilizer is fruitful for better production (Okareh et al., 2014; Scotti et al., 2016). Our experimental results revealed that MSWC itself a good source of nutrients and potential alternatives to inorganic fertilizer based on yield performance but the application rate is high (15 t ha$^{-1}$). So, this high amount of MSWC application could be reduced to 5 t ha$^{-1}$ in combination with inorganic fertilizer (100 kg N ha$^{-1}$ + 100 kg TSP ha$^{-1}$ + 50 kg MoP ha$^{-1}$).

## 4. CONCLUSION

Preparing MSWC from MSW is a very effective management practice of organic waste because the compost acts as a great nutrient source and it promotes plant growth. The results revealed that the fresh weight of tomato was significantly increased ($p$ < 0.001) with higher rate of sole MSWC application and significantly higher at 15 t ha$^{-1}$. Whereas, when MSWC was applied with inorganic fertilizer (Urea, TSP and MoP) it also promoted crop yield even in lower rate (5 t ha$^{-1}$) of MSWC. Higher tomato yield was ($p$ < 0.001) found at 5 t ha$^{-1}$ MSWC + 100 kg N ha$^{-1}$ + 100 kg TSP ha$^{-1}$ + 50 kg MoP ha$^{-1}$ application. Though sole application of MSWC in soil could improve soil fertility and crop productivity but MSWC in combination with inorganic fertilizer can be recommended to reduce the volume of MSWC application. But further research should be needed to find the highest dose of MSWC and inorganic fertilizer especially N in the growth of tomato.

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