Effects of banana peel compost rates on Swiss chard growth performance and yield in Shirka district, Oromia, Ethiopia

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ABSTRACT

Increasing Population growth and expansion of urbanization lead to the emission of solid waste, including household waste, which causes environmental pollution. However, these wastes can be converted into forms used for organic farming. Therefore, the study was conducted to examine the effect of banana peel compost rates on the growth performance and yield of Swiss chard. The experiment took place in the Kulumsa Agricultural Research Center Greenhouse, with an area of 1.42m² and pot area of 628cm². The randomization of both treatments and replication was done by using Randomized Complete Block Design (RCBD). Field and laboratory data were subjected to one-way analysis of variance (ANOVA) by using general linear model (GLM) of the SAS statistical package version 9.0 to determine the existence of any statistical difference among the treatments. Soil and 10, 20, and 30g rates of banana peel compost were characterized by a variety of plant nutrients. These include nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, micronutrients (iron, manganese, zinc, and molybdenum), power of hydrogen, organic carbon, and cat ion exchange capacity, carbon to nitrogen ratio, moisture content, and electrical conductivity. Each of plant nutrients were tested in the soil and banana peel compost rates(10, 20 and 30g), with nitrogen of 0.46, 1.54, 1.93 and 2.58%; phosphorus of 1.51, 5.77, 5.8, and 5.91mg/kg, potassium of 11.82, 41.28, 41.98, and 42.34mg/kg; calcium of 5.55, 25.04, 27.08, and 29.02mg/kg, magnesium of 6.2, 20.48, 23.93mg/kg; and sulfur of 5.79, 13.00, 14.38, and 16.45mg/kg, respectively. Similarly, iron of 9.65, 15.72, 17.85, and 18.16mg/kg; manganese of 1.41, 4.23, 6.38, and 8.91mg/kg; zinc of 1.17, 2.95, 4.25, and 5.60mg/kg; molybdenum of 0.53, 1.21, 3.28, and 5.30mg/kg were tested, respectively. In addition to these, power of hydrogen was 6.34, 6.10, 6.22, and 7.30; organic carbon was 1.31, 15.0, 23.47, and 25.50%; carbon to nitrogen ratio was 2.85, 9.81, 12.16, and 9.88; cat ion exchange capacity was 21.08, 24.21, 34.58, and 36.94 (cmol (+) /kg; moister content was 5.75, 7.24, 8.81, and 9.85%; and electrical conductivity was 0.11, 2.06, 3.23, and 4.09(ds/cm), respectively, for soil and 10, 20, and 30g rates of banana peel compost. The height of the plants, the number of leaves, the leaves area, the leaves area index (LAI), the length of the leaf and the width of the leaves were all parameters of Swiss chard growth performance based. Each of the Swiss Chard growth parameters was measured in 10g, 20g, and 30g treatments, with average plants height of 22.00, 24.67 and 26.33 cm, average leaves number of 9.00, 12.00 and 8.00, average leaves area of 111.33 and 134.30cm² and average leaves width of 8.33, 10.80, and 12.77cm, respectively. Similarly, the mean leaves area index (LAI) was 0.10, 0.30, and 0.5; leaves length was 12.80, 13.00, and 14.67cm, respectively, for 10g, 20g, and 30g treatments. In addition to the Swiss chard growth parameters, the Swiss chard yield parameters have also been measured. Fresh and dry weights were the Swiss chard yield parameters. For each treatment (10g, 20g and 30g), fresh weights 2.44, 2.03 and 3.41g, and dry weights 0.11, 0.08 and 0.14g were recorded, respectively. In conclusion, all the rates of banana peel compost were enhanced and improved Swiss chard growth performance and yield, better than the no compost control.

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1. Introduction

Solid wastes are hazardous materials that can be defined as any refuse or garbage that emanated from different sources such as industries, agriculture, households and commercial activities. Before starting of industrial activities, generating rate of wastes and management activities were negligible. However, now days the basic concern of the global environment is generating rate and management of wastes due to population and consumption growth consequence in increasing the amount of wastes (Birhanu and Berisa, 2015).

Solid waste handling techniques are all including term which defines numerous different processes. It includes the removal of waste, reprocessing of waste material, the treatment and distraction of waste that is, actually destroying, chemically detoxifying or otherwise execution waste permanently harmless and disposing wastes in to environment. As expansion of urbanization increases, the disposition of solid wastes increases and the problem for the societies become serious (Kassie, 2016).

Composting organic desecrate capable to decaying the organic materials into a more compact form for management (Benson, 1993). Compost is made up of various kinds of raw materials such as agricultural Fields wastes and vegetable gardens, animal waste (manure), household food waste, kitchen waste, yard waste (garden and park trimmings), commercial food waste, and industrial wastewater processing sludge (bio-solids).

Composting is a process of allowing decomposition of different solid wastes by using different living organisms such as bacteria, fungi, worms, insects, and other organisms in to a soil for converting huge amounts of organic wastes to compost. Organic compost can be added to soil to increase the availability of primary, secondary and micronutrients for plants, increase soil fertility and increase the porosity of clay soil (Birhanu and Berisa, 2015).

Inappropriate solid waste handling technique and disposal activities causes pollution. Dumping of different types of wastes cause different types of environmental pollution such as air pollution, soil pollution and water such as clogging water drains, creating stagnant water for different organisms such as insects breeding during summer season (Alam and Ahmade, 2013).

Banana peel compost offers the following benefits. These benefits are important organic fertilizer for soil fertility, plant feeding, environmental protection, increasing soil fertility and increasing the growth of microorganisms that accelerate the growth of plants and roots. In addition, the conversion of banana peel into compost contributes significantly to the environment. This is because banana peel attracts a variety of pathogens. These pathogens can cause various diseases in humans (Alam and Ahmade, 2013). Therefore, the study of the use of various types of solid waste, especially banana peel, as compost for agricultural purposes, was very important for the environment and human health. It will also provide guidance for future research and extension programs that will benefit the local community.

2. Data analysis

Field and laboratory data were subjected to one-way analysis of variance (ANOVA) using general linear model (GLM) of the SAS statistical package version 9.0. This software also used to determine the existence of statistical mean difference among the treatment.

3. Research methodology

3.1. Description of the study area

Shirka district is part of the Arsi Zone of Oromia Region. Rainfall is evenly distributed throughout most parts of the district, with annual rainfall ranging from 800 to 2000 mm. Annual temperatures range from 23 to 25 degree Celsius (°C). It is bordered by the Wabe Shebele River, Bekoji, Digelu and Tijo, Tena and Ars Robe districts. Geographically, it is located 273km south-east of Addis Ababa. The altitude of this district is 350–1350m above sea level, with a latitude of 7° 36' 51.43" in the north and a latitude of 39° 29' 34.62 " in the east (see Figure 1).

3.2. Experimental materials

Meters, shovels, sacks, sample packs, plastic bins, auger, polyethylene bags, electronic weight scales, oven-dry and banana peel was used for the study. Based on seed availability and the ripening season, one Swiss chard variety was selected for the study.

3.3. Compost preparation procedure

Composting was carried out using three different sizes of plastic bins (15, 20 and 25 l). The Banana peel and its leaves were the basic raw materials for composting process. The peel was collected from restaurants, households and fruit marketing areas of Shirka district. The banana leaves was collected from farmlands. Compost was prepared followed the steps outlined by Memon et al. (2012). Before being added to the container, the banana peel and its leaves were dried for up to 60% at room temperature for 3 weeks, cut into 1–2 inches pieces and placed in three separate composting bins.

Watering was carried out regularly to prevent dehydration, and the container was covered by its coverage to prevent excessive evaporation or extreme weather conditions. Manual mixing was performed every 21 days (three weeks) to distribute the un-decomposed materials uniformly and aerate the system (Ethiopian Institute of Agricultural Research center (ETARC, 2009). Mixing was generally performed 4 times in time to reach ready-made compost (ETARC, 2009).

Organic carbon (14%), nitrogen (1.49%), carbon and nitrogen ratio (9.4), hydrogen (5.2), phosphorus (4.65mg/kg) and potassium (34mg/kg) were analyzed for banana leaves prior to composting. Matured banana peel compost was also analyzed for the same plant nutrients after its maturity period (84 days). This composting process was supported by Kalemelewa et al. (2012), who analyzed the essential plant nutrients prior to composting and after maturity period of compost.

The composting process was observed and evaluated up to 84 days or until the compost was judged mature. Compost maturity was assessed based on the compost odor and color. Therefore, good odor and dark brown color compost was an-aerobically produced. This compost color was approved by Bowden et al. (2010), who stated the matured compost was dark brown in color.

Compost temperature and oxygen evolution were not monitored while the mean ambient daily temperature during the composting process ranged from 23–24°C to 24–25°C minimum and maximum, respectively. In general, banana peel alone was used to produce banana peel compost. Its efficiency had been successfully tested on Swiss chard growth performance and yield. This was supported by Memon et al. (2012) and ElNour et al. (2015), who confirmed that banana peel alone, can be used to produce banana compost (see Figure 2).

3.4. Experimental design

The experiment took place on 1.42m² (1.35m (L) by 1.05m(W) of land at the Kulumsa Agricultural Research Center. The pot experiment was designed in a randomized complete block with four treatments and three replications per treatment (Grant, 2010). The blocks were 25 cm apart, and the pots were 15 cm apart. A surface soil (0–15 cm depth) contained 14% of sand, 15% of silt and 71% of clay was collected, air dried, sieved through 5 mm sieve, 5 kg of soil was placed in each of the 12 pots. Each pot also received 10g, 20g, and 30g rates of banana peel compost. The treatments were 0 (control), 10, 20 and 30 g rates of banana peel compost. Swiss chard seeds were sown in 628cm² of pots at 1.5cm depth, with 2 seeds, 7cm apart in each pot. The swish chard plants were grown for 8 weeks at a 12h day and a 12-h night regime, with day
temperature of 24 °C and night temperature of 18 °C. The plants were watered once every 24 h (see Figure 3).

3.5. Data collection and procedure

3.5.1. Sampling and chemical analysis

Soil samples were taken using auger. Composited Samples of matured banana peel compost (10g, 20g, and 30g) were taken by mixing the compost thoroughly in three different composting bins. Nitrogen, phosphorus, potassium, calcium, magnesium, iron, manganese, zinc, molybdenum, power of hydrogen, organic carbon, cat ion exchange capacity, moisture content and electrical conductivity were analyzed for raw feed stock prior to composting and matured compost after maturity period of composting (after 84 days). These all properties were analyzed at the horticulture private limited company soil and water analysis laboratory. Nitrogen was expressed in the Kjeldahl digestion method (Bremner, 1960), and phosphorus was expressed in the Olsen method (Pawar and Shah, 2009). Potassium was measured by a flame photometer, and calcium and magnesium were measured by a titration method (Pawar and Shah, 2009). Power of hydrogen was measured at the
in an oven at 60 degree Celsius (placing the used plants for fresh weight in an envelope and drying them with an electronic weight scale. Dry plant weight was obtained by \( \text{Max.LA/occupied plant surface area} \). Fresh plant weight was determined using the formula of Pearcy and Hindle (1989). LAI was determined using the formula of Pearcy and Hindle (1989). LAI = \( \frac{\text{Max.LA/occupied plant surface area}}{\text{Leaf Area (LA)}} \). Leaf Index (LAI), Leaf Number (LN), Plant Height (PH), Leaf Fresh Weight (FW) and Dry Weight (DW) were measured separately for each treatment. The length of the leaves (cm) was measured from the lower end to the top of the leaves, and the width (cm) of the leaves was measured along the widest part of the leaves by using meters.

The number of leaves of the plants was counted in accordance with the observation. The plant height in cm was measured by meter from ground level (leaf base) to the highest point or the tip of the leaves. The LA was determined using the formula of Pearcy and Hindle (1989). LAI = \( \frac{\text{Max.LA/occupied plant surface area}}{\text{Leaf Area (LA)}} \). Leaf Index (LAI), Leaf Number (LN), Plant Height (PH), Leaf Fresh Weight (FW) and Dry Weight (DW) were measured separately for each treatment. The length of the leaves (cm) was measured from the lower end to the top of the leaves, and the width (cm) of the leaves was measured along the widest part of the leaves by using meters.

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recorded for 30g rate of banana peel compost (Table 3). This pH range was in the optimum range for growing media as mentioned by Bunt (1988) who stated that the optimal range is from 5.2 to 7.3. Organic carbon was ranged from 15.01 to 23.50%. The lowest organic carbon was recorded for 10g rate of banana peel compost, and the highest value was recorded for the highest rate (30g) of banana peel compost (Table 3). This result was agreed with the result of Batjes (1996), as cited in Khater (2015), who found that the optimum value of total organic matter higher than 10%. This is also supported by Premalatha et al. (2019), who defined that Compost add better organic matter level and enhance soil organic matter status. This result also supported by Sharma et al. (2019), who described that using readily available organic wastes compost in agriculture enables recycling essential plant nutrients.

Carbon to ratio was ranged from 9.81 to 12.16. The lowest value was recorded for 10g rate of banana peel compost, and the highest value was recorded for 20g of banana peel compost (Table 3). This result is disagreed with the result obtained by Rosen et al. (1993), who found that the C/N ratio ranged from 15:1 to 20:1 is ideal for ready-to use compost. This result was supported by Gómez-Brandón et al. (2008) and Singh et al. (2009), who stated as the C: N ratio within the range of 10–15 shows a stable, mature material.

The cat-ion exchange capacity was ranged from 24.21 to 36.94 (cmol (+)/kg), the lowest value (24.21 (cmol (+)/kg) of cat-ion exchange capacity was recorded for 10g rate of banana peel compost, and the highest value was recorded for 30 g rate of compost. This result showed that chemical properties of soil can be highly improved by adding of organic compost. This is supported by Giveira (2010), who described that addition of compost improve physicochemical properties of soil. The value of electrical conductivity was ranged from 2.06 to 4.09 (ds/cm). The lowest value was recorded for 10g rate of banana peel compost, and the highest value was recorded for 30 g rate of compost. This EC range is in the optimum range (2.0–4.0) for growing media as mentioned by Hanlon and Bartos (1993).

### 4.2. The effects of banana peel compost rates on Swiss chard growth performance

The mean values of leaf length, leaf width, leaf area, leaf area index, plant height and number of leaves were recorded at Table 4. The lowest leaf length (12.80 cm), leaf width (8.33 cm), leaf area (108.33 cm), leaf area index (0.10) and plant height (22.00 cm) were recorded at 10 g of banana peel compost, and the highest leaf length (14.67 cm), leaf width (12.77 cm), leaf area (134.30 cm), leaf area index (0.30) and plant height (24.67 cm) were recorded at 30 g of banana peel compost (Table 4).

This result showed that organic waste compost can stimulate plant growth. This could be supported by Giveira (2010), who stated that organic waste compost stimulate plant growth. All the rates of compost treatments were better than the no compost control with respect to all growth parameters. This indicated that application of organic compost affects Swiss chard growth performance. This result was confirmed with the result of Imthiyas and Seran (2014)).

### 4.3. The effects of banana peels compost rates on Swiss Chard yield

Table 5. The Effects of Banana peels compost rates on Swiss Chard Yield.

| Treatments | Leaf Weight (FW) | Dry Weight (DW) |
|------------|-----------------|-----------------|
| T0         | 1.07            | 0.05            |
| T1         | 2.44            | 0.11            |
| T2         | 2.03            | 0.08            |
| T3         | 3.41            | 0.14            |

Average values of plant fresh weight and dry weight are recorded in Table 5. Application of banana peel compost showed increment of dry weight. The lowest fresh weight (2.44g) and dry weight (0.11g) were recorded for 10 g of banana peel compost, and the highest value was recorded at 30g rate of banana peel compost. This result showed that organic waste compost increased crop yields. This is supported by Hossein et al. (2017), who defined that organic compost improve physical and chemical properties of soil, stimulate plant growth and increase the crops yield.

Organic wastes compost can influence soil characteristics and stimulate the growth and development of plants and improve agricultural productivity (Hossain et al., 2017). All the rates of compost treatments were better than the no compost control with respect to plant fresh and dry weight. This result was supported by Afriyie and Amoabeng (2017), who stated that all the levels of compost produced plant weights that were significantly (P=0.05) better than the no compost Control.

### 5. Conclusion

Municipal solid wastes are one of the major sources of pollution in urban areas. In this study, it was found that banana peel compost contains nutrients and affects the growth of Swiss chard. The highest nitrogen, available phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, zinc, molybdenum, organic carbon, cat-ion exchange capacity, moisture content and electrical conductivity were recorded for 30g of banana peel compost, and the lowest value was recorded for 10g of banana peel compost. The treatment of Swiss chard using 30g application of banana peel compost significantly improved leaf length, leaf width, plant height, leaf area, and other agronomic parameters as compared to the 10g application of banana peel compost. This indicated that higher amount of banana peel compost was highly improves Swiss chard growth performance and yield. In other way, all rates of compost brought better...
performance on Swiss chard growth and yield than control group (no-compost).

**Declarations**

**Author contribution statement**

Zawde Tadesse Teshome: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

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**Data availability statement**

Data associated with this study has been deposited at Zawde Tadesse.

**Declaration of interest’s statement**

The authors declare no conflict of interest.

**Additional information**

No additional information is available for this paper.

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