



Amelioration of Soil Fertility by the Application of Different Fruit Waste Composts

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The soil health status of Bangladesh decreased day by day, particularly organic matter and major nutrient content. The organic matter content in most of the agricultural soil in Bangladesh is <2%, which indicates poor soil health condition. In Bangladesh, almost every day, an enormous amount of waste material is produced from different kinds of seasonal and unseasonal fruit's peels. Lack of proper recycling methods, most of these wastes are thrown away in drains, canals, rivers, etc. which indicates a major threat to environmental safety. Composts derived from the wastes of different fruit's peels can be an excellent source of organic matter and essential nutrients for soil health improvement. Therefore, the present study was carried out to evaluate the changes in physicochemical properties and nutrient contents of experimental soil treated with compost

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prepared from different types of fruit's waste. The compost was prepared accordingly using different types of fruits waste and then the collected compost was thoroughly mixed with the soil and kept for six months. The experimental treatment consisted of three organic composts (jackfruit peel compost, mango peel compost, and banana peel compost) and three rates of application (1000, 1500, and 2000 kg ha⁻¹). The experiment was arranged in a factorial completely randomized design and replicated thrice. The analyzed data showed that, the physicochemical properties and nutrient contents of experimental soil varied significantly with the use of different types of fruit's wastes compared to no waste added soil, except in the case of particle size. Soil mixed with mango peel compost at a rate of 2000 kg ha⁻¹ resulted in a higher available N content (2520 mg kg⁻¹) and available P content (42.56 mg kg⁻¹), whereas the available K content (219.88 mg kg⁻¹), EC (1.55 dS m⁻¹) and CEC (1209.56 meq 100g⁻¹) were found higher in soil treated with banana peel compost of 2000 kg ha⁻¹. On the other hand, soil treated with jackfruit peel compost of 1500 kg ha⁻¹ showed the higher available Ca content (1533.33 mg kg⁻¹) and the jackfruit peel compost of 2000 kg ha⁻¹ resulted in the higher organic carbon (1.98%) and organic matter (3.41%). The findings of this experiment revealed that, compost prepared from different types of fruit peels can be an excellent source of organic matter and nutrients and among the tested composts, mango peel compost was better to improve the physiochemical properties of soil and supply sufficient nutrients for plant growth.

Keywords: Fruit waste; compost; physico-chemical properties; soil fertility; soil health.

1. INTRODUCTION

Fruits play a unique role both in the social and economic spheres for nutritional status and improving income. Globally, Bangladesh is an important producer of both temporary and permanent fruits. In the 2020-21 growing season, the total area covered by fruits was 362.8 thousand hectares, with a total production of 53.34 lakh metric tons [1]. Fruits are important sources of antioxidants, vitamins, beta-carotene, iron, zinc, copper, and manganese. Mango, jackfruit, and banana are the major fruits produced in Bangladesh. According to FAO, the growth in the production of fruit from 2010-2019 is 25%, and the current yield is 10.4 t ha⁻¹.

There is abundant production of fruit waste during the processing of raw agricultural products into finished products. Globally, on average, 30–40% of total food is wasted, considering production, transportation, and consumption [2,3]. Different industries related to the agricultural sector generate a lot of waste in the form of peels, seeds, whey, waste liquid, molasses, bagasse, and so on [4]. With the arrival of seasonal fruits in the market, the amount of garbage on the roads also increases. The fruit traders in different areas of the capital leave all the waste fruits and leftover fruits, along with the leaves used to decorate the fruit baskets and branches, on the road. As a result, day after day, garbage is seen lying on the road. About 70 to 80% of jackfruit consists of waste and by-products. There were around 3.5 million tons of

banana peel waste generated per year by the food industry around the world [5]. The fruit wastes are dumped on the adjacent canals, drains, rivers, lowlands, and farming lands [6]. These are usually treated by direct landfilling, burning, and composting, which have become increasingly unfeasible for environmental issues such as methane (CH₄) and carbon dioxide (CO₂) emissions [7,8].

Fruit waste has been identified as a critical bio-waste source in populous human communities and is considered a great challenge to urban waste management [9,8]. The unsystematic disposal of peels imposes a serious burden on the environment. The environment is losing its serenity. The main elements of survival are soil, water, and air, which are polluted. The generated fruit wastes are not only biodegradable but also rich in nutrient components such as carbohydrate, protein, and vitamins, depending on the sources. However, proper utilization of these fruit wastes not only increases the economic value but also reduces the cost of disposal. Recycling is one of the most important means of converting fruit waste components into a number of new products, such as organic fertilizer. Recovery of beneficial bioactive compounds from fruit and vegetable wastes is a new research trend [10,11].

Organic fertilizer or manure can release essential nutrients in the soil to plants [12]. The fertility of the soil is maintained by the presence of organic matter in the soil [13]. The compost is a good

source of organic fertilizer, and it contains essential nutrients and organic matter. Organic matter increases yield, reduces production costs, improves crop growth and the economy, increases water-holding capacity, and improves the soil structure. In Bangladesh, available reports indicate that most soils have low organic matter content. A good soil should have at least 2.5% organic matter but in Bangladesh, most soils have less than 1.5%, and some soils have even less than 1% organic matter [14]. Composts from the peels of jackfruits, mangoes and bananas can be used as organic fertilizer for crop production. Their use can enhance soil health by supplying necessary plant nutrients, and organic matter and improving physical properties. In addition, utilization of these waste materials also reduces the waste load and minimizes the use of costly and harmful chemical fertilizers [15].

2. METHODS AND MATERIALS

2.1 Experimental Site

The experiment was conducted in the experimental field of Soil, Water and Environment Discipline, Khulna University Campus, Khulna from March 2021 to September 2021. The experimental site was easily accessible to water sources with proper sunlight.

2.2 Collection of Soil Samples and Preparation of Pots

The required soil was collected from the field of Khulna University campus, air-dried and sieved. 30 pots were collected for the experiment. 3.5 kg of collected soil samples were kept in each pot. The collected soil for pot preparation was clayey in nature.

2.3 Composts Preparation and Application in Pots

Peels of three fruit namely jackfruit, mango, and banana were selected for the experiment. For preparing compost, the peels of these fruits were kept individually beneath the soil for six months. Then the composts made from three different wastes were applied at 1000, 1500, and 200 kg ha⁻¹ in the respective soil sample and incorporated thoroughly with the soil. Afterwards, the pot was filled with the prepared soil as per the treatment and kept for six months. Three pots were used as a control where no compost was added.

2.4 Experimental Design and Treatments

The experiment was organized in a completely randomized design (CRD). Nine treatments and one control treatment with three replications were conducted. The experimental treatment consisted of three types of organic composts (jackfruit peel compost, mango peel compost, and banana peel compost) and three rates of compost (1000, 1500, and 2000 kg ha⁻¹).

2.5 Sampling and Analysis of Physicochemical Properties

After 6 months of applying compost, soil samples were collected by the proper method from each pot for laboratory analysis. The collected soil samples were then air dried by spreading them on a separate sheet of paper. After drying in the air, the larger aggregates were broken gently with the help of a wooden hammer. The crusted soil samples were then sieved through a 2.0 mm sieve and stored in a plastic box for laboratory analysis. The particle size of soil samples was determined by the hydrometer method [16]. Organic carbon in the soil samples was determined by the wet oxidation method [17] and organic matter was calculated by multiplying the percent value of organic carbon with the conventional van-Bemmelene's factor of 1.724 [18]. The pH of soil samples was determined by a glass electrode pH meter [19] at a soil: water ratio of 1:5 [20] and the electrical conductivity was measured at a soil: water ratio of 1:5 with the help of EC meter [21]. The CEC was determined by the flame photometric method. The available nitrogen (N) was determined by the Kjeldahl's method following H₂SO₄ acid digestion [19]. Available phosphorous (P) was extracted from the soil samples with 0.5 M NaHCO₃ Olsen's Method [22] at pH 8.5, followed by the spectrophotometric method. Available potassium (K) was determined from NH₄OAc (pH, 7.0) extract [23] followed by the flame photometric method. Available magnesium (Mg) was determined by the titrimetric method [19].

2.6 Statistical Analysis

All the data collected from laboratory analysis were presented in tabular form and statistically analyzed by using analysis of variance (two-way ANOVA) with the support of the statistical package Minitab. Means of all treatments were compared with the help of the Duncan Multiple Range Test (DMRT) (Gomez and Gomez 1984) at a 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Effect on Physical Properties of Soil

Data obtained from the analysis of variance showed that the percentage of sand, silt, and clay in treated soil varied significantly with different fruit peel compost, rate of application, and their interaction yet the textural class was clay type for all the cases (Table 1). Among the compost types, soil treated with banana peels had the highest sand and silt percentage, while the lowest was found in the no compost added treatment. Application of compost @ 2000 kg ha⁻¹ resulted the highest percentages of sand and silt. In the interaction of compost types and rate of application, banana peels compost with 2000 kg ha⁻¹ provided the highest sand and silt percentages, which was statistically at par to mango peels compost with 2000 kg ha⁻¹ and

banana peels compost with 1500 kg ha⁻¹ while the lowest sand and silt percentage was measured from no compost added treatment. The highest clay percentage was found from no compost added soil which was on similarity with jackfruit peels compost applied @ 1000 kg ha⁻¹ while the lowest clay percentage was measured from banana peels compost at 2000 kg ha⁻¹. There was an increasing pattern of sand and silt particle percentage with the higher rate of compost application as compared to the control treatment (no compost added), but clay particle percentage steadily declined with the increasing rate of compost. An increasing percentage of sand and silt with a decreasing of clay percentage indicates that the treated soil has been improving. Texture of a soil is very slowly changeable or unchangeable [24,25,26]. Billah [27] also found a similar result by applying green manure crops to the soil of Bajoa Soil Series.

Table 1. Effect of compost types, rate and their interaction on particle size of soil

Compost	Rate (kg/ha)	Sand (%)	Silt (%)	Clay (%)	Textural class
No compost added		6.69d	30.27d	63.04a	
Jackfruit peel	1000	7.18c	30.65d	62.17ab	
	1500	8.31b	31.85cd	59.84bc	
	2000	8.91b	32.21c	58.88b	
Mango peel	1000	9.47bc	37.51b	53.02c	Clay
	1500	9.60bc	37.57b	52.83c	
	2000	10.73ab	38.34ab	50.93d	
Banana peel	1000	9.83bc	37.85bc	52.32c	
	1500	10.23a-c	38.57ab	51.20cd	
	2000	11.24a	39.19a	49.57e	
Effect					
Compost type (CT)		**	*	*	
Compost rate (CR)		**	**	**	
CT * CR		**	*	*	
CV (%)		2.64	7.73	5.79	

Here, CV indicates co-efficient of variation and ***, **, and * indicates significant at 0.01%, 1%, 5% level respectively

Table 2. Effect of compost types, rate of application and their interaction on chemical properties of soil

Compost	Rate (kg ha ⁻¹)	pH	EC (dS m ⁻¹)	CEC (meq/100g)	OM (%)
No compost added		6.70	1.09	933.30	1.80
Jackfruit peel	1000	6.20	1.21	955.70	2.79
	1500	6.10	1.35	1067.70	3.07
	2000	6.07	1.37	1187.16	3.41
	1000	6.17	1.21	948.23	2.89
Mango peel	1500	6.14	1.24	1067.70	2.99
	2000	6.10	1.31	1187.16	3.26
	1000	6.07	1.41	948.23	2.74
Banana peel	1500	6.07	1.46	1060.23	3.02
	2000	6.00	1.55	1209.56	3.15
	Effect				
Compost type (CT)		ns	*	ns	Ns
Compost rate (CR)		*	*	*	*
CT × CR		ns	ns	ns	Ns
CV (%)		0.91	11.46	4.67	7.78

Here, CV and ns indicates co-efficient of variation and non-significant; ***, **, and * indicates significant at 0.01%, 1%, 5% level respectively

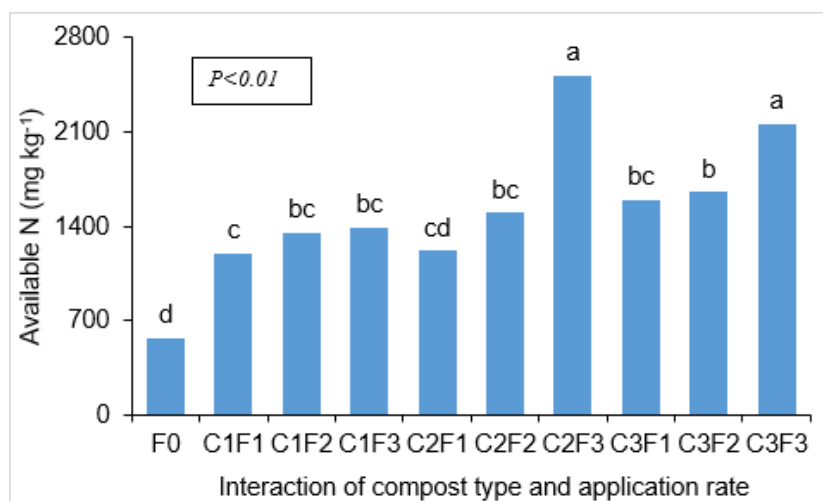


Fig. 1. Interaction effect of compost type and rate of application on available nitrogen content in soil

Here, C₁= jackfruits peels compost, C₂= mango peels compost and C₃= banana peels compost; F₀= no compost added, F₁= 1000 kg ha⁻¹, F₂= 1500 kg ha⁻¹ and F₃= 2000 kg ha⁻¹

3.2 Effect on Chemical Properties of Soil

Soil pH, electrical conductivity (EC), cation exchange capacity (CEC) and organic matter content varied significantly with the rate of compost application, but compost types and the interaction of compost types and rate of application were not significant (Table 2). The highest soil pH was measured from the control treatment (no compost added), while the lowest was measured from the application of 2000 kg ha⁻¹. The soil pH slightly declined with the increased rate of compost application. EC, CEC and organic matter content of the soil gradually increased with the higher rate of compost application. Application of compost @ 2000 kg ha⁻¹ resulted in higher EC, CEC and organic matter content, while the lowest was noticed from no compost added treatment. The results are in accordance with the findings of Billah et al. [13] and Akter [28] who reported that compost types and rates of application had negligible effects on soil pH, yet the addition of composts to soil helps to acidify the soil because of microbial activities.

3.3 Effect on the Macro Nutrient Content

The presence of an adequate amount of nutrients in the soil helps to grow healthy crops. The nutrients must be present in their available form so that plants can easily uptake for their growth. Compost from various fruit peels can help to enhance essential nutrients in the soil. Type of compost, rate of application, and their interaction had substantial influence on the

available N content of the soil. Among the compost types, banana peel compost resulted the highest N content which was on parity with mango peels compost whereas the lowest was measured from jackfruit peels compost. There was an increasing trend in N content with the higher rate of compost application. The available N content was higher in the interaction of mango peel compost with the application @ 2000 kg ha⁻¹ which was statistically identical to banana peel compost with a 2000 kg ha⁻¹ application rate, while the lowest was found in the control treatment (no compost added).

The available P content of soil was affected significantly by the types of compost, rates of application, and their interaction (Fig. 2). Among the compost types, significantly highest P content was noticed in mango peel compost, while the lowest was found in banana peel compost. Application of compost @ 2000 kg ha⁻¹ resulted the higher P content while the lowest was recorded from the no compost added treatment. Due to the interaction effect of compost type and rate of application, the highest available P content was measured from mango peel compost with 2000 kg ha⁻¹. Organic matter plays a major role in P availability in soils. Organic matter is a direct source of available P in soils through the mineralization of dead organic matter and through the release from microbial biomass [29]. Billah et al. [13] found a similar result on the assessment of the physical and physicochemical properties of soil by the application of green manure crops to the Bajoa Soil Series.

The available K content was changed due to the application of different compost types and rates of application, but their interaction had no significant effect (Fig. 3). The highest P content was found in banana peel compost over mango and jackfruit peel compost. In terms of rate of application, 2000 kg ha⁻¹ resulted the higher P content, while the lower was observed in no compost added treatment.

interaction was not significant (Fig. 4). The highest Mg content was observed in jackfruit peel compost, and the lowest was recorded from mango peel compost. Mg content gradually declined with the enhanced rate of compost application. Incorporation of different fruit waste composts showed a reduction of Mg in comparison with reference soil (no compost added). The reduction of Mg can be caused by the replacement of other nutrients. The results are in accordance with the findings of Paul [24] and Akter [28].

Compost type and rate of application significantly influenced the Mg content of the soil, yet their

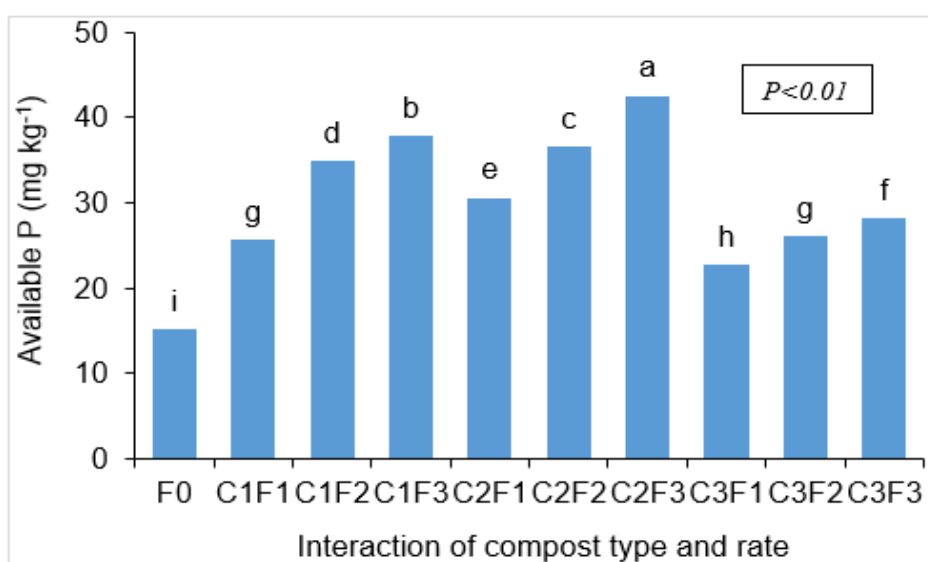


Fig. 2. Interaction effect of compost type and rate of application on available phosphorous content in soil

Here, C₁= jackfruits peels compost, C₂= mango peels compost and C₃= banana peels compost; F₀= no compost added, F₁= 1000 kg ha⁻¹, F₂= 1500 kg ha⁻¹ and F₃= 2000 kg ha⁻¹

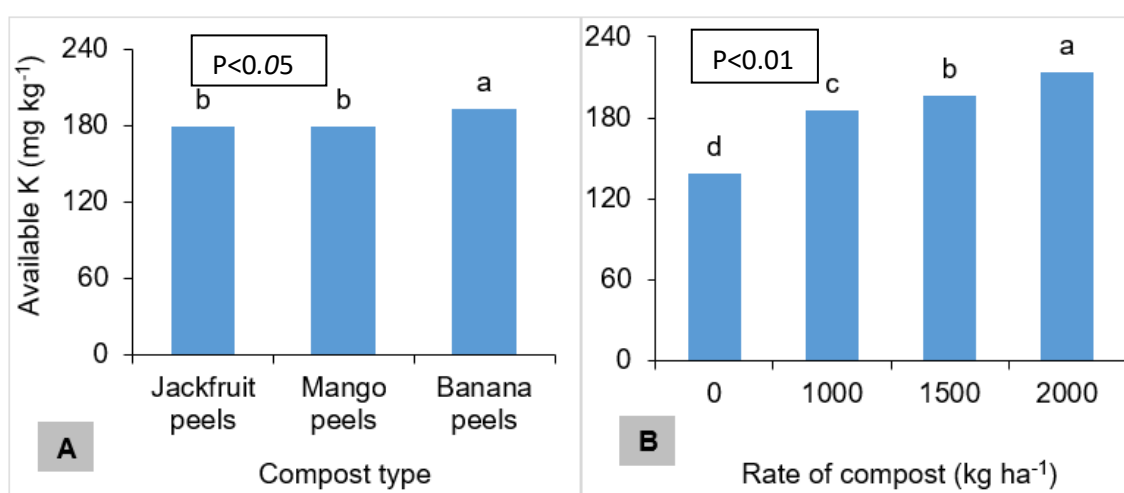


Fig. 3. Effect of compost type (A) and rate of application (B) on available potassium content in soil

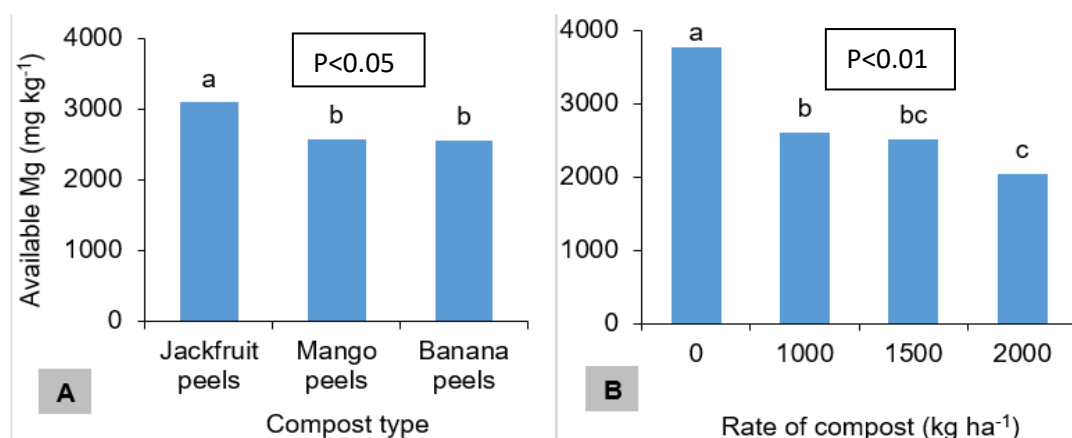


Fig. 4. Effect of compost type (A) and rate of application (B) on available magnesium content in soil

4. CONCLUSION

Compost type and rate of application had substantial influence on the physico-chemical properties of the soil and amended its health. Banana peel compost improved the physical properties and K content mango peel compost enhanced the chemical N and P content, while Mg content was enriched with jackfruit peel compost. Application with higher rate (2000 kg ha⁻¹) augmented the physical and chemical properties of the soil except for Mg, which was reduced with a higher rate of compost application. From the findings of this study, it can be suggested that the application of mango peel compost could be an efficient way of improving soil health. In addition, the proper use of fruit wastes, such as compost, may reduce the waste load on the environment and maintain environmental safety.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that no generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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