Research Article

Efficacy of Prepared Composts on Onion Productivity and Quality

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Abstract | Composting is a natural process of decomposing organic wastes into valued fertilizer that enriches plants and soil. The present research was undertaken to prepare composts utilizing organic wastes and to testify their impacts on onion cultivation. Three dissimilar composts with variable recipes viz. banana plants + poultry manure (Compost 1), banana plants + goat manure (Compost 2) and banana plants + cattle manure (Compost 3) in 3:1 ratio were prepared in cemented pits. The prepared composts were sampled and analyzed for selected parameters. Afterwards, a field experiment was executed to study the effect of prepared composts and their integration with inorganic fertilizer on growth and yield of onion (*Allium cepa* L.). The treatments were: T_1=Control (No NPK and/or Compost), T_2=Recommended NPK (120-60-60 kg ha^{-1}), T_3=Compost 1 (15 tons ha^{-1}), T_4=Compost 2 (15 tons ha^{-1}), T_5 Compost 3 (15 tons ha^{-1}), T_6=Compost 1 (10 tons ha^{-1}) +1/2 NPK, T_7=Compost 2 (10 tons ha^{-1}) +1/2 NPK, and T_8 Compost 3 (10 tons ha^{-1})+1/2 NPK. Results showed that in various composts, the ranges of different parameters were EC: 2.50 to 3.34 dS m^{-1}, pH: 7.9 to 8.4, total C: 13.34 to 32.48%, total N: 0.64 to 1.86%, total P: 1.36 to 1.46%, total K: 1.45 to 3.05%, C:N ratio: 16.85 to 22.20, C:P ratio: 10.39 to 23.56 and C:K ratio: 14.64 to 17.66. All these values were inside the satisfactory limits of a matured compost. In the field trial, the plants treated with T_6 (Compost 1 (10 tons ha^{-1}) +1/2 NPK) significantly improved the growth and yield attributes of onion crop than all other treatments. Compost or NPK application either in integration or alone boosted the NPK levels in onion leaves with respect to control treatment. The upmost content of N (0.91 %), P (0.91 %) and K (2.80 %) were recorded from T_8, T_2, and T_7 respectively. We suggest that an integration of compost with inorganic fertilizer is a better choice for improved growth, yield and quality of onion crop.

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Introduction

Agricultural wastes have been a major source of pollution in recent years, and the challenges posed by them are receiving attention worldwide (Abdel-Shafy and Mansour, 2018). Agriculture sector generates a considerable number of wastes in the form of crop straw and animal manures which

are usually subjected to open dumping at landfills or uncontrolled incineration (Sadh *et al*., 2018). This improper disposition of agricultural wastes not only result in environmental pollution, but also waste a lot of valuable biomass resources (Pan *et al*., 2021). If tackled properly these wastes are full of resources which can be utilized in variety of agricultural operations. Therefore, the effective transformation of agricultural waste recycling and utilization is important.

Composting has emerged as the preferred method of treating agricultural wastes to generate a final sterilized product that can be utilized as an organic amendment (Sayara *et al*., 2020). Composting is a flexible approach for transforming biodegradable materials into soil amendments (Erana *et al*., 2019). Upsurge in conversion organic wastes into compost, that could improve soil fertility and health, as well as crop production, is being encouraged by rising inorganic fertilizer prices and their negative implications on agriculture sustainability (Kandil *et al*., 2020). Composting promotes organic matter content, water retention capacity, soil aggregation, nutrient availability, biomass production, microbial activity, and lessens soil bulk density and plant diseases, all of which contribute to agricultural sustainability (Bhatti *et al*., 2021). Consequently, adopting composting strategy for recycling agricultural wastes is vital for crop husbandry.

Onion plant (*Allium cepa* L.) possesses significant economic importance and is the most important vegetable crop across the world (Mishra *et al*., 2013; Gererufael *et al*., 2020). It is widely used as condiment either as mature bulb or as green leaves in salad and also for preparation of many different dishes (Khan *et al*., 2011). Onion are rich source of minerals, nutrients, vitamins, quercetin, and flavonoids along with significant water content (Kazimierczak *et al*., 2021). During 2020-21, world onion production was about 99,968,016 tons (FAO STAT, 2021). Pakistan produced 2,058.2 thousand tons from 146.1 thousand hectares under onion cultivation (Pakistan Economic Survey, 2019-20). Before planting, onions are known to require a significant amount of fertilizers (particularly nitrogen). The amount of fertilizer used and how it is applied have previously been demonstrated to alter onion yields and nutritional content (Bettoni *et al*., 2016). In recent times the non-availability and price hike of chemical fertilizers have drastically affected the production of onion in the country. Therefore, the farmers have been looking for the alternatives to the chemical fertilizers and they have opted the composts for sustaining onion production.

Despite many known benefits of compost for soil and crop, little work has been done in Pakistan on compost preparation and analysis (Iqbal *et al*., 2007; Nasreen and Qazi, 2012; Irshad *et al*., 2013). In Pakistan, approximately 47920 tons of organic waste is generated on daily basis, and this waste is not handled properly (Iqbal *et al*., 2007). Hence this study aimed to enhance the importance of recycling organic waste that has been generated in tones via composting. Banana residues were selected for this study because its large quantity is dumped near the fields, roadsides, and landfills despite its richness in nutrients and carbon content (Zhang *et al*., 2013; El Nour *et al*., 2015). Similarly, animal wastes (cattle and poultry) contain a significant amount of plant nutrients NPK, their application in soil improves soil physico-chemical properties (Hussain *et al*., 2000; Boateng *et al*., 2006). The prepared composts were used with and without inorganic fertilizers to determine their influences on organic and inorganic fertilizers on the vegetative growth and bulb yield of onion.

Materials and Methods

Preparation of compost

The composts were prepared in cemented pits (1.1 m long and wide, and 1.3 m deep) at the Department of Soil Science, Sindh Agriculture University (SAU) Tandojam during May to November 2018. Banana plant residues and animal manures were filled in the pit in 3:1 ratio. First, a layer of chopped banana residues (leaves and trunk) was laid, while cattle and poultry manure were put on top of banana residues in separate pits. This pattern remained continued until the pit became full. Each pit was turned after 15 days interval and temperature of the composting material was monitored at each turning and the material was moistened as per requirement. The turning process continued for four months, followed by one month for stabilization. After five months, when the compost maturity indicators (color of the compost became dark brown, no smell of bad odor and the texture looks like soil appeared, Alfadlli *et al*., 2018), compost samples were collected for analysis from each pit by following the methods suggested by Manna *et al*. (2012).

Compost analysis

The prepared composts were air dried in the laboratory followed by sieving with 2 mm stainless steel sieve. The values for EC and pH were determined in 1:5 compost: water extract using EC and pH meters (Tandon *et al.*, 2005). For the determination of total carbon % the proposed method of Qureshi *et al.* (2014) was adopted.

$$\text{Total C \%} = \frac{\text{Total organic matter}}{1.724}$$

Total nitrogen in compost was analyzed by Kjeldahl method (Bremmer, 1965). Total phosphorus was determined using spectrophotometer by adopting vanadate-molybdate phosphoric acid technique as suggested by Manna *et al.* (2012). The analysis of K was performed by following the ammonium acetate K extraction method of Estefan *et al.* (2013). The carbon nitrogen ratio in compost samples was calculated by dividing the values of total carbon (%) with nitrogen (%) and carbon phosphorus ratio in compost samples was calculated by dividing the values of total carbon (%) with phosphorus (%) (Goyal *et al.*, 2005).

Experimental site and design

The present research was undertaken at an experimental site in southern Pakistan (lat. 25°25'28" N, long. 68°32'6"E, elev. 26 m AMSL) belonging to the Department of Soil Science, Sindh Agriculture University, Tandojam, from January to April 2019. The experiment was conducted in large, cemented pots which were filled with 60 kg arable soil collected from the experimental area. The experimental soil was Haplic Yermosol (FAO, 2006) loamy in texture (43.5% sand, 44% slit and 12.5% clay), slightly alkaline (pH: 7.9. non saline (EC: 0.68 dS m^{-1}) and having organic matter (0.94%), lime content (7.5%), N (0.88), P (1.48 mg kg^{-1}) and extractable K (150 mg kg^{-1}). The experiment was laid out in randomized complete block design where each treatment was replicated for 4 times.

Nursery transplanting and crop management

Three weeks old seedlings of Onion (cv. Local Sindhi) were obtained from a local grower based at Halani city district Naushero Feroz, Sindh Pakistan. The seedlings were transplanted in pots during the month of January 2019. All the management practices including weeding were practiced as recommended. Irrigation was provided as per crop need.

Treatment plan

The tested treatments were T_1= Control (No NPK and Compost), T_2= Recommended NPK (120 N-60 P_2O_5-60 K_2O kg ha^{-1}), T_3= Compost 1 (Banana plant leaves + Poultry manure 15 tons ha^{-1}); T_4= Compost 2 (Banana plant leaves + Goat manure 15-ton ha^{-1}); T_5= Compost 3 (Banana plant leaves + Cattle manure 15 t ha^{-1}); T_6= 10-ton compost 1 + 1/2 NPK; T_7= 10-ton compost 2 + 1/2 NPK; T_8= 10-ton compost 3 + 1/2 NPK. The nitrogen was supplied via urea, phosphorus via SSP and K via SOP. Full dose of composts, P and K were mixed with soil during pot filling. Nitrogen was added in 3 splits during transplanting, one and two months after transplanting.

Agronomic observations

The onion plants were harvested during the 1st week of April 2019. Five plants were selected from each replication and data related to plant height (cm), bulb size (cm), bulb fresh weight (g), and bulb yield (g) was recorded.

Nutrient analysis

The leaves of selected plants were utilized for the determination of nitrogen, phosphorus, and potassium concentrations. Nitrogen was analyzed by adopting the Kjeldahl method (Bremmer, 1965). The concentrations of P and K in onion leaves were determined by adopting the wet digestion technique as delineated by Estefan *et al.* (2013).

Soil analysis

The experimental soil was examined for a variety of physico-chemical characteristics before the experiment. The EC and pH were determined in 1:2.5 soil water extract using an EC meter (Sartorius PB-11) and pH meter (Schott Lab 960). The protocols outlined by Estefan *et al.* (2013) were employed to determine the texture, organic matter, and lime content. Nitrogen concentration was evaluated by wet oxidation technique, while the determination of phosphorus and potassium concentration in samples was performed by adopting the AB-DTPA method as described by Estefan *et al.* (2013).

Statistical analysis

The gathered data was confined to the analysis of variance (One way ANOVA), using Statistix 8.1 computer software. At 5% probability level, the treatment means were differentiated using Fisher's least significant difference (LSD) test.

Results and Discussions

Chemical properties of compost

The prepared composts varied in their quality with respect to selected chemical parameters i.e., EC, pH, total C, N, P, K, and C:N, C:P, C:K ratios (Tables 1 and 2). The variation in selected quality parameters of prepared composts may be associated mainly to the difference in chemical composition, chemical properties, and elements concentration in selected animal manures (Bernal *et al.*, 2009; Irshad *et al.*, 2013). In prepared compost, the EC values ranged from 2.50 ± 0.07 to 3.34 ± 0.03 dS m^{-1}, which was below the recommended upper limit of EC (4.0 dS m^{-1}), a level tolerable by most plants (Lasaridi *et al.*, 2006; Kalemelawa *et al.*, 2012). The presence of soluble salts in compost is attributed to release of soluble salts during decomposition of organic materials and/or the concentration effect that occurs due to loss of dry mass (Kalemelawa *et al.*, 2012). The values of pH ranged from 7.9 ± 0.08 to 8.4 ± 0.05 in various composts prepared in this study. These values indicate the alkaline nature of the composts. It has been suggested that the alkaline nature of compost occurs during change of mesophilic phase to thermophilic phase where the protons are consumed during decomposition of volatile fatty acids and conversion of organic N compounds to NH_4^+-N occurs (Tognetti *et al.*, 2007). The obtained pH values of this study are within the acceptable limit for organic fertilizers (Lasaridi *et al.*, 2006). The values for total C ranged from 13.34 ± 1.32% to 32.48 ± 1.42% in prepared composts. These values correspond to the minimum acceptable level for an organic waste. According to Indonesian standard for organic fertilizer, mature compost must contain at least 10% organic carbon (Alfadlli *et al.*, 2018). Total N ranged from 0.64 ± 0.08% to 1.86 ± 0.14% in composts prepared from banana residues blended with various animal manures. Alfadlli *et al.* (2018) proposed that mature compost should contain no less than 0.40% N. The high N content in composts may be associated to high level of this nutrient in banana tissues and animal manures (El-Nour *et al.*, 2015). Total P in various prepared composts ranged from 1.36 ± 0.19% to 1.46 ± 0.18%. These values are well above the proposed minimum value for total P in compost i.e., 0.1% P (Alfadlli *et al.*, 2018). The values for total K in various composts ranged from 1.45 ± 0.60% to 3.05 ± 1.09%. These values are much higher than the projected minimum level of K in mature compost, 0.2% K (Alfadlli *et al.*, 2018). A high level of K in prepared composts may be associated to high level of nutrients (especially K) in banana tissues (Kadir *et al.*, 2016). In present study, the values for C:N ratio were 16.85 ± 1.57 to 22.20 ± 0.87 in prepared composts. A compost should contain C:N ratio value of < 25 (Gautam *et al.*, 2010). The C:N ratio values of current study are below this proposed value indicating the maturity of the composts and its subsequent utilization in the field. The values for C:P ratio ranged from 10.39 ± 2.20 to 23.56 ± 2.43 and for C:K ratio the values ranged from 14.64 ± 5.23 to 17.66 ± 8.23 in final composts. Narrow values for these ratios may be associated to the low values of C and high values of P and K in prepared composts.

Growth and yield of Onion

Plant height: The height of onion plants was greatly influenced due to the addition of chemical NPK and compost (Table 3). It was noticed that the sole application of NPK and prepared composts enhanced the height of onion plants, but the effects were more

Table 1: *EC, pH, total carbon %, and total N % of prepared composts.*

Compost	EC (dS m^{-1})	pH	Total C (%)	Total N (%)
Compost 1 (Banana plants + poultry manure)	2.50 ± 0.07 ^{B}	7.9 ± 0.08 ^{B}	13.34 ± 1.32 ^{B}	0.64 ± 0.08 ^{C}
Compost 2 (Banana plants + goat manure)	3.34 ± 0.03 ^{A}	8.4 ± 0.05 ^{A}	30.74 ± 1.59 ^{A}	1.86 ± 0.14 ^{A}
Compost 3 (Banana plants + cattle manure)	2.69 ± 0.05 ^{B}	8.3 ± 0.03 ^{A}	32.48 ± 1.42 ^{A}	1.47 ± 0.04 ^{B}

Each value is mean ± SE (n = 4); Means followed by different letters describe the significant difference among various composts (P < 0.05).

Table 2: *Total P %, total K %, carbon phosphorus ratio and carbon potassium ratio of prepared composts.*

Compost	Total P (%)	Total K (%)	C:P ratio	C:K ratio
Compost 1 (Banana plants + poultry manure)	1.41 ± 0.21	1.45 ± 0.60	10.39 ± 2.20	14.64 ± 5.23
Compost 2 (Banana plants + goat manure)	1.36 ± 0.19	2.50 ± 0.57	23.56 ± 2.43	17.07 ± 6.94
Compost 3 (Banana plants + cattle manure)	1.46 ± 0.18	3.05 ± 1.09	23.26 ± 2.85	17.66 ± 8.23

Each value is mean ± SE (n = 4) Means followed by different letters describe the significant difference among various composts (P < 0.05).

Table 3: *Effect of organic and inorganic amendments on growth and yield attributes of onion.*

Treatments	Plant height (cm)	Bulb size (cm)	Bulb fresh weight (g)	Yield (tons ha^{-1})
$T_{1:}$ Control	34.2 FG	3.0 D	34.1 G	12.1 F
$T_{2:}$ NPK (120-60-60 kg ha^{-1})	41.1 D	4.1 C	44.5 D	16.1 D
$T_{3:}$ Compost 1 (15 tons ha^{-1})	37.2 EF	3.9 C	37.5 F	14.5 E
$T_{4:}$ Compost 2 (15 tons ha^{-1})	36.28 F	3.8 D	38.2 F	14.2 E
$T_{5:}$ Compost 3 (15 tons ha^{-1})	37.8 E	4.1 C	41.1 C	14.5 E
$T_{6:}$ Compost 1 + NPK (10 t + ½ NPK)	50.5 A	5.4 A	49.4 A	20.7 A
$T_{7:}$ Compost 2 + NPK (10 t + ½ NPK)	44.0 C	4.0 C	45.9 C	17.6 C
$T_{8:}$ Compost 3 + NPK (10 t + ½ NPK)	46.9 B	4.6 B	48.3 B	19.5 B

Each value is mean ± SE (n = 4). Values with the same letter within a column are not significantly different at P < 0.05

prominent under integrated supplementation of chemical and organic sources. Among the tested treatments, the maximum increment in height (37%) was observed under the combined application of Compost 1 + ½ NPK. Such increment in plant height under the integrated supplementation can be linked to the adequate release of nutrients especially N from organic and inorganic sources, that might have fostered crop growth (Sahoo *et al.*, 2022). The findings were consistent with those of Amare (2020) and Gererufael *et al.* (2020), who also reported the maximum height of onion plants under the supplementation of organic manures in conjunction with inorganic fertilizer.

Bulb size: The bulb size differed significantly among the tested treatments, whereby the plants subjected to the integrated application of compost 1 and NPK (T6) produced elevated bulb size (5.4 cm), while the minimum (3.4 cm) was observed within the plants of control treatment (Table 3). Over control, the bulb size increased from 27 to 80% due to the addition of composts and inorganic NPK under various combination. The demonstrated increment in bulb size could be attributed to the provision of macronutrients (N, P, and K) and micronutrients (B) via composts and NPK. These nutrients are required for cell growth, timely root development and good water uptake, and promotes bulb size and vegetative growth of onion (Erkalo *et al.*, 2022). These results are in harmony with the findings of Yohannes *et al.* (2017) and Erkalo *et al.* (2022) who also noticed a higher bulb size of onion under the integrated supplementation of organic manures and mineral fertilizers.

Bulb fresh weight (g): All tested treatments significantly enhanced the fresh weight of bulb with respect to control treatment (Table 3). The addition of composts and inorganic NPK under various combinations enhanced fresh weight of onion bulb from 10 to 45% over control treatment. The maximum increment in bulb weight was noticed within the plants that were subjected to the combined application of compost 1 and ½ NPK (T6). The results are in confirmation with the findings of other researchers who also noticed a significant increment in fresh weight of onion bulb as a function of integrated application of composts and inorganic fertilizers (Sahoo *et al.*, 2022; Singh, 2022).

Onion yield (t ha^{-1}): The yield of onion varied significantly among all the treatments ranging from 12.1 to 20.7 t ha^{-1}. Onion yield enhanced under the sole and integrated application of composts and NPK fertilizers. The major increment in onion yield (61 % over control) was noticed under the integrated application of compost 1 and ½ NPK (T6). Outcomes from the integrated use of fertilizers and composts may be attributed to the regulated release of nutrients in the soil via mineralization of composts, which might have assisted crop yield (Sing, 2022). Addition of organic fertilizers in combination with chemical fertilizers not only supply ample amount nutrients but also improves soil physico-chemical characteristics and use efficiency of fertilizers which in turn results in higher yields as compared to sole application of NPK and composts (Kumar *et al.*, 2018). The findings of current research are in consistency with the findings of Khatun *et al.* (2022) and Maida *et al.* (2022) who reported a better yield of onion under the combined supplementation of organic and inorganic fertilizers.

Nutrient concentrations in onion leaves

The concentrations of nitrogen, phosphorus and potassium in onion leaves varied significantly within the tested treatments (Table 4). The application of organic and inorganic supplements increased

nitrogen concentration up to 2.7 times, phosphorus concentration up to 85% and potassium concentration up to 1.1 times with respect to control treatment. The plants which were amended with Compost 1 + ½ NPK recorded highest N concentration, while the maximum P concentration was found in the plants subjected to the application of recommended NPK. The maximum K concentration was observed with the application of compost 2 + ½ NPK. The increment in the NPK concentration increase in plant tissues is due to the increase of N, P, and K concentration in root zone which caused an upsurge in its absorption and uptake by plants (El-Dardiry *et al*., 2015; Singh and Ram, 2015). The results of our experiment are supported by findings of Kamble and Kathmale (2014), who stated that the addition of fertilizers significantly increased the nutrient content in onion plant. Similarly, a significant enhancement in the uptake of nitrogen, phosphorus and potassium in onion leaves was observed under the combined application of organic and inorganic fertilizers (Negi *et al*., 2022).

Table 4: *Effect of organic and inorganic amendments on N, P and K concentration in onion leaves.*

Treatments	N %	P %	K %
$T_{1:}$ Control	0.24 E	0.46F	1.29E
$T_{2:}$ NPK (120-60-60 kg ha^{-1})	0.67BC	0.91A	2.23BC
$T_{3:}$ Compost 1 (15 tons ha^{-1})	0.45 D	0.56E	1.96D
$T_{4:}$ Compost 2 (15 tons ha^{-1})	0.46 D	0.58E	1.90D
$T_{5:}$ Compost 3 (15 tons ha^{-1})	0.47 D	0.65D	2.12CD
$T_{6:}$ Compost 1 + NPK (10t+½NPK)	0.71 B	0.75C	2.63B
$T_{7:}$ Compost 2 + NPK (10t+½NPK)	0.64 C	0.77C	2.80A
$T_{8:}$ Compost 3 + NPK (10t+½NPK)	0.910A	0.85B	2.53B

Each value is mean ± SE (n = 4). Values with the same letter within in rows are not significantly different at P < 0.05

Conclusions and Recommendations

The objective of present research was to testify the efficiency of prepared composts for sustaining onion yields. The integrated application of composts with NPK fertilizers resulted with better onion yield and quality. This study concludes that the supplementation of composts in combination with inorganic NPK can produce better onion yield and quality and reduces the use of chemical fertilizers up to 50% without sacrificing onion yields.

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Novelty Statement

Onion yields and quality can be pushed higher with the use of composts prepared from banana.

Author's Contribution

Zaheer Ahmed Lashari: Executed the field experiment and write up of Thesis (as MSc student).
Muhammad Saleem Sarki: Conceived the idea of field experiment, data analysis and write up work (Main Supervisor of the student, 1st Author).
Saleem Maseeh Bhatti: Conceived the idea of composts preparation and analysis, Overall management of the work and manuscript write up (Main Supervisor of the student, 4th Author).
Muhammad Sachal Khokhar: Executed the trial related to compost preparation and analysis and write up of Thesis (as MSc student).
Zohaib ur Rehman Bughio: Helped in manuscript management (formatting, latest references) and journal correspondence.

Conflict of interest

The authors have declared no conflict of interest.

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