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Exploring the Effects of Enriched Urban Compost and Wastes on Growth and Yield Parameters in Maize (*Zea mays* L.)

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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

Maize (*Zea mays* L.) is a crucial global crop, vital for food security and diverse applications. Maize cultivation heavily depends on fertilizers, particularly nitrogen-based ones and their widespread use poses risks like nutrient runoff, causing pollution and economic challenges.

Balancing growth optimization with environmental/economic considerations requires optimizing fertilizer application and sustainable practices. This study aims to reduce reliance on chemical fertilizers by replacing them with microbial-enriched urban compost and wastes in various combinations with inorganic fertilizers to enhance maize yields.

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A treatment incorporating 75% NPK + 7.5 t ha-1 of microbial-enriched urban solid waste compost demonstrated the highest plant height, leaf count, cob length, kernel yield, and stover yield. The combined use of enriched compost and chemical fertilizers resulted in increased nutrient availability, improved soil properties, and a favorable microbial environment, contributing to enhanced overall yield.

Keywords: Chemical fertilizers; urban compost; microbial-enriched; soil properties.

1. INTRODUCTION

Maize (*Zea mays* L.) commonly known as corn, stands as one of the most vital cereal crops globally, playing a pivotal role in global food security and agricultural economies. Originating from the Americas, maize has evolved into a versatile and adaptable crop, thriving in diverse climates and soil conditions. Its significance extends beyond its role as a staple food; maize is a key component in livestock feed, biofuel production, and various industrial applications.

Maize cultivation is heavily reliant on fertilizers to optimize growth and maximize yields. Fertilizers, particularly nitrogen-based ones, play a crucial role in enhancing the nutrient content of the soil, promoting vigorous maize plant development, and increasing overall productivity. However, the widespread use of fertilizers in maize farming comes with its set of implications and risks in agriculture.

Excessive and improper application of fertilizers can lead to nutrient runoff, contributing to soil and water pollution. Nitrogen runoff, in particular, poses environmental concerns, such as the contamination of water bodies and the release of greenhouse gases. Moreover, the economic implications for farmers can be significant, as the rising costs of fertilizers may impact profitability.

Striking a balance between optimizing maize growth through fertilizer use and mitigating the associated environmental and economic risks requires adopting optimizing fertilizer application rates, and integrating sustainable practices. As agriculture strives for a more sustainable future, understanding the intricate relationship between maize crops, fertilizer use, and the associated risks becomes imperative for developing practices that promote both agricultural productivity and environmental stewardship.

Enriching urban compost and wastes with a microbial consortium is particularly essential for optimizing maize crop productivity. Incorporating a diverse microbial community into urban compost, enhances nutrient cycling, improves soil structure, and fosters a symbiotic relationship between soil microorganisms and maize roots. This microbial enrichment not only accelerates the decomposition of organic residues but also enhances the availability of essential nutrients, promoting robust maize growth. Furthermore, a balanced microbial consortium contributes to disease suppression and pest resistance, thus supporting sustainable and resilient maize cultivation. This not only addresses waste management challenges but also fosters sustainable agriculture practices that align with ecological balance and long-term environmental stewardship. In view of the above, the current study is conducted to explore the impact of enriched urban compost and waste on the growth and yield parameters of maize.

2. MATERIALS AND METHODS

The experiment was carried out in late winter 2022 in Bettahalli, Bangalore North taluk, Located in the Eastern Dry Zone of Karnataka, it lies at 13º 05' N latitude and 77º 34' E longitude, with an elevation of 924 meters above Mean Sea Level (MSL).

The initial soil analysis revealed specific characteristics, a pH of 5.36, an electrical conductivity (EC) of 0.02 dSm-1, with an organic carbon content of 0.68%. Notably, macronutrient levels per hectare were measured at 183.97 kg of nitrogen (N), 45.32 kg of phosphorus (P_2O_5), and 240.16 kg of potassium (K_2O).

The compost and wastes were enriched with the liquid microbial consortium, Twelve days before sowing, nine treatments (Table 1) involving various combinations of enriched and unenriched FYM, sewage sludge, urban solid waste compost, and humanure compost were applied. The basal dose of 50% N and 100% of P, K, and Zn fertilizers were supplied, remaining nitrogen was top-dressed at 30 days after sowing.

The study followed a Randomized Complete Block Design (RCBD) with three replications. The cultivation of the maize hybrid BRMH-8 adhered to recommended cultural practices and observations on growth and yield parameters were recorded at 30, 60, and 90 days after sowing (DAS), as well as during the harvest.

The data, derived by averaging observations from five plants at different growth stages within each plot, underwent statistical analysis according to the methodology outlined by Gomez and Gomez [1]. The study adhered to a significance level of p=0.05 for both 'F' and 'T' tests.

3. RESULTS AND DISCUSSION

The growth parameters, such as plant height and leaf count, were observed at intervals of 30, 60, 90 days, and at the harvest stage, revealing significant variations due to the utilization of enriched urban compost and waste materials, as detailed in Table 2. Notably, the treatment incorporating a fertilizer dose of 75% NPK along with 7.5 t ha-1 of microbial-enriched USWC exhibited a significant increase in both plant height and leaf number compared to other treatment combinations. Conversely, the absolute control (T1) resulted in significantly lower plant height and leaf count. The combined application of enriched urban compost with fertilizers demonstrated a positive impact on the growth parameters, aligning with findings reported by Ali et al. [2] and Kavitha and Subramanian [3].

At the harvest stage, a reduced leaf count was noticed primarily attributed to the remobilization of nutrients stored in the plant's short or mid-term reserves, coupled with the senescence of leaves serving as sources to facilitate the growth of new organs, such as nitrogen (N) as reported by Malagoli et al. [4] or sulfur (S) according to Abdallah et al. [5].

The impact of enriched urban compost and waste materials on the yield and related traits like cob length, kernel yield, and stover yield are outlined in Table 3. The treatment involving 75% NPK + 7.5 t ha-1 of microbial enriched USWC (T_7) exhibited a significantly higher cob length at 18.67 cm, in contrast to the absolute control (T_1) with a recorded length of 13.57 cm. Similarly, the application of 75% NPK + 7.5 t ha-1 microbial enriched USWC (T_7) resulted in a significantly increased kernel yield of 8512 kg ha-1, on par with all other treatments except for the control (T_1) with a yield of 5195 kg ha-1.

The stover yield exhibited a significant increase in the treatment involving the application of 75% NPK + 7.5 t ha-1 microbial enriched USWC (T_7), reaching 12115 kg ha-1. These results were on par with other all treatments except for the control (T_1), which recorded a stover yield of 6832 kg ha-1.

The combined use of enriched compost alongside chemical fertilizers yielded higher quantities of both kernels and stover compared to the application of chemical fertilizers alone. These treatments likely supplied sufficient nutrients in an accessible form and created a favorable microbial environment, consequently enhancing soil fertility and leading to increased overall yield. These findings align with similar observations reported by Kavitha and Subramanian [3].

The rise in yield observed in the aforementioned treatments may be attributed to enhanced crop growth and improved yield parameters. In treatments involving the application of urban solid waste compost, the elevated yield resulted from the augmented availability of plant nutrients, enhancements in soil physico-chemical properties and a reduction in the wastage of applied nutrients. Notably, a parallel increase in maize yield due to the utilization of urban kitchen waste compost was observed by Naderi and Ghadiri [6].

The utilization of enriched urban compost and waste materials led to significant enhancement in both kernel and stover yield. This improvement can be attributed to the co-inoculation of a microbial consortium, which positively influenced crop yield through various mechanisms like enhanced nutrient absorption, mineralization, carbon addition, and phytochrome production. Additionally, the easily available nutrients supplied by inorganic fertilizers facilitated rapid uptake by plants. The markedly lower yield values observed in the absolute control plots may be attributed to the absence of nutrient application through fertilizers, relying solely on native nutrients as observed by Rashid et al. [7] and Meena et al. [8].

The evident impact of treatments on both elevated and diminished growth parameters is distinctly manifested in the yield and yield parameters of maize. These findings align with the results reported by Selvamurugan et al. [9] and Rangaraj et al. [10]. Sushil Kumar [11] and Terman et al. [12] also reported an enhancement in the yield component of wheat and maize with the application of urban compost and sewage sludge.

Table 1. The nine different treatments combinations are as follows

T_1	Control
T_2	100% NPK + FYM @ 7.5 t ha^{-1} (POP)
T_3	100 % NPK + 7.5t ha^{-1} HC
T_4	100 % NPK + 7.5t ha^{-1} USWC
T_5	100 % NPK + 7.5t ha^{-1} SS
T_6	75 % NPK + 7.5t ha^{-1} Microbial enriched HC
T_7	75% NPK + 7.5t ha^{-1} Microbial enriched USWC
T_8	75 % NPK + 7.5t ha^{-1} Microbial enriched SS
T_9	75 %+ NPK + 7.5t ha^{-1} Microbial enriched FYM

Note: *10Kg of ZnSO4 per ha was added in T2 to T9 treatments USWC: Urban Solid Waste Compost, SS: Sewage Sludge FYM: Farm Yard Manure HC: Humanure Compost*

Table 2. Effect of enriched urban compost and wastes on growth parameters

Treatment	**Plant height (cm)**				**Number of leaves plant-1**			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**
T_1: Control	22.73	165.93	179.64	183.64	5.53	9.50	12.47	12.14
T_2: 100% NPK + FYM @ 7.5 t ha^{-1} (POP)	28.53	184.87	212.08	214.73	6.27	12.03	14.40	14.02
T_3: 100 % NPK + 7.5 t ha^{-1} HC	28.07	184.93	212.52	205.40	6.33	12.67	14.53	14.10
T_4: 100 % NPK + 7.5 t ha^{-1} USWC	28.60	184.80	213.18	213.87	6.73	12.53	14.81	14.15
T_5: 100 % NPK + 7.5 t ha^{-1} SS	28.73	182.87	211.25	206.73	5.93	12.13	14.32	14.01
T_6: 75 % NPK + 7.5 t ha^{-1} microbial enriched HC	29.40	187.13	216.42	219.52	7.67	13.04	15.20	14.89
T_7: 75 % NPK + 7.5 t ha^{-1} microbial enriched USWC	30.67	189.80	219.65	223.15	7.80	13.73	15.40	14.96
T_8: 75 % NPK + 7.5 t ha^{-1} microbial enriched SS	28.65	185.73	214.32	216.28	7.07	12.80	15.16	14.78
T_9: 75 % NPK + 7.5 t ha^{-1} microbial enriched FYM	28.81	186.40	215.71	218.36	7.27	12.93	15.08	14.57
S.Em±	**0.27**	**1.04**	**1.04**	**3.36**	**0.54**	**0.73**	**0.18**	**0.04**
CD at 5%	**0.80**	**3.12**	**3.13**	**10.06**	**NS**	**2.20**	**0.55**	**0.13**

Note: *10Kg of ZnSO4 per ha was added in T2 to T9 treatments*
**HC= Humanure Compost*
**USWC= Urban Solid Waste Compost*
**SS= Sewage Sludge*
**FYM=Farm Yard Manure*
**NS=Non-Significant*

Table 3. Effect of enriched urban compost and wastes on yield and yield attributes of maize

Treatment	**Cob length (cm)**	**Kernel yield (Kg ha-1)**	**Stover yield (Kg ha-1)**
T_1: Control	13.57	5195	6832
T_2: 100% NPK + FYM @ 7.5 t ha^{-1} (POP)	17.20	8255	10609
T_3: 100 % NPK + 7.5 t ha^{-1} HC	17.32	8240	10789
T_4: 100 % NPK + 7.5 t ha^{-1} USWC	17.53	8293	10875

Treatment		**Cob length (cm)**	**Kernel yield (Kg ha-1)**	**Stover yield (Kg ha-1)**
T_5:	100 % NPK + 7.5 t ha^{-1} SS	17.10	8157	10551
T_6:	75 % NPK + 7.5 t ha^{-1} microbial enriched HC	17.84	8455	11952
T_7:	75 % NPK + 7.5 t ha^{-1} microbial enriched USWC	18.67	8512	12115
T_8:	75 % NPK + 7.5 t ha^{-1} microbial enriched SS	17.45	8323	11631
T_9:	75 % NPK + 7.5 t ha^{-1} microbial enriched FYM	17.60	8405	11745
S.Em±		**0.32**	**241.52**	**658.31**
CD at 5%		**0.97**	**724.06**	**1973.61**

Note: *10Kg of ZnSO4 per ha was added in T2 to T9 treatments*
**HC= Humanure Compost*
**USWC= Urban Solid Waste Compost*
**SS= Sewage Sludge*
**FYM=Farm Yard Manure*
**NS=Non-Significant*

4. CONCLUSION

This study advocates for sustainable practices and optimized fertilizer use. The key discovery is that replacing chemical fertilizers with a blend of 75% NPK and 7.5 t ha-1 of microbial-enriched urban compost significantly improves maize growth and yield. This approach enhances plant characteristics and overall productivity while also improving soil quality and fostering a beneficial microbial environment. The study suggests that combining microbial-enriched compost with inorganic fertilizers is a promising strategy to reduce reliance on chemical fertilizers, promote sustainability, and boost maize yields.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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