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Evaluating the influence of enriched urban compost and wastes on plant nutrient uptake

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Abstract

Enriched compost, infused with beneficial microorganisms, enhances soil quality for maize cultivation. Bacteria, fungi, and other microbes in the compost form symbiotic relationships with plant roots, breaking down organic matter and releasing essential nutrients. Symbiotic interactions aid in nitrogen fixation, optimizing soil nutrient status. Using microbial-enriched urban compost in maize cultivation is a sustainable strategy, promoting nutrient absorption, plant vigor, and increased yields. This study is taken to analyzes the influence of enriched urban compost on plant nutrient uptake.

The experiment carried out during 2022 late winter season with nine treatments in Randomized Complete Block Design (RCBD) with three replications. Kernel and stover samples were analyzed for N, P, K, and heavy metals (Pb, Ni, Cr) using standard procedures. Treatment (T_7) involving 75% NPK and 7.5 tons per hectare of microbial-enriched urban solid waste compost (USWC), exhibited significantly higher nitrogen, phosphorus and potassium uptake is attributed to improved root and shoot growth, and enhanced nutrient availability. The enriched compost did not significantly alter for heavy metal concentration like chromium, nickel, lead uptake and its impact varies based on soil properties and compost composition.

Keywords: Heavy metal, urban solid waste compost, nutrient uptake

Introduction

The enriched compost and wastes with beneficial microorganisms result in a biologically active soil amendment that enhances the nutrient availability and uptake efficiency of maize plants. Microorganisms such as bacteria, fungi, and other beneficial microbes present in the compost form symbiotic relationships with plant roots, aiding in the breakdown of organic matter and the release of essential nutrients. This microbial activity not only transforms organic residues into plant-available forms but also contributes to the creation of a healthy rhizosphere, fostering a more robust root system.

The symbiotic interactions also play a pivotal role in nitrogen fixation and nutrient cycling, further optimizing the nutrient status of the soil for maize. Consequently, the incorporation of microbial-enriched urban compost in maize cultivation serves as a sustainable and eco-friendly strategy, promoting enhanced nutrient absorption, improved plant vigor, and ultimately, increased yields. Considering the significance emphasized above, this study is undertaken to analyze the influence of enriched urban compost and waste on plant nutrient uptake.

Material and Methods

The experiment was carried out during late winter 2022 at Bettahalli, situated in the Bangalore North taluk within the Eastern Dry Zone of Karnataka. To enrich the compost and wastes, a liquid microbial consortium was incorporated. Twelve days prior to sowing, nine treatments (as detailed in Table 1), encompass diverse combinations of enriched and unenriched farmyard manure (FYM), sewage sludge (SS), urban solid waste compost (USWC), and humanure compost (HC). The basal dose included 50% nitrogen (N) and 100% phosphorus (P), potassium (K), and zinc (Zn) fertilizers, and the remaining nitrogen was top-dressed 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. Kernel and stover samples were collected, powdered, and analyzed for N; P, K, and Heavy metals (Pb, Ni, Cr) content, standard procedures (Table 2) were used for estimation. The uptake of macro and micronutrients was worked out by multiplying the nutrient content and biomass yield of the plant as given in the formulae.

$$\text{Macronutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%)} \times \text{Biomass yield (kg ha}^{-1})}{100}$$

$$\text{Heavy metal uptake (g ha-1)} = \frac{\text{Nutrient content (ppm)} \times \text{Biomass yield (kg ha-1)}}{1000}$$

Table 1: The nine different treatment 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: 10 Kg of $ZnSO_4$ per ha was added in T_2 to T_9 treatments
USWC: Urban Solid Waste Compost
SS: Sewage Sludge
FYM: Farm Yard Manure
HC: Humanure Compost

Table 2: Methodologies adopted for plant analysis

Sl. No.	Parameters	Procedure	Method and Reference
1	Total nitrogen	In this method 0.5 g of powdered samples (grain and straw) was digested with concentrated sulphuric acid (H_2SO_4) in the presence of digestion mixture (K_2SO_4: $CuSO_4.5H_2O$: Selenium in 100:20:1 proportion) and distilled under alkaline medium. The liberated ammonia was trapped in boric acid containing mixed indicator and titrated against standard sulphuric acid.	Kjeldahl digestion and distillation method (Piper, 1966) [12]
	Digestion of plant samples using diacid mixture	One gram of the powdered plant samples (kernel and stover) was pre-digested with 10 ml of HNO_3 (62%) for 12 hours. Later digested in a digestion chamber at 85° C with the following steps: the pre-digested samples were treated with 10 ml of di-acid mixture reagent (HNO_3 + $HClO_4$ at a 10:4 ratio) and kept in a digestion chamber until a white precipitate was left at the bottom of the flask. The digested samples were diluted with distilled water to a known volume after filtration. This extract was used for estimation purposes	Piper (1966) [12]
2	Total phosphorus	The phosphorus content in the di-acid digested plant samples was estimated by Vanado-molybdo-phosphoric yellow color method and the color intensity was measured at 430 nm wavelength.	Diacid digestion and vanadomolybdate method (Piper, 1966) [12]
3	Total potassium	The potassium content in plant samples was determined by flame photometer.	Diacid digestion and flame photometer method (Piper, 1966) [12]
4	Heavy metal	The digested extracts of samples were diluted and fed to AAS to determine the content of respective metal ions (Pb, Ni, and Cr) using a suitable hallow cathode lamp and expressed in ppm.	Diacid digestion and atomic absorption spectrophotometry (Lindsay and Norvell, 1978) [10]

Results and Discussion

The uptake of primary nutrients like nitrogen, phosphorus, and potassium contents in kernel and stover are presented in Table 3 and Fig. 1. Significantly, higher nitrogen uptake was recorded for kernel and stover in the treatment 75% NPK +7.5 t ha^{-1} microbial enriched USWC (T_7: 112.07 kg ha^{-1} and 136.09 kg ha^{-1}, respectively). Interestingly, it was found to be on par with T_6 and T_9 treatments. Similarly, an increase in dry matter yield and nitrogen uptake was noticed by Balasubramanian *et al.* (2002) [2], and Hajna *et al.* (1992) [6] with the enrichment of urban waste compost involving *Azotobacter chroococcum* in rice. The microbial consortium consists of *Azotobacter* spp. which is greatly involved in nitrogen fixation, it is reported that 35.08 mg of nitrogen per gram of carbon was produced within 72 hours of inoculation (Din *et al.*, 2019) [4], with an increase in incubation period there is an increase in the nitrogenase enzyme production and hence fix higher nitrogen.

Significantly, higher Phosphorus uptake in kernel and stover was recorded in treatment 75% NPK +7.5 t ha^{-1} microbial enriched USWC (T_7: 28.66 kg ha^{-1} and 29.08 kg ha^{-1}, respectively) in comparison to absolute control with (T_1: 5.71 kg ha^{-1} and 5.27 kg ha^{-1}) manifested lower Phosphorus uptake. The elevated phosphorus (P) uptake can be attributed to heightened nitrogen (N) rates, enhanced root and shoot growth, and increased nutrient availability facilitated by added fertilizers. Additionally, the solubilizing action of organic acids generated during the decomposition of organic materials contributes to this phenomenon, leading to a more substantial release of both native and applied phosphorus nutrients, as discussed by Bellaki *et al.* (1997) [3]. Notably, Hajna *et al.* (1992) [6] observed an augmented dry matter yield in rice and enhanced phosphorus uptake when urban waste compost was enriched with *Azotobacter chroococcum*. The higher population of phosphorus-solubilizing bacteria converts the insoluble phosphates into a soluble form using different processes such as exchange reaction, acidification, and chelation (Din *et al.*, 2019) [4].

Significantly, higher Potassium uptake in kernel and stover was recorded with 75% NPK +7.5 t ha^{-1} microbial enriched USWC (T_7: 95.61 kg ha^{-1} and 156.28 kg ha^{-1}, respectively). However, it was found to be on par with treatments T_6 and T_9. On the contrary, significantly lower potassium uptake was recorded in absolute control. The increase in the uptake can be attributed to the initial supply of K by inorganic fertilizers and at later stages by mineralization of potassium from organic sources with the aid of soil microbes. The results are in agreement with Punitha (2016) [14], Hossain *et al*. (2010) [7], Prasad *et al*. (2010) [13] and Kumari *et al.* (2013) [9].

The uptake of heavy metals in the kernel and stover is presented in Table 4 and Fig. 2. The uptake of chromium in both kernel and stover of maize was found to be statistically non-significant. However, numerically higher was noticed with 75% NPK + 7.5 t ha^{-1} microbial enriched USWC (T_7: 5.05 g ha^{-1} and 13.89 kg ha^{-1}, respectively) over the absolute control (T_1:1.11 g ha^{-1} and 1.95 g ha^{-1}). Ayari *et al.* (2010) [1] observed an increase in nickel and chromium content, uptake, and translocation in wheat plants amended with urban compost.

Nickel Uptake by both kernel and stover of maize was found to be statistically non-significant. However, numerically higher uptake was recorded with 75% NPK +7.5 t ha^{-1} microbial enriched SS (T_8: 30.56 g ha^{-1} and 87.32g ha^{-1}, respectively) over the absolute control with (T_1: 11.34 g ha^{-1} and 23.10 g ha^{-1}), respectively. Jordao *et al.* (2007) [8] reported higher Ni uptake in plants with the increased dose of urban compost.

The uptake of lead by both kernel and stover of maize was found to be statistically non-significant. However, numerically higher with 75% NPK +7.5 t ha^{-1} microbial enriched SS (T_8: 9.52 g ha^{-1} and 26.83g ha^{-1}, respectively) over the absolute control with (T_1: 2.08 g ha^{-1} and 6.87 g ha^{-1}), respectively. Dixon *et al.* (1995) [5] showed that the concentration of Pb and Cd in plants grown on compost-enriched soil decreased and was unaffected by compost treatments. They believed that this might be due to an increase in soil pH following the compost addition, low Pb and Cd concentration in the material, and strong metal-binding capacity of the bio-solid. Adding compost did not change significantly the heavy metal concentration in plants and the values remained below or close to the tolerated values according to EEC norms (Sauerbeck, 1982) [15]. Heavy metals accumulation on crops depends on numerous factors, including soil properties, plant species, compost application rate, and compost content in metals (Pinamonti *et al*. 1999, Zheljazkov, 2004) [11, 16].

Table 3: Effect of enriched urban compost and wastes on N, P, and K uptake in Kernel and Stover of maize

Treatments	**N (kg ha^{-1})**		**P (kg ha^{-1})**		**K (kg ha^{-1})**	
	Kernel	**Stover**	**Kernel**	**Stover**	**Kernel**	**Stover**
T_1: Control	48.14	53.00	5.71	5.27	40.52	64.70
T_2: 100% NPK + FYM @ 7.5 t ha^{-1} (POP)	94.96	96.90	14.27	15.21	74.27	116.35
T_3: 100% NPK + 7.5 t ha^{-1} HC	97.23	99.98	15.10	16.54	77.46	125.51
T_4: 100% NPK + 7.5 t ha^{-1} USWC	100.05	103.31	16.59	18.13	79.59	130.14
T_5: 100% NPK + 7.5 t ha^{-1} SS	91.30	90.39	12.86	12.66	69.14	112.55
T_6: 75% NPK + 7.5 t ha^{-1} microbial enriched HC	109.92	130.27	25.93	26.69	92.44	150.99
T_7: 75% NPK + 7.5 t ha^{-1} microbial enriched USWC	112.07	136.09	28.66	29.08	95.61	156.28
T_8: 75% NPK + 7.5 t ha^{-1} microbial enriched SS	102.92	117.09	20.26	22.10	84.89	141.51
T_9: 75% NPK + 7.5 t ha^{-1} microbial enriched FYM	106.74	125.28	22.13	23.88	87.13	145.64
S.Em±	2.61	5.26	0.85	1.40	2.21	6.48
CD at 5%	7.83	15.77	2.54	4.21	6.64	19.41

Note: 10 Kg of $ZnSO_4$ per ha was added in T_2 to T_9 treatments
*HC= Humanure Compost
*USWC= Urban Solid Waste Compost
*SS= Sewage Sludge
*FYM=Farm Yard Manure

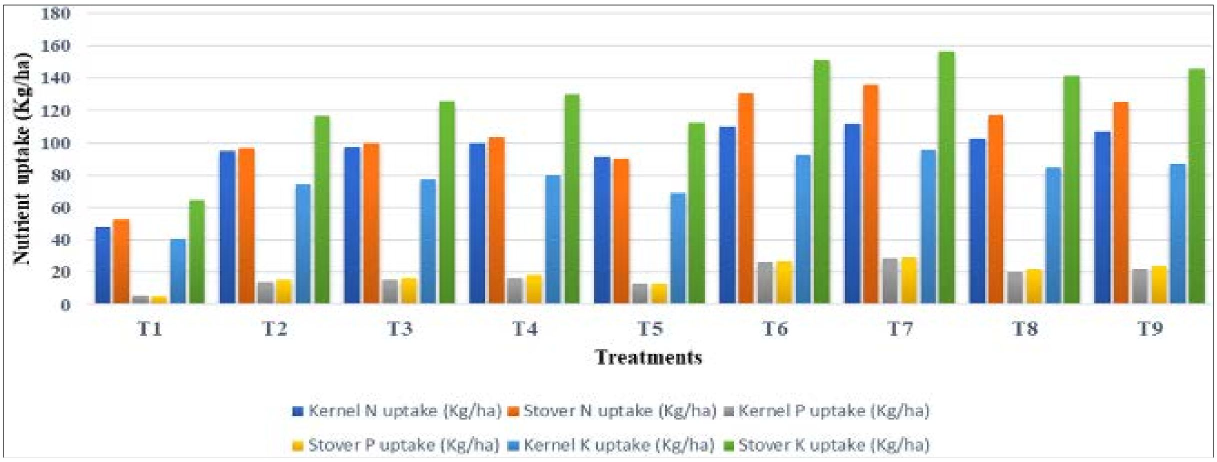

Fig 1: Effect of enriched urban compost and wastes on N, P and K uptake (kg ha-1) in Kernel and Stover after harvest of maize

Treatment details
T1: Control
T2: Package of practice
T3: 100% NPK + 7.5 t ha^{-1} HC
T4: 100% NPK + 7.5 t ha^{-1} USWC
T5: 100% NPK + 7.5 t ha^{-1} SS
T6: 75% NPK + 7.5 t ha^{-1} microbial enriched HC
T7: 75% NPK + 7.5 t ha^{-1} microbial enriched USWC
T8: 75% NPK + 7.5 t ha^{-1} microbial enriched SS
T9: 75% NPK + 7.5 t ha^{-1} microbial enriched FYM

Table 4: Effect of enriched urban compost and wastes on heavy metals uptake in Kernel and Stover of maize

Treatments	Cr (g ha^{-1})		Ni (g ha^{-1})		Pb (g ha^{-1})	
	Kernel	Stover	Kernel	Stover	Kernel	Stover
T_1: Control	1.11	1.95	11.34	23.10	2.08	6.87
T_2: 100% NPK + FYM @ 7.5 t ha^{-1} (POP)	3.53	9.90	23.86	59.91	6.61	16.13
T_3: 100% NPK + 7.5 t ha^{-1} HC	3.86	10.36	25.25	60.34	7.11	18.41
T_4: 100% NPK + 7.5 t ha^{-1} USWC	3.61	12.47	26.13	73.37	6.45	19.00
T_5: 100% NPK + 7.5 t ha^{-1} SS	4.19	11.54	26.12	78.75	7.48	23.14
T_6: 75% NPK + 7.5 t ha^{-1} microbial enriched HC	4.06	12.91	28.18	66.92	9.02	25.82
T_7: 75% NPK + 7.5 t ha^{-1} microbial enriched USWC	5.05	13.89	29.51	82.54	8.09	17.77
T_8: 75% NPK + 7.5 t ha^{-1} microbial enriched SS	4.46	12.99	30.56	87.32	9.52	26.83
T_9: 75% NPK + 7.5 t ha^{-1} microbial enriched FYM	3.95	11.12	28.58	79.24	8.97	23.26
S.Em±	0.72	2.48	3.56	12.63	1.52	3.70
CD at 5%	NS	NS	NS	NS	NS	NS

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

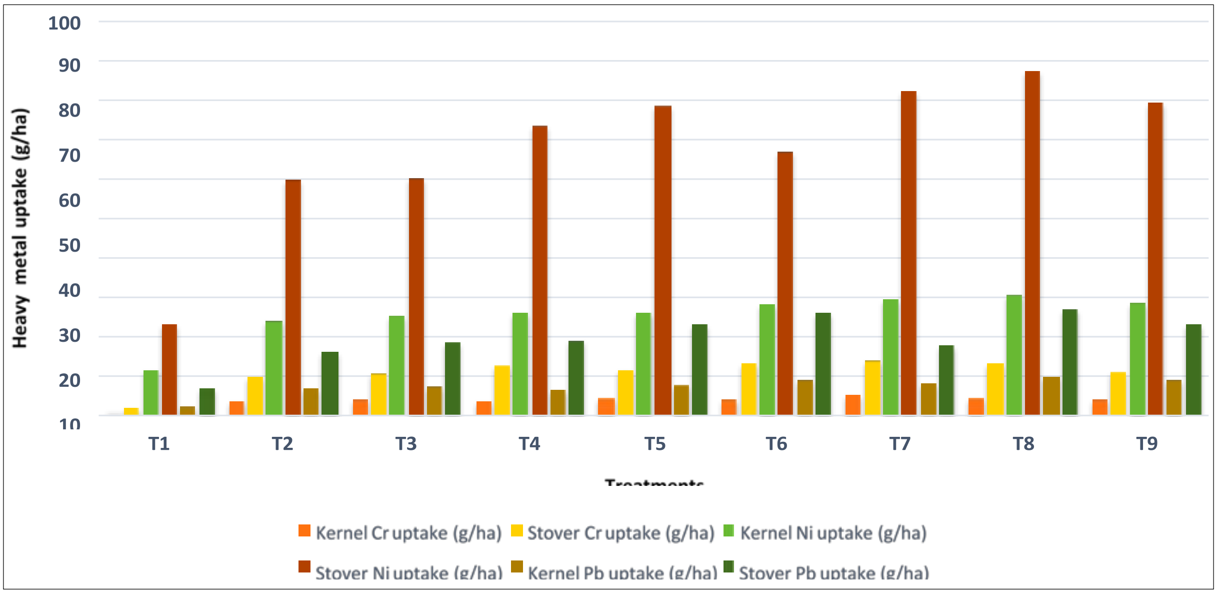

Fig 2: Effect of enriched urban compost and wastes on heavy metals uptake (g ha-1) in Kernel and Stover after harvest of maize

Treatment details

T_1: Control
T_2: 100% NPK + FYM @ 7.5 t ha-1 (POP)
T_3: 100% NPK + 7.5 t ha^{-1} HC
T_4: 100% NPK + 7.5 t ha^{-1} USWC
T_5: 100% NPK + 7.5 t ha^{-1} SS
T6: 75% NPK + 7.5 t ha^{-1} microbial enriched HC
T7: 75% NPK + 7.5 t ha^{-1} microbial enriched USWC
T8: 75% NPK + 7.5 t ha^{-1} microbial enriched SS
T9: 75% NPK + 7.5 t ha^{-1} microbial enriched FYM

Conclusion

The use of microbial-enriched urban compost has shown remarkable benefits for maize cultivation. The symbiotic relationships between beneficial microorganisms and plant roots have improved soil quality, resulting in enhanced nutrient absorption, increased plant vigor, and higher yields. This study demonstrated that the treatment involving 75% NPK and 7.5 tons per hectare of microbial-enriched urban solid waste compost (USWC) significantly increased nitrogen, phosphorus, and potassium uptake. This positive effect can be attributed to improved root and shoot growth, as well as enhanced nutrient availability.

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