



Residual Effect of Municipal Solid Waste Compost on Yield and Economics of Blackgram (*Vigna mungo* L.)

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ABSTRACT

Background: A field experiment was conducted at Regional Agricultural Research Station Nandyal, ANGRAU, during *rabi* from 2022-23 to 2023-24 to study the residual effect of municipal solid waste compost on yield, economics and soil properties of blackgram.

Methods: The experiment was laid out in a split-plot design with three main plots and five sub plots replicated thrice. The main-plots comprised of three levels inorganic fertilizer viz., M₁: 0% RDF, M₂: 75% RDF and M₃: 100% RDF. The sub plots comprised of different levels of municipal solid waste compost and FYM viz., S₁: Control, S₂: FYM @ 10 t ha⁻¹, S₃: MSWC @ 5 t ha⁻¹, S₄: MSWC @ 10 t ha⁻¹ and S₅: MSWC @ 15 t ha⁻¹. MSWC and FYM treatments were imposed only to *kharif* maize and the residual effect was studied in *rabi* blackgram. The inorganic fertilizers like nitrogen, phosphorus and potassium were applied as per the treatments during both years.

Result: Highest yield and yield attributes were recorded with 100% RDF (M₃) among three NPK levels and MSWC @ 15 t ha⁻¹ (S₅) in MSWC treatments. After harvest of blackgram the highest available nutrients N, P₂O₅, K₂O values were found in 100% RDF (M₃), followed by 75% RDF (M₂). Among different levels municipal solid waste compost, MSWC @ 15 t ha⁻¹ (S₅) showed the highest values and lowest with the control (S₁). DTPA extractable micronutrients viz., Fe, Mn, Zn and heavy metals viz., Cd, Cr, Ni and Pb were not influenced by different levels of inorganics and municipal solid waste compost and their combinations. However the DTPA extractable heavy metals were recorded numerically the highest at MSWC @ 15 t ha⁻¹ (S₅) in blackgram during *rabi* (2023-2024) in the maize-blackgram cropping sequence. The heavy metals detected at higher doses were also within the permissible limits. Among different doses of municipal solid waste compost, MSWC @ 15 t ha⁻¹ (S₅) had the highest microbial and enzyme activity, which is statically on par with the application of MSWC @ 10 t ha⁻¹ (S₄) and the lowest in control (S₁) during both the years of the study. In blackgram higher gross returns, net returns and B:C ratio were recorded in 100% RDF (M₃), followed by 75% RDF (M₂) and 0% RDF (M₁). Among organic sources, MSWC @ 15 t ha⁻¹ (S₅) was superior which was on par with FYM @ 10 t h ha⁻¹ (S₂).

Key words: Blackgram, Economics, Heavy metals, Municipal solid waste compost, Residual effect, Yield.

INTRODUCTION

Municipal solid waste management (MSWM), a critical element towards sustainable metropolitan development, comprises segregation, storage, collection, relocation, carry-age, processing and disposal of solid waste to minimize its adverse impact on environment. Unmanaged MSW becomes a factor for propagation of innumerable ailments (Kumar *et al.*, 2009). These wastes are traditionally being disposed in the landfill sites or send for gasification which causes a serious soil and air pollution due to release of pollutants in the environment. Though, there are many negative issues related to solid waste, it also provides many opportunities that not only mitigates its negative impact but also helps in meeting the demand for energy and employment generation as well as in soil health improvement.

Composting of waste is the best method for waste management in Indian cities which can be used for various crops (Pathak *et al.*, 2011). Composting is the natural biological process in which degradable part of waste is transformed to a stable material with excellent characteristics for application to soils. Municipal solid waste from Indian cities estimated to have 40%-60% organic matter, which

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could be recycled as compost (Rawat *et al.*, 2013). Composting of municipal solid waste (MSW) has recently gained good attention from the point of protection of environmental degradation, saving of land filling area, cost of incineration and scope of its use for crop production. Composting of MSW is recognized as a cost effective method for waste management that results in an end product that can be used as a soil conditioner with beneficial effects on soil productivity.

The inclusion of legumes in crop rotations with cereal crop has been proposed as a practice for increasing soil fertility. Blackgram (*Vigna mungo* L.) is one of the important pulse crop in India because of its adaptation to short growth duration and lesser water requirement. Being a leguminous crop, it has the capacity to fix atmospheric nitrogen through symbiotic nitrogen fixation. Keeping these points a experiment was carried out to study. Effect of municipal solid waste compost (MSWC) on properties of vertisols and productivity of maize-blackgram cropping sequence.

MATERIALS AND METHODS

A field experiment was carried out to study the residual effect of municipal solid waste compost (MSWC) on yield and economics blackgram in of maize-blackgram cropping sequence during *rabi* seasons of 2022-23 and 2023-24 in field No. XVII C of Regional Agricultural Research Station Nandyal of Acharya N.G. Ranga Agricultural University. Geographically Nandyal is situated at 15.44646°N latitude and 78.46760°E longitude with an altitude of 215 m above mean sea level, which falls under Scarce Rainfall Climatic Zone of Andhra Pradesh. The experiment was laid out in a split-plot design with three main plots and five sub plots replicated thrice. The main-plots comprised of three levels inorganic fertilizer *viz.*, M: 0% RDF, M₂: 75% RDF and M₃: 100% RDF. The sub plots comprised of different levels of municipal solid waste compost and FYM *viz.*, S₁: Control, S₂: FYM @ 10 t ha⁻¹, S₃: MSWC @ 5 t ha⁻¹, S₄: MSWC @ 10 t ha⁻¹ and S₅: MSWC @ 15 t ha⁻¹. MSWC and FYM treatments were imposed only to *kharif* maize and the residual effect was studied in *rabi* blackgram. In *rabi* season, black gram was grown to study the residual effects of applied municipal solid waste compost. The layout and treatments were the same as that of *kharif* maize. However, the *rabi* crop was grown without addition of any manure in sub plots while in main plots inorganic fertilizers were applied as per the treatments. FYM @ 10 t ha⁻¹ and MSWC @ 5, 10 and 15 t ha⁻¹ applied two weeks before sowing to the preceding maize crop as per treatments. Nutrient content of FYM was 0.60, 0.21 and 0.57% N, P and K and MSWC 0.61, 0.19 and 0.34% N, P and K respectively. Recommended dose of nitrogen @ 20 kg ha⁻¹ was applied as urea in two splits *viz.*, 10 kg ha⁻¹ at sowing and 10 kg ha⁻¹ at 30 DAS. Phosphorus @ 50 kg ha⁻¹ was applied as basal dose at sowing as single super phosphate. The blackgram variety used in the present was TBG-104 released from Regional Agricultural Research Station, Tirupati of Acharya N.G. Ranga Agricultural University.

The blackgram crop was harvested, when the pods were fully ripened and turned brown. Threshed seeds were sun-dried for 2-3 days to reduce the moisture content and then the seed yield per plot was recorded. Observations on growth, yield attributes and yield were analysed and statistically analyzed with R software. The soil samples were collected after the harvest of the blackgram crop and analyzed for physical, physico-chemical, chemical, biochemical and microbiological properties by using standard procedures. To elucidate significant differences between means ($p < 0.05$), post hoc comparisons were made using Tukey's HSD by using R studio version 1.4.1717. The input and output prices of the commodities prevailing during the study were taken into an account for calculating the net returns and benefit-cost ratio.

RESULTS AND DISCUSSION

Residual effect of municipal solid waste compost on yield and yield attributes of blackgram

Residual effect of municipal solid waste compost on yield and yield attributing characters in succeeding crop blackgram during *rabi* 2022-23, 2023-24 and pooled data presented in Table 1. Among different levels of NPK, 100% RDF (M₃) recorded significantly the highest number of pods/plant (24.33, 24.51 and 24.41) which was statically on par with 75 % RDF (M₂) and both of them were superior to 0% RDF (M₁) during *rabi* 2022-23, 2023-24 and pooled data respectively. Among various doses of municipal solid waste compost, the highest number of pods per plant (23.22, 23.35 and 23.25) was recorded with application of MSWC @ 15 t ha⁻¹ (S₅) which was statistically onpar with application MSWC @ 10 t ha⁻¹ (S₄). The lowest (16.85, 17.08 and 17.01) was recorded in control (S₁). However, the interaction effect between application of inorganic fertilizers and municipal solid waste compost was non significant on number of pods per plant in blackgram during *rabi*, 2022-23 and 2023-24 (Prakash and Meena, 2020).

Number of seeds per pod of blackgram was significantly influenced by different inorganic fertilizers and organic nutrient sources. Highest number of seeds per pod of blackgram (5.06, 5.08 and 5.05) was recorded in 100% RDF (M₃), which is statically on par with 75% RDF (M₂) and lowest (3.37, 3.38 and 3.37) was recorded with 0% RDF (M₁) during *rabi* 2022-23, 2023-24 and pooled data respectively. Among various doses of municipal solid waste compost, the highest number of seeds per pod of blackgram (4.21 and 4.47) was recorded with application of MSWC @ 15 t ha⁻¹ (S₅) which was statistically on par with application MSWC @ 10 t ha⁻¹ (S₄) and the lowest (4.07 and 4.09) was recorded in control (S₁) during *rabi* 2022-23, 2023-24. Similar trend was followed in pooled data. The interaction effect between application of inorganic fertilizers and municipal solid waste compost showed non significant influence on number of seeds per pod of blackgram. Similar findings were reported by Roohi and Meena (2018).

Among different levels of fertilizer, significantly the highest test weight (4.92, 4.95 and 4.93 gm) was recorded

Table 1: Residual effect of municipal solid waste compost on yield and yield attributing characters of blackgram during *rabi*.

	No. of pods per plant			No. of seeds per pod			Test weight (g)			Pod yield kg ha ⁻¹			Hulum yield kg ha ⁻¹		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Main plots															
M ₁ : 0% RDF	16.52 ^b	16.72 ^a	16.65 ^b	3.37 ^b	3.38 ^b	3.37 ^b	3.85 ^b	3.87 ^b	3.86 ^b	599 ^b	607 ^b	602 ^b	839 ^b	850 ^b	842 ^b
M ₂ : 75% RDF	19.60 ^a	19.76 ^a	19.62 ^a	4.18 ^a	4.20 ^a	4.18 ^a	4.61 ^a	4.63 ^a	4.62 ^a	1056 ^a	1064 ^a	1059 ^a	1478 ^a	1490 ^a	1481 ^a
M ₃ : 100% RDF	24.33 ^a	24.51 ^a	24.41 ^a	5.06 ^a	5.08 ^a	5.05 ^a	4.92 ^a	4.95 ^a	4.93 ^a	1095 ^a	1102 ^a	1101 ^a	1533 ^a	1543 ^a	1538 ^a
SEM _±	1.89	0.51	0.50	0.15	0.09	0.11	0.13	0.11	0.12	26.27	25.55	25.62	33.80	37.17	35.21
CD (P=0.05)	4.73	2.01	1.98	0.43	0.38	0.37	0.51	0.47	0.48	103.18	100.33	101.32	132.74	145.98	136.25
Sub plots															
S ₁ : Control	16.85 ^b	17.08 ^c	17.01 ^c	4.07 ^b	4.09 ^b	4.08 ^b	4.30 ^c	4.32 ^c	4.31 ^c	795 ^c	803 ^b	798 ^b	1114 ^c	1125 ^b	1119 ^b
S ₂ : FYM 10 t ha ⁻¹	19.49 ^{ab}	19.68 ^{bc}	19.51 ^{bc}	4.13 ^b	4.14 ^b	4.13 ^b	4.39 ^{bc}	4.41 ^{bc}	4.40 ^{bc}	823 ^{bc}	830 ^b	826 ^b	1152 ^{bc}	1163 ^b	1158 ^b
S ₃ : MSWC 5 t ha ⁻¹	20.10 ^{ab}	20.22 ^b	20.18 ^{abc}	4.16 ^b	4.17 ^b	4.16 ^b	4.45 ^{abc}	4.47 ^{abc}	4.45 ^{abc}	945 ^{ab}	957 ^{ab}	949 ^{ab}	1323 ^{ab}	1340 ^{ab}	1335 ^{ab}
S ₄ : MSWC 10 t ha ⁻¹	21.08 ^a	21.32 ^{ab}	21.20 ^{ab}	4.15 ^{ab}	4.22 ^{ab}	4.18 ^{ab}	4.53 ^{ab}	4.55 ^{ab}	4.54 ^{ab}	998 ^a	1006 ^a	1001 ^a	1398 ^a	1409 ^a	1401 ^a
S ₅ : MSWC 15 t ha ⁻¹	23.22 ^a	23.35 ^a	23.25 ^a	4.21 ^a	4.47 ^a	4.35 ^a	4.63 ^a	4.66 ^a	4.64 ^a	1021 ^a	1025 ^a	1020 ^a	1430 ^a	1435 ^a	1431 ^a
SEM _±	1.30	0.90	1.02	0.12	0.08	0.11	0.06	0.06	0.06	44.73	31.46	38.41	61.58	47.50	49.25
CD (P=0.05)	3.81	2.63	3.62	0.25	0.25	0.31	0.19	0.20	0.19	130.57	91.93	94.21	179.74	138.64	151.24
Interactions															
S at M															
SEM _±	2.26	1.56	1.81	0.21	0.15	0.18	0.11	0.11	0.11	77.48	54.55	58.12	106.66	82.27	88.61
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
M at S															
SEM _±	2.08	1.48	1.75	0.24	0.16	0.20	0.16	0.16	0.16	74.12	55.08	61.25	101.12	82.44	89.34
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

with application of 100% RDF (M_3) which is statically on par with application of 75% RDF (M_2) and the lowest (3.85, 3.87 and 3.86 gm) was recorded in 0% RDF (M_1) during *rabi* 2022-23, 2023-24 and pooled data respectively. Among various doses of municipal solid waste compost, the test weight (4.63, 4.66 and 4.64 gm) was recorded with application of MSWC @ 15 t ha⁻¹ (S_5) which was statistically on par with application MSWC @ 10 t ha⁻¹ (S_4) and the lowest (4.30, 4.32 and 4.31 gm) was recorded in control (S_1). The interaction effect between application of inorganic fertilizers and municipal solid waste compost was found non significant influence on test weight of blackgram (Satyanarayana *et al.*, 2002).

The pod yield of blackgram differed significantly with different levels of inorganic fertilizers and organic manures, as well as their interaction effects, which were consistent in both years and pooled data. The highest pod yield (1095, 1102 and 1101 kg ha⁻¹) was observed with the application of 100% RDF (M_3), which was statistically on par with 75% RDF (M_2) and both of these were significantly superior to 0% RDF (M_1). Similar results were also reported by Khan *et al.* (2018).

Among various doses of municipal solid waste compost, the highest pod yield (1021, 1025 and 1020 kg ha⁻¹) was recorded with application of MSWC @ 15 t ha⁻¹ (S_5) which was statistically higher with application MSWC @ 10 t ha⁻¹ (S_4) and the lowest (795, 803 and 798 kg ha⁻¹) was recorded in control (S_1). The interaction effect between application of inorganic fertilizers and municipal solid waste compost showed non significant influence on pod yield of blackgram. Weerasinghe *et al.* (2017) also reported that municipal solid waste compost combined with chemical fertilizers significantly enhanced blackgram yield.

Among different levels of NPK, 100% RDF (M_3) recorded significantly the highest haulm yield (1533, 1543 and 1538 kg ha⁻¹) which was statistically on par with 75% RDF (M_2) and both of these were significantly superior to

0% RDF (M_1) during *rabi* 2022-23, 2023-24 and pooled data respectively. These results are in accordance with the findings of Reddy *et al.* (2018).

Among various doses of municipal solid waste compost, the highest haulm yield (1430, 1435 and 1431 kg ha⁻¹) was recorded with application of MSWC @ 15 t ha⁻¹ (S_5) which was statistically higher with application MSWC @ 10 t ha⁻¹ (S_4) and the lowest (1114, 1125 and 1119 kg ha⁻¹) was recorded in control (S_1) *rabi* 2022-23, 2023-24 and pooled data respectively. Biologically, MSWC stimulates microbial biomass and enzymatic activities such as dehydrogenase and phosphatase by supplying labile carbon substrates that enhance microbial proliferation. Increased microbial activity promotes nutrient cycling, better root growth and improved nodulation in legumes like blackgram. Overall, MSWC improves soil fertility through a combined enhancement of nutrient supply, nutrient retention and biological activity that supports efficient nutrient use by crops which ultimately increase the yields (Prakasha and Meena, 2020).

Residual effect of municipal solid waste compost on economics of blackgram:

Data on gross returns, net returns and B:C ratio of blackgram as influenced by different municipal solid waste compost applied to preceding maize and different levels of inorganic fertilizer applied to succeeding blackgram was presented in Fig 1 and 2.

Among the different levels of inorganic fertilizer applied to blackgram during *rabi*, 2022-23 and 2023-24, 100% RDF (M_3) recorded significantly higher gross returns (65736 and 66156 ₹ ha⁻¹) followed by 75% RDF (M_2) and the lowest (35958 and 36466 ₹ ha⁻¹) were recorded in 50 % RDF (M_1). Among the various municipal solid waste compost applied to preceding maize, the application of MSWC @ 15 t ha⁻¹ recorded the highest gross returns (61287 and 61530 ₹ ha⁻¹), which was statistically on par with the application of MSWC @ 10 t ha⁻¹. The lowest (47747 and 48233 ₹ ha⁻¹) were recorded in control (S_1).

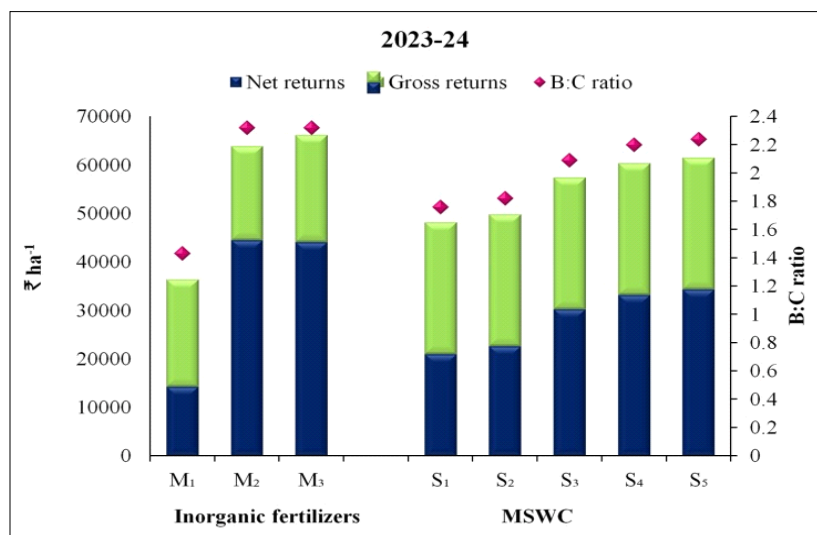


Fig 1: Effect of municipal solid waste compost on gross, net returns (₹ ha⁻¹) and B:C ratio of blackgram during *rabi* 2023-24.

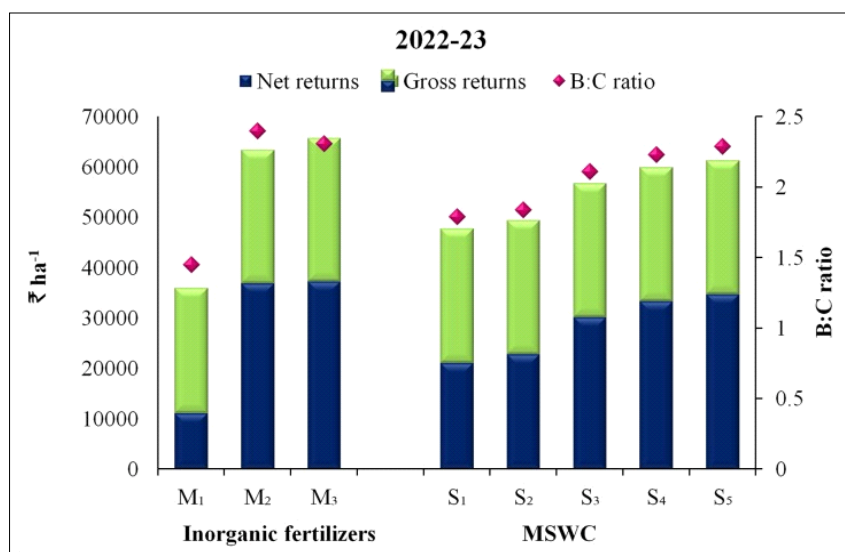


Fig 2: Effect of municipal solid waste compost on gross, net returns (₹ ha⁻¹) and B:C ratio of blackgram during *rabi* 2022-23.

The application of inorganic fertilizers and municipal solid waste compost and their interaction showed a significant influence on gross returns in blackgram during *rabi*, 2022-23 and 2023-24. Similarly, the combined application inorganic fertilizers and municipal solid waste compost was shown significant influence on gross returns. Application of MSWC @ 15 t ha⁻¹ to preceding crop maize along with the application of 100% RDF to succeeding crop blackgram (M₃S₅) recorded the highest gross returns (72940 and 73060 ₹ ha⁻¹), which was on par with M₃S₄ and M₂S₅. However, the lowest were found in M₁S₁ (34100 and 34480 ₹ ha⁻¹) in *kharif* 2022 and 2023 respectively. Similar trend was followed in pooled data analysis. Similar results were also reported by Bose *et al.* (2021).

Among the different levels of inorganic fertilizer applied to blackgram 100% RDF (M₃) recorded the highest net returns (37236 and 37656 ₹ ha⁻¹), which was comparable with 75% RDF (M₂) and the lowest (11146 and 10916 ₹ ha⁻¹) were recorded in 0% RDF (M₁) during *rabi*, 2022-23 and 2023-24 respectively.

Among the various municipal solid waste compost applied to preceding maize, the application of MSWC @ 15 t ha⁻¹ recorded the highest net returns (34699 and 34347 ₹ ha⁻¹), which was statistically on par with the application of MSWC @ 10 t ha⁻¹. The lowest (21159 and 21050 ₹ ha⁻¹) were recorded in control (S₁). Similarly, the integrated application of various inorganic fertilizers and municipal solid waste compost showed significant influence on net returns. Application of MSWC @ 15 t ha⁻¹ with 75% RDF (M₂S₅) recorded the highest net returns (44970 and 44560 ₹ ha⁻¹), which was on par with M₃S₅, M₃S₄ and M₂S₄. However, the lowest were found in M₁S₁ (9288 and 8930 ₹ ha⁻¹) in *rabi* 2022-23 and 2023-24 respectively.

Among the different levels of inorganic fertilizer applied to blackgram 75% RDF (M₃) recorded the highest B:C ratio (2.40 and 2.32), which was comparable with 100% RDF (M₂) and the lowest (1.45 and 1.43) were recorded in 0%

RDF (M₁) during *rabi*, 2022-23 and 2023-24. Among the various municipal solid waste compost applied to preceding maize, the application of MSWC @ 15 t ha⁻¹ (S₅) recorded the highest B:C ratio (2.29 and 2.24), which was statistically on par with the application of MSWC @ 10 t ha⁻¹. The lowest (1.79 and 1.76) were recorded in control (S₁). Similarly combined application of MSWC @ 15 t ha⁻¹ along with the application of 75% RDF (M₂S₅) recorded the highest B:C ratio (2.71 and 2.61), which was on par with M₂S₄, M₃S₃ and M₃S₅. However, the lowest were found in M₁S₁ (1.38 and 1.35) in *rabi* 2022-23 and 2023-24 respectively. The highest B:C ratio recorded with 75% RDF (M₂) might be due to lower cost of cultivation because of lower doses of application of fertilizers which was evident from the data presented. Economically, MSWC can reduce the reliance on costly inorganic fertilizers, especially when applied at moderate rates along with 75-100% RDF, as observed in the present study. Increased yields, improved soil health and residual nutrient benefits contribute to higher net returns over time. Although transport and application costs must be considered, several economic analyses indicate that the benefit-cost ratio improves when compost is used in integrated nutrient management rather than as a complete substitute. Similar results were also reported by Jena *et al.* (2022).

CONCLUSION

Municipal solid waste compost (MSWC) is a viable soil amendment, improving soil properties and enhancing crop productivity. The application of MSWC, particularly at higher doses (15 t ha⁻¹), significantly increased organic carbon concentration, nutrient availability and microbial activity while maintaining heavy metal concentrations within permissible limits. The benefit-cost (B:C) ratio analysis revealed that lower doses of MSWC (5 t ha⁻¹) achieved the highest economic returns, making it a cost-effective option for farmers and a potential substitute for farmyard manure (FYM).

Conflict of interest

As the corresponding author, I hereby confirm that all co-authors have carefully reviewed the manuscript, approved its contents, and have made their respective contributions to the preparation of the research article.

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