Original Research Article

Evaluation and production of Enriched (Bio-fertilizers) Vermi-compost on Bio-waste by earthworms (*Eisenia fetida sp.*)

ABSTRACT

This investigation was associated with different materials and techniques on bio-fertilizer application in soybean stover (dry matter) and fresh Cow dung for effect of bio fertilizer and earthworms (*Eisenia fetida sp.*) on bio waste decomposition. This study was analyzed by RBD (Randomized Block Design) with 6 treatments have to bio fertilizers combination *i.e.* (E_1-control, E_2- Rhizobium, E_3-Rhizobium+PSB, E_4-Rhizobium+KSB, E_5-Rhizobium+PSB+KSB, and E_6-Rhizobium+PSB+KSB+Trichoderma) and earthworms with 4 replications. The research was conducted at MRPC in Department of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur during the Rabi season of 2021-22 and 2022-23. The result interpreted by partial decomposition, duration of completion, conversion rate and recovery percentage of vermicomposting. The result revealed that partial decomposition (kg) found in enriched vermicompost higher to lower sequence *i.e.* E_5 (7.11 kg)> E_3 (7.18 kg) > E_2 (7.19 kg) > E_4 (7.20 kg) = E_6 (7.20 kg) > E_1 (7.28 kg) from initial weight (10 kg). The production of enriched vermicompost maximum found in E_6 (5.58, 5.63 and 5.61 kg pot^{-1}) within respective duration (42, 40 and 41 days) of vermicomposting in sequent years and statically pooled analysis. Conversion rate and recovery percentage of enriched vermicompost were increase with the combination of bio-agents. This investigation useful to making vermicompost using of agricultural waste through bio-fertilizer.

Keyword: *Rhizobium, Trichoderma, PSB, KSB* and microorganisms *etc.*

Commented [JD1]: Include more targeted keywords for better indexing.

1. INTRODUCTION

Commented [JD2]: Expand on why the study is important, particularly emphasizing the global challenges of waste management and bio-fertilizer production.
Clearly articulate what gap in the existing literature this study addresses

Waste management (solid, liquid and gaseous waste) is a major global challenge with increasing demand for protecting human health and the environment. In this research review, the classification and overview of research will help us identify the most important research areas for waste management. Furthermore, to promote the transition from a linear to a circular economy, waste management should be supported by policy-based initiatives and management policies (Maqsoodi et al., 2023). The case of vermicomposting, or with mixed agricultural and eco-vermicomposting, the earthworms can assist in detoxifying commercial and ecological wastes and their very last product is useful for plant increase as natural fertilizers (Raza et al., 2024). Millions of tons of agricultural and industrial waste are discarded every year at considerable financial and environmental cost. Instead of discarding the food scraps and waste, we can recycle these with the help of earth worms (Fayaz *et al.,* 2016).The Vermicompost is an eco-friendly, low cost, and effective way to recycle agricultural and kitchen waste. It is a mixture of earthworm castings, organic materials, humus, and other organisms. It has been advocated in integrated nutrient management systems in field crops due to its rich source of macro and micronutrients, vitamins, enzymes, antibiotics, and growth hormones. It also improves fertilizer and water use efficiency even better than FYM (Singh and Agarwal, 2005). Organics, inorganic and bio-fertilizers are essential to raise the crop yield. Vermicomposting of non-toxic biodegradable matter produces a stabilized humus like product known as vermicompost, which has a great potential as soil amendment. Vermicompost is a good soil conditioner that is rich in NPK, micronutrients, and growth hormones. Vermicompost application to soil also increases microbial populations and activities that further influence nutrient cycling, production of plant growth-regulating materials, and build up plant resistance to pathogen and nematode attacks (Gopal *et al.,* 2009). Composting waste and using it in agriculture is the most economical way to deal with it. Worldwide, there is a systematic improvement in the methods of treating waste and then recycling it for use in technological processes. This approach can be applied in a circular economy in which the value of raw materials and finished products can be preserved for as long as possible, minimizing the amount of waste (Szulc *et al.,* 2021). In agriculture, production is massive every year, but millions of tons of agricultural products are lost during the agricultural process (Serpil *et al.,* 2012). To achieve maximum and quality production, fertilizers are used. The necessary elements are absorbed by plants from fertilizers. This is called plant nutrition. In permanent agriculture, the nutrient content is reduced to compensate for this excessive use of artificial fertilizers [6]. With excessive use, soils are salinized, heavy metals come into contact with humans, and nitrates accumulate in water sources. They have harmful effects on the environment. Instead of artificial fertilizers, bio-fertilizers are used for mass and quality food production. In this case, agricultural waste produces bio-fertilizer and energy. Composting is a biological process in which microorganisms decompose organic matter and lower the carbon-nitrogen ratio of the substrate. It is generally prepared from organic waste material such as crop residue, household waste etc. this research focus the using of different bio agent on agricultural waste.

2. METHOD AND MATERIAL

The experiment was conducted in the Department of soil science and agriculture chemistry, JNKVV, Jabalpur. The Enriched vermicompost made through biowaste of soybean stover (dry matter) and fresh cow dung with earthworms (*Eisenia fetida sp.*) under 6 treatments of biofertilizer combination with 4 replications and the data was statically analysis by RBD design (Gomez and Gomez, 1984). Vermicompost made by continue two years (2022 or 2023) completely in *Rabi* season. This experimental trial have using different materials and technology that is following heading listed below.

Commented [JD3]: Provide more clarity on specific processes, such as how the bio-fertilizers were mixed or applied.

2.1 Collection of bio wastes, bio agents and earthworms

Soybean stover and cow dung were gathered from study campus Breeder Seed Research Unit and Dairy Research Farm respectively, for use in the current study as vermicomposting substrates. However, bio fertilizers and earthworms were obtained from the Microbes Research Production Centre and Dairy Research Farm of the vermicompost unit at JNKVV, Jabalpur, Madhya Pradesh respectively. The dry matter contents of soybean stover and fresh cow dung were determined using the oven dry method at 105 ^{0}C and were 67.8, 22.3%, respectively.

2.2 Partial decomposition after adding of bio fertilizers and earthworms in pot^{-1}

The earthworms have a completely unique capacity to transform degradable bio wastes into precious composts. However, those wastes need to be partly decomposed bio inoculate and launch of earthworms throughout the start of decomposition technique can be survival and improvement of earthworms. Before pre decomposition, dung was turned into delivered as additive in reputable substrata in an identical proportion (1:1) which allowed to decompose for 28 days. After pre-decomposition technique Rhizobium, PSB, KSB and Trichoderma have been injected discretely @ 10 g kg^{-1} every pots. Desired moisture stage of 70-80% turned into maintained with inside the decomposing bio-waste with normal watering on the price of 4 liter water for 8 kg of substrata at 7 days periods throughout the partial decomposition (28 days) duration the partial decomposition was calculated through following formula.

Partial Decomposition (kg) = Fresh weight of substrata (at initial) - Oven dry weight of substrata (after 28 days)

2.4 Duration of vermicomposting

The total number of days required to complete the composting process, including 28-days for partial decomposition, were recorded as vermicompost duration for every treatment.

2.5 Conversion rate of vermicompost

The vermicomposting rate is the daily conversion of bio waste into decomposed organic matter by bio inoculants and earthworms were recorded in the final stage of vermicomposting. In fact, the amount of vermicompost produced during a treatment period is known as the conversion rate and is determined for each treatment according to a given method.

$$\text{Conversion rate (g/day)} = \frac{\text{Quantity of vermicompost (weight)}}{\text{Number of days } \textbf{it took to convert the substrate} \text{ into vermicompost}}$$

2.6 Recovery of vermicompost

Vermicompost recovery was calculated based on the final dry matter obtained from each treatment from the total dry matter used for decomposition according to the following formula:

$$\text{Recovery of vermicompost (\%)} = \frac{\text{Dry weight of vermicompost}}{\text{Dry weight of substrata}} \text{x}100$$

3. RESULT AND DISCUSSION

Commented [JD4]: Elaborate on why certain treatments performed better or worse
Discuss how the results compare to similar studies more comprehensively to highlight their significance.
The text sometimes repeats results unnecessarily. Focus on key findings

3.1 Partial decomposition of bio-waste

The data table 1 revealed that the partial decomposition of bio-waste shows non-significantly in the both year and statistical pooled data. However, The partial decomposition maximum observed in treatment E_4 (Rhizo.+PSB+KSB) *i.e.* 7.11 kg found in both year and pooled data followed by E_3 - Rhizobium + PSB (7.12, 7.24 and 7.18 kg) letter on E_4 -Rhizobium + PSB (7.13, 7.27 and 7.20 kg) and the minimum partial decomposition found in E_1 - control *i.e.* 7.25, 7.31 and 7.28 in the year 2021,2022 and pooled data respectively. Wiharyanto *et.al.,* 2018 reported that the partial decomposition in addition of local microorganisms mixture of food waste can accelerate the process of compost maturity.

Table 1. Partial Decomposition (kg) of bio-waste under different bio agent with earthworm after 28 days

Treatments	2021	2022	Pooled
E_1 (Control)	7.25	7.31	7.28
E_2 (Rhizobium)	7.16	7.22	7.19
E_3 (Rhizobium + PSB)	7.12	7.24	7.18
E_4 (Rhizobium + KSB)	7.13	7.27	7.20
E_5 (Rhizo. + PSB + KSB)	7.11	7.11	7.11
E_6 (Rhizo.+PSB+KSB+Tricho)	7.18	7.21	7.20
SEm±	0.23	0.13	0.19
CD (P=0.05)	0.69	0.37	0.55

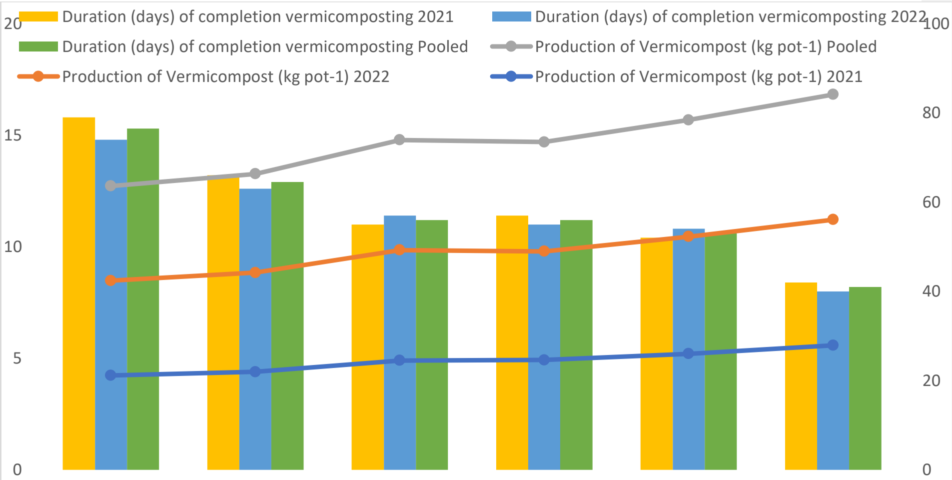
3.2 Production of vermicompost under different treatments with duration of completion of vermicomposting

Production of vermicompost and vermicompost completion under different treatments were presented in Table 2 and Figure 1. The results were found significantly on production and duration of completion of vermicompost. The production of vermicompost found in E_6 - Rhizo. + PSB+ KSB+ Tricho (5.58, 5.63 and 5.61 kg plot^{-1}) within respective duration of vermicomposting (42, 40 and 41 days) followed by E_5 - Rhizo. + PSB + KSB (5.20, 5.25 and 5.23 kg plot^{-1}) within 52, 54 and 53 days after completion of decomposition of bio- waste significantly superior to E_2 (Rhizobium) *i.e.* 4.39, 4.45 and 4.42 kg plot^{-1} within 66, 63 and 64.50 days and E_1 (Control) *i.e.* 4.23, 4.25 and 4.24 kg plot^{-1} within 79, 74 and 76.50 days of bio-waste decomposition. While, the treatments E_3 -Rhizobium + PSB (4.90, 4.95 and 4.93 kg plot^{-1}) and E_4 -Rhizobium + KSB (4.92, 4.87 and 4.90 kg plot^{-1}) within E_3 (55, 57 and 56 days) and E_3 (57, 55 and 56 days) respective duration of vermicomposting. Addition of the bio-fertilizers altered the soil physicochemical properties due to the microbial activity from the bio-fertilizers. Zea Mays showed an enhanced growth and reproduction rate upon application of the bio-fertilizers. Vermicomposting can be used as a waste corn pulp management strategy and at the same time obtain bio-fertilizers reported by Manyuchi, 2013. Under paddy straw based vermicomposting reported by Vijaya *et al.,* 2008 and similarly observation obtained in different agricultural crops reported by researcher that is Kalantari *et al.,* 2010, Kumari *et al.,* 2011 and Ansari and Sukhraj, 2010.

Table 2. Production of Vermicompost (Kg pot^{-1}) under various treatments.

Treatments	Vermicompost Production (kg pot^{-1})			Duration (days) of completion vermicomposting		
	2021	2022	Pooled	2021	2022	Pooled
E_1 (Control)	4.23	4.25	4.24	79.00	74.00	76.50
E_2 (Rhizobium)	4.39	4.45	4.42	66.00	63.00	64.50
E_3 (Rhizobium + PSB)	4.90	4.95	4.93	55.00	57.00	56.00
E_4 (Rhizobium + KSB)	4.92	4.87	4.90	57.00	55.00	56.00
E_5 (Rhizo. + PSB + KSB)	5.20	5.25	5.23	52.00	54.00	53.00
E_6 (Rhizo.+PSB+KSB+Tricho)	5.58	5.63	5.61	42.00	40.00	41.00
SEm±	0.28	0.26	0.27	2.62	2.55	2.58
CD (P=0.05)	0.82	0.77	0.79	7.72	7.51	7.62

Figure 1. Production of Vermicompost (Kg pot^{-1}) and Duration (days) of completion vermicomposting under various treatments.



3.3 Vermicompost recovery percentage under various treatments

The data Table 3 and Figure 2 shows that vermicompost recovery percentage on E_6- Rhizo.+ PSB+ KSB+ Tricho (69.75, 70.38 and 70.06 %) and E_5 - Rhizo. + PSB + KSB (65.00, 65.63 and 65.31%) were significantly superior to E_2 –Rhizobium (54.88, 55.63 and 55.25 %) and E_1-Control (52.88, 53.13 and 53.00 %). While, the treatments E_3 -Rhizobium + PSB (61.25, 61.88 and 61.56 %) and E_4 -Rhizobium + KSB (61.50, 60.88 and 61.19 %) were found partly in the year of 2021 and 2022 as well as statically pooled analysis. The recovery percentage depend on dry vermicompost production *i.e.* increase with the increasing the different bio-fertilizer numbers.

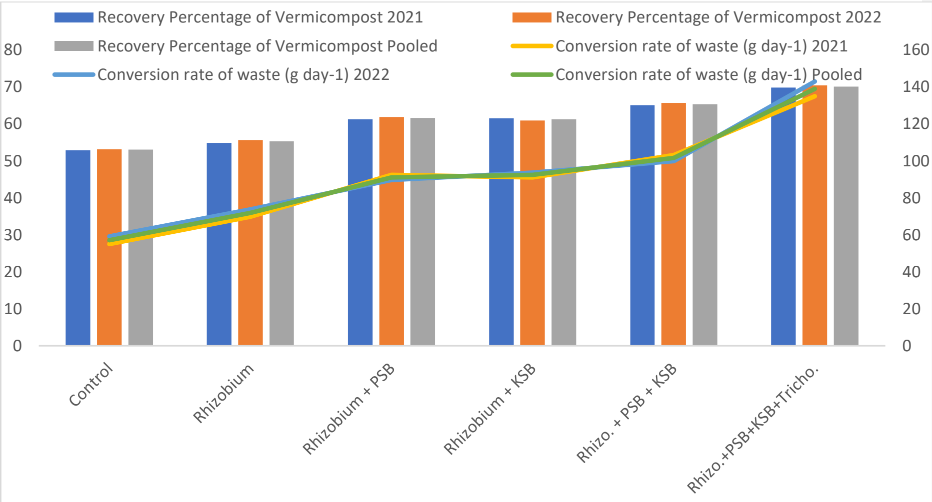
Table 3. Vermicompost recovery percentage and Conversion rate of bio-waste (g day^{-1}) under various treatments.

Treatments	Vermicompost Recovery (%)			Conversion rate of waste (g day^{-1})		
	2021	2022	Pooled	2021	2022	Pooled
E_1 (Control)	52.88	53.13	53.00	55.00	59.15	57.07
E_2 (Rhizobium)	54.88	55.63	55.25	69.80	73.76	71.78
E_3 (Rhizobium + PSB)	61.25	61.88	61.56	92.34	89.70	91.02
E_4 (Rhizobium + KSB)	61.50	60.88	61.19	90.97	93.67	92.32
E_5 (Rhizo. + PSB + KSB)	65.00	65.63	65.31	103.16	99.85	101.50
E_6(Rhizo.+PSB+KSB+Tricho)	69.75	70.38	70.06	134.90	142.88	138.89
SEm±	3.47	3.26	3.37	6.77	6.51	6.64
CD (P=0.05)	10.24	9.62	9.93	19.96	19.20	19.58

3.4 Conversion rate of bio-waste (g day^{-1}) under different treatments

The data have present in Table 3 and Figure 2 Bio-waste Conversion rate estimated that significantly in the both year and pooled analysis. The heights conversion rate computed in E_6-Rhizo.+PSB+KSB+Tricho (134.90, 142.88 and 138.89 g day^{-1}) *i.e.* was significantly superior to all bio agent based treatments. While, E_5 - Rhizo. + PSB + KSB (103.16, 99.85 and 101.50 g day^{-1}), E_4- Rhizo.+ KSB (90.97, 93.67 and 92.32 g day^{-1}) E_3- Rhizo.+ PSB (92.34, 89.70 and 91.02 g day^{-1}) were found significant to E_2- Rhizo. (69.80, 73.76 and 71.78 g day^{-1}) and E_1- control (55.00, 59.15 and 57.07 g day^{-1}) in the year of 2021, 2022 and statically pooled analysis data. The conversation rate might be dependent on the bio-fertilizer effected to deteriorate the cellulose tissue in soybean straw so that earthworm easy to digest the soybean straw. Similar finding reported by Tsai *et al.,*2007, Yong *et al.,*2021, Dikko *et al.,*2019, Srivastava *et al.,*2024.

Figure 2. Vermicompost recovery percentage and Conversion rate of bio-waste (g day^{-1}) under various treatments.



ABBREVIATIONS

Rhizo= Rhizobium, PSB= Phosphorus solubilizing bacteria, KSB= Potassium solubilizing bacteria, Tricho.= Trichoderma, i.e. = that is

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