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Production of quality vermicompost through *Eisenia fetida* under different substrata and additives

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Abstract
A pot experiment was conducted with an object to produce enriched vermin-compost with the use of different substrata and additives. Therefore twelve treatment combination consisted of two substrata of soybean stover and paddy straw and six additives (without additive, Trichoderma+ PSB, CD+ mixed to gather and left for partial decomposition for 21 days and subsequently, allowed for dization by earthworms. During the experiment observation with respect to change in ₚH, Temperature, dry weight of substrata as well as content of NPK were recorded up to 21 days. There after 200 gm worms to each treatment were released.
Higher multiplication (2.31) and conversion rate of 186.31 g/day were recorded under T4 which was significantly superior over rest of the treatment combinations except T3 and T6. More over, it required a ttal of 59 days to complete the vermicompost process including partial decomposition of 21 days. Whereas, paddy straw without additive CD based amendments and inoculation with Trichoderma + PSB found beneficial with respect to growth and development of earthworms. The maximum weight gained by earthworms was 208 g under the treatment of T4 (Soybean stover+CD+Tricho+PSB). Higher content of N (2.10%), P (0.89%) and found to bevermicompost produced from soybean stover amended with CD as well as inoculation of Trichoderma+PSB.

Keywords: vermicompost, earthworm, soybean stover, paddy straw

Introduction
The development of highly productive system for modern agriculture, undoubtedly depends on the consumption of huge quantity of fossil fuels. It is now being forced to change into an alternative system where the interaction between organisms and environment along with organic matter are properly realized (Edward et al., 1990) [2]. However, the transformation of alternative system of agriculture faces many problems like depleting available fossil natural resources coupled with excessive use of fertilizers and agrochemicals. However, response is decreasing exponentially and eventually. In addition to these, the rate of returns of input used is also decreasing. On the other hand, use of manures as a source of plant nutrients is a traditional practice of Indian farming system. However, the bulky manures are low in nutrients content and take more time to transform nutrients into available form. Thus, an alternate methods need to be evolved so that desired quantity of quality manures can be obtained within shortest period. The ability of microbes to enhance the rate of decomposition has also been studied by numbers of workers and reported that the cellulytic and lignolytic fungi have an ability to decompose almost all the biowaste at a faster rate. Moreever, the bacteria obtained either from culture or natural source of dung to decreased the C:N ratio and decomposition period of substrata. Subsequently inoculation of suitable and effective species of earthworm will convert the biowaste into valuable vermicompost. Keeping the above points in views, the present experiment was conducted to find out the suitable additive for enhancing the rate of decomposition of substrata and rate of conversion into vermicompost under the activities of *Eisenia fetida* species of earthworm.

Materials and Methods
An experiment was conducted at vermicompost Production Unit, Krishi Vigyan Kendra, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (MP) during 2015-16 and 2016-17. A total of twelve treatment combination consisted of two substrata (Soybean and paddy) and 6 additives without additives, Trichoderma+PSB, Cowdung+Traichoderma, Cowdung+Trichoderma+PSB, Rock Phosphate+PSB, Rock Phosphate+PSB+Trichoderma were tested in a Completely Randomized Design with three replications.
Biowastes of paddy and soybean stover were used as substrata for vermicomposting in present investigation which were collected from Research Farm of JNKVV, Jabalpur.

Whereas, cowdung was taken from the livestock farm, Nanaji Deshmukh Pashu Chikitsa Vigyan Vishwa Vidyalaya, Jabalpur (MP). The dry matter contents of paddy straw, soybean stover and cow dung were 68.1, 66.5 and 23.8% respectively. Cowdung, Trichoderma + PSB and Rock Phosphate were an used as additive. Trichoderma culture and PSB were obtained from the Department Soil Science and Agricultural Chemistry, College of Agriculture, Jabalpur, (MP).

The earthworms have a unique ability to convert biodegradable wastes into valuable composts. Hence, these wastes have to be partially decomposed prior to inoculate culture and release of earthworms so that generated heat and toxicant during the beginning of decomposition process may be neutralized in order to provide the congenial conditions for survival and development of earthworm. Before partial decomposition, dung was added as additive as per treatment in respected substrata in an equal proportion (1:1) and put into earthern pots. All pots were covered with wetted gunny bags and then allowed to decompose partially for 21 days. After partial decomposition process, Trichoderma viride and PSB was inoculated separately at the rate of 10 g/kg. whereas, rock phosphate was added at the rate of 20 g/kg on dry weight basis. Desired moisture level of 50- 60% was maintained in the decomposing substrata with regular watering at the rate 5 litre water for 10 Kg of substrata at 7 days intervals during the period of partial decomposition. Temperature and pH of the substrata were recorded from each decomposing substrata during partial decomposition up tp 21 days at an interval of 7 days. After partial decomposition, *Eisenia fetida* species of earthworms was recorded at the rate of 200 g in each pot. Worms of this species are surface feeder and move up to deeper layer into pots and convert bio waste into vermicompost.

The various observations with respect to change in pH as well as dry matter of substrata during partial decomposition and process of vermicomposting was recorded. The vermicompost was collected and put in the form of heap on ploythene sheet in shadow separately as per the treatments for 2 to 3 hours. By this time, the worms present in vermicompost was gathered at the bottom of the heap and then the vermicompost passes through 2.5 g sieves to separate out the worms. Simultaneously weight of vermicompost and worms was recorded on electric balance for each treatment. The counting of worms was also done at the same time to determine the multiplication ratio of earthworms under different treatments.

Results and Discussion

Changes in pH of biowaste during decomposition

In the beginning of the process of partial decomposition, all the treatments showed alkaline trend and recorded the pH ranging from 6.8 to 7.4 at 21 day of partial decomposition (Table-1). The pH of almost all treatment showed declining trend towards neutral. Hence, earthworms were released and allowed for quick decomposition after 21 days period of partial decomposition. The down swing in a pH is because of decomposition of organic wastes produces several organic acids and emit out certain gases which are acidic in nature (Mitchell and Edwards, 1997) [6]. Similar results were reported by Ndegwa et al, 2000, who found the shift in pH towards the down turn because of the bio conversion of organics into organic acids. Further, the pH of the all the treatments orderly reduced by subsequently allowing then for vermicomposting and reached nearly to neutral and stabilized at the process of vermicomposting.

Changes in biomass during partial decomposition

Changes in biomass during partial decomposition was determined after 21 days and presented in Table -2. It is evident from the data that biomass of substrata significantly changes due to change of substrata and additives. The significantly lowest biomass of 7.79 kg was recorded in soybean stover amended with RD+PSB+Trichoderma which was significantly lower to other treatment, expect T_3, T_4 and T_5. Which is recorded maximum reduction (28.36%) in weight. Moreover, the paddy straw treatments showed that the same trend with respect to reduction in weight corresponding with the change of additives. These results are in agreement with the findings of Talashikar et al (1999) and Smith (2005) [11]. The reduction in dry weight with the use of cowdung and rockphosphate as on additives might be due to the rapid decomposition of substrata in the presence of dung and rockphosphate. These finding were in close conformity with the results of Lal and Kang (1982) [5]. However, the substrata of paddy straw showed the same trend but the rate of reduction in weight corresponding with the change of substrata was lower than the soybean.

Multiplication ratio of earthworms

Equal quantity (200g) of earthworms by weight was released in all treatment after 21 days of partial aerobic decomposition. The number of earthworms from the constant weight was also counted before releasing them for vermicomposting. The earthworms were collected from all the treatments at maturity of vermicopost and then counted their number for each treatments. The multiplication ratio was determined by dividing the number of earthworms received at maturity by the number of earthworm released at the beginning of the process. Result of study showed that the maximum multiplication ratio of 2.31 was recorded under T_4. This study gave an indication for the growth and development of earthworms while paddy straw was least preferred by the earthworms. Thus, it had the lowest multiplication ratio of earthworms ranging from 1.74 to 2.13 under different additives. Higher multiplication and development of worms under soybean waste as feed for the earthworms which provide sufficient amount of well digestable metabolizable organic matter and availability of non-assimilated carbohydrate, which favoured the growth and development of earthworms. These results are in close conformity with the finding of Edwards (1988) [1], whereas, Naushauser et al (1980) [7] reported that an acceptance of any feeding material by the earthworms depends upon the composition of substrata.

The treatment T_1 and T_7 consisted of paddy and soybean biowastes without additives had the lowest multiplication ration of 1.92 and 1.74, respectively. The number of earthworms were significantly maximum when cowdung was added as an additive either in combination of PSB+Tricoderma or alone for enhancing the process of decomposition. The superiority of combinations of dung + PSB + Tricoderma over without cowdung or control was might be due to presence of E.coli bacteria, come from the rumen of the cattle along with the faeces help to decompose lignified substrata which are easy to intake by earthworms which favoured to reproduction and development. The findings are in close conformity with the findings of Hand et al (1988) [3]. Higher content of carbohydrates and less lignin in dung also provide congenial condition for hatching of cocoons and development of worms. These views are also collaborated by Rodriguez and Pineda (1995) [10].

The main objective of the present investigation was to identify the suitable substrata with the use of different additives to get the production of vermicompost. Soybean stover produces maximum quantity (7.08 kg) of vermicompost out of 10 kg biowaste and also significantly superior over paddy straw under the set of additives. The rate of decomposition significantly for treatment and quantity of final product as vermicompost also found markedly differ for treatments. In this regards, maximum conversion rate of vermicompsot 186.31 g/day was recorded under soybean stover with Cowdung + tricoderma and PSB. The conversion rate of different treatment of substrata amended with additives convert in to vermicompost is an out come of intake of waste which was mainly attributed to the multiplication of worms. In this investigation, soybean stover amended with cowdung, Trich and PSB degraded at faster rate due to activities of microbes and subsequently intake by earthworms. This process ultimately converted the higher quantity of wast in vermicompost. Similar findings were also observed by Kabiraj and Sharma (2003) [4].

Table 1: Change in pH of substrata during partial decomposition and vermicomposting (days interval)

S. No	Treatment	Days interval												
		0	2	7	14	21	28	35	42	49	56	63	70	77
T_1	Soybean stover + without additive	8.4	8.2	7.8	7.4	7.1	6.9	6.7	6.6	6.5	6.5	6.5	6.5	6.5
T_2	Soybean stover +Trichodema + PSB	8.1	7.9	7.6	7.2	7.0	6.8	6.6	6.5	6.4	6.4	6.4	6.4	6.4
T_3	Soybean stover + Cd +Trichoderma	8.2	8.1	7.8	7.3	7.1	6.9	6.8	6.7	6.5	6.5	6.5	6.5	6.5
T_4	Soybean stover +Cd + Trichoderma +PSB	8.6	8.4	8.0	7.6	7.4	7.1	7.0	6.9	6.8	6.7	6.7	6.7	6.7
T_5	Soybean stover +Rock p. +PSB	8.4	8.2	7.9	7.4	7.3	7.0	6.8	6.7	6.5	6.5	6.5	6.5	6.5
T_6	Soybean stover + Rock p. + PSB+Trichoderma	8.7	8.3	8.1	7.5	6.9	6.8	6.7	6.6	6.5	6.5	6.5	6.5	6.5
T_7	Paddy straw + without additive	8.4	8.2	7.7	7.3	6.9	6.8	6.7	6.5	6.4	6.4	6.4	6.4	6.4
T_8	Paddy straw +Trichoderma + PSB	8.2	7.9	7.7	7.1	6.8	6.6	6.5	6.4	6.4	6.4	6.4	6.4	6.4
T_9	Paddy straw+ Cd +Trichoderma	8.4	8.2	7.8	7.0	6.8	6.7	6.6	6.6	6.6	6.6	6.6	6.6	6.6
T_{10}	Paddy straw +Cd +Trichoderma +PSB	8.7	8.3	8.0	7.4	7.3	7.1	6.9	6.8	6.7	6.6	6.6	6.6	6.6
T_{11}	Paddy straw + Rock p. + PSB	8.4	8.2	8.0	7.3	7.1	6.9	6.7	6.6	6.4	6.4	6.4	6.4	6.4
T_{12}	Paddy straw+Rock p. + PSB+Trichoderma	8.5	8.2	8.0	7.3	7.2	7.0	6.9	6.8	6.7	6.7	6.6	6.6	6.6

Table 2: Changes in biomass during partial decomposition under different Treatments

S. No	Treatment	Initial weight(kg) 0f substrata	Weight (kg) after partial decomposition (21day)	Percent reduction in weight of biomass
T_1	Soybean stover + without additive	10	8.79	13.76
T_2	Soybean stover + Tricho + PSB	10	8.55	16.95
T_3	Soybean stover + Cd+Tricho	10	8.07	23.91
T_4	Soybean stover +Cd+ Tricho +PSB	10	7.83	27.71
T_5	Soybean stover +RP+PSB	10	7.88	26.90
T_6	Soybean stover +RP+ PSB+ Tricho	10	7.79	28.36
T_7	Paddy straw + without additive	10	9.42	6.15
T_8	Paddy straw + Tricho + PSB	10	9.09	10.01
T_9	Paddy straw+ Cd+ Tricho	10	8.70	14.94
T_{10}	Paddy straw+Cd + Tricho +PSB	10	8.66	15.47
T_{11}	Paddy straw + RP + PSB	10	8.31	20.33
T_{12}	Paddy straw +RP+ PSB+ Tricho	10	8.33	20.04
SEm±			0.14	
CD5%			0.43	

Table 3: Number of earthworms and multiplication ratio as influenced by various treatments during vermicmposting

S.No.	Treatment	No. of earthworm released after partial decomposition (No.)	No.of earthworm obtained at maturity of vermicompsting (No.)	Multiplica-tion ratio
T_1	Soybean stover + without additive	222	427	1.92
T_2	Soybean stover + Tricho + PSB	226	478	2.11
T_3	Soybean stover + Cd+Tricho	239	532	2.22
T_4	Soybean stover +Cd+ Tricho +PSB	237	549	2.31
T_5	Soybean stover +RP+PSB	226	498	2.20
T_6	Soybean stover +RP+ PSB+ Tricho	245	515	2.10
T_7	Paddy straw + without additive	230	402	1.74
T_8	Paddy straw + Tricho + PSB	227	436	1.92
T_9	Paddy straw+ Cd+ Tricho	235	489	2.08
T_{10}	Paddy straw+Cd + Tricho +PSB	229	488	2.13
T_{11}	Paddy straw + RP + PSB	241	451	1.87
T_{12}	Paddy straw +RP+ PSB+ Tricho	227	436	1.92
SEm±			20	
CD5%			63	

Table 4: Effect of various treatments on Weight gained (g) by worms during vermicomposting

S. No.	Treatment	Initial weight of worms(g)	Weight of worms (g) obtained after vermicomposting	Weight gain(g)
T_1	Soybean stover + without additive	200	285	85
T_2	Soybean stover + Tricho + PSB	200	336	136
T_3	Soybean stover + Cd+Tricho	200	377	177
T_4	Soybean stover +Cd+ Tricho +PSB	200	408	208
T_5	Soybean stover +RP+PSB	200	352	152
T_6	Soybean stover +RP+ PSB+ Tricho	200	380	180
T_7	Paddy straw + without additive	200	242	42
T_8	Paddy straw + Tricho + PSB	200	298	98
T_9	Paddy straw+ Cd+ Tricho	200	321	121
T_{10}	Paddy straw+Cd + Tricho +PSB	200	345	145
T_{11}	Paddy straw + RP + PSB	200	309	109
T_{12}	Paddy straw +RP+ PSB+ Tricho	200	317	117
SEm±			13.8	
CD5%			42.1	

Table 5: Production of Vermicompost (kg) and its recovery (%) as influenced by various treatments

S.No.	Treatment	Vermicompost Produced (Kg)	Recovery(%)
T_1	Soybean stover + without additive	5.81	58.1
T_2	Soybean stover + Tricho + PSB	6.28	62.8
T_3	Soybean stover + Cd+Tricho	6.90	69.0
T_4	Soybean stover +Cd+ Tricho +PSB	7.08	70.8
T_5	Soybean stover +RP+PSB	6.52	65.2
T_6	Soybean stover +RP+ PSB+ Tricho	6.81	68.1
T_7	Paddy straw + without additive	5.00	50.0
T_8	Paddy straw + Tricho + PSB	5.29	52.9
T_9	Paddy straw+ Cd+ Tricho	5.83	58.3
T_{10}	Paddy straw+Cd + Tricho +PSB	5.91	59.1
T_{11}	Paddy straw + RP + PSB	5.70	57.0
T_{12}	Paddy straw +RP+ PSB+ Tricho	5.83	58.3
SEm±		0.18	
CD5%		0.55	

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