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Effect of Simultaneous Deployment of Two or Three Earthworm Species on Vermicomposting of the Terrestrial Weed Mimosa (Mimosa pudica)

S.G. Antony godson*

[1]Department of Hindusthan Arts and Science College, Nava India, Coimbatore-641028, Tamil Nadu, India

Abstract

Mimosa (Mimosa pudica) was vermicomposted with Eudrilus eugeniae, Eisenia fetida, and Perionyx excavatus, singly or in different combinations, to see whether the process efficiency is enhanced when two or three species are used in the reactor instead of one.In all cases, the authors directly vermicomposted mimosa, without any pre-treatment, supplementation of cow dung or any other form of precomposting/processing, utilizing the high rate vermicomposting system. Over a longterm (150-day) pulse-fed operation, it was seen that vermicomposting occurred briskly in all the reactors, leading to a consistent high vermicast output, which demonstrated the success of the highrate vermicomposting paradigm as no other author has so far achieved direct /or comparably rapid vermicomposting of mimosa.The most efficient vermicast production was obtained by E. fetida, closely followed by E eugeniae. Statistically, there was no significant difference observed in the reactor performance when two or three of the species were used together.

Keywords: Pulse-fed operation, Mimosa pudica, Eisenia fetida, Eudrilus eugeniae, Biodegradation

Keywords: Blue Gold; Urbanization; Industrialization; Biomagnification;

Multicultures; Aerobic; Anaerobic

Introduction

In nature, earthworms process enormous quantities of plant debris and convert it into vermicast.The latter has nutrients in a more bioavailable form than are present in the parent substratethe vermicast is also very rich in enzymes, hormones, and microorganisms that rejuvenate the soil and help it support better primary production.Earthworms also ingest animal droppings and transform it, too, into vermicast but the quantities of phytomass that earthworm process is several times larger than the zoomass they act upon. All the three major classes of earthwormphytophagous or epigeics, geophytophagous or anecics and geophagous or endogeicsingest phytomass, but epigeics and anecics do it in a much measure than endogeics do when the earthworm–based biodegradation of zoomass or phytomass is mimicked through human intervention, it is termed vermicomposting. However, whereas, in nature several species of earthworms are usually operative in any vegetated land area, in the mimicked systems, only one or the other epigeic or anecic species are utilized. This leads to the question: will the vermicomposting be quicker or better if more than one species is simultaneously deployed.

The previous attempts to address this issue are summarized in Table 1.Twoimportant determinations can be inferred from the prior art claim that use of consortia of earthworm species leads to better vermicomposting while others report no such gain.one on sugar mill filter mud and the other on digested sludge the former was reported to benefit from the use of multiple species while the latter was not.

It is hard to draw conclusions from the past studies, because the studies are not based on any objective of quantification of vermicomposting.In each of the study substrates and earthworms have been put together in arbitrarily taken quantities for an arbitrarily pre–set number of days, and the resulting worm–worked substrate has been deemed 'vermicompost'.There is no clarity on the degree to which the biodegradation of the substrate had been completed about its expected full stabilization nor on whether the vermireactors had attained a steady state. Moreover, it is the vermicast production that lies at the core of vermicomposting, and vermicast represents a product that can be easily separated from the parent substrate and quantified.In turn, assessment of vermicast production provides a means to monitor the performance of any vermireactor and by identifying the factors that influence the rate of vermicast production, the vermireactor operation can be controlled as well as its yield optimized.However, all these features are absent in the prior art that, possibly, explains the contradictory findings.Some authors have even used the term monoculture/polyculture culture in the context of whether a single or a combination of species was used by them to treat bio-waste.However, since the studies were not aimed at culturing of earthworms but on the assessment of vermicomposting, this has further introduced self–contradiction in the reports. The present work is distinct on several counts.

It is the first–ever work in which mimosa has been successfully vermicomposted without the need of any pre–treatment or manure supplementation.Secondly, it has used vermicast as the readily distinguishable and quantifiable end product of vermicomposting and has shown that by pulse–fed operation with concomitant periodic vermicast removal, vermireactors can be indefinitely used to obtain vermicast at desired rates.It specifically demonstrates that the vermireactors that were operated with the mimosa as the only feed generated robust and consistent performance over the entire 150-day span of the study period with each of the three earthworm species that were employed, singly or in various combinations. The study reinforces the ability of the high-rate

***Corresponding author:** S.G. Antony Godson, Department of Hindusthan Arts and Science College, Nava India, Coimbatore-641028, Tamil Nadu, India, E-mail: dr.s.g.antonygodson@gmail.com

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vermicomposting system and relevant technology in making it possible to vermicompost directly and efficiently a wide variety of phytomass.

Sl.no	Author (s)	Species and their combinations studied	Nature of feed and earthworm density	Duration of study (time)	Aspects studied	Key findings
1	Loehr et al., 1985	E. fetida, E. eugeniae, and M. megascolex in single, and double species combinations	Aerobically digested sludge (two weeks old); Less than 10 mg per earthworm was used.	140 days	Factors such as moisture content, temperature, polyculture studies on the vermi-stabilization process.	The reproduction and best growth of earthworm species happened in 20-25°C and reduced at 30°C.
2	Elvira et al., 1996	L. rubellus, E. andrei, and D. rubida, in single, and double species combinations	800 gm fresh cow manure; the number of earthworms used 40 (75% clitellated and 25% immature).	90 days	Feasibility of vermicomposting with L. rubellus and D. rubida with Eisenia andrei for their growth and reproduction.	Results are shown to have better performance with E. andrei concerning its growth rate.
3	Khwairakpam and Bhargava, 2007	E. eugeniae, E. fetida, P. hawayana and P. excavatus in reactor with single and one or two species together	Cow dung; each earthworm combination was weighing 50 gm.	45 days	Comparing the efficiency of one local and two exotic earthworm species.	The high rate of volatilization, a decrease of BOD / COD indicates vermicast is non-biodegradable or stable.
4	Suthar and Singh, 2008	E. fetida, P. excavatus, L. mauritii in single, double, triple species combinations	Leaf litter Mangifera indica amended with cow dung; the number of earthworms 30 (approximately 305-312 mg).	90 days	Comparing efficiency ecologically two different categories (epigeic, anecic); microbial analysis and physical and chemical characteristics	The pH, Total Organic Carbon (TOC), Carbon-Nitrogen ratio.
5	Suthar, 2008	E. fetida, L. mauritii in single, and double species combinations	750 gm fresh cow dung; the number of earthworms used 10 (approximately 305-312 mg/ worm).	21 days	To assess the various earthworm species belonging to different ecological categories (epigeic and anecic). Assessment of microbial efficiency in mineralization process as well as dehydrogenase.	The substrate-induced respiration was shown to have achieved maximum rate.
6	Khwairakpam and Bhargava, 2009	E. eugeniae E. fetida and P. excavatus in single, double, and triple species combinations	2-week sun light dried sewage sludge; the number of earthworms used 100-120 (approx. 50 g).	45 days	Comparing the efficiency of three epigeic species concerning co-existence.	Heavy metals in vermicast are present within the permissible limit.
7	Khwairakpam and Bhargava, 2009	E. fetida, P. excavatus and E. eugeniae in single, double, and triple species combinations	2-3-week shade dried sugar mill filter mud blended with sawdust; the number of earth -worms used 100-129 (approximately 50 g).	45 days	Comparing the efficiency of two exotic and one local earthworm species.	A significant decline in Carbon/Nitrogen ratio, pH, TOC; Increase in EC, TN, TP, K, Ca, Na.

8	Munnoli and Bhosle, 2011	E. fetida, E. eugeniae, and M. megascolex in single, and double species combinations	Seven days old press mud, and soil: cow manure (1:3); the number of earthworms used 100.	40 days	To determine water-holding/retention capacities with mono and polyculture.	Monoculture reactor with M. megascolex can retain 110 to 170% and polyculture reactor.
9	Khwairakpam and Ajay, 2011	E. eugeniae, P. excavatus, and E. fetida in single, and double species combinations	2-3-week shade dried vegetable residues (0.85 kg) amended with cow dung (0.25 kg) and sawdust (0.1 kg); the number of earth -worms used 100-120 (Approximately 50 g).	45 days	Comparing the efficiency of two exotic and one local species.	Many fold increase in TN, TP, K, Na; reduction in Coliforms, faecal streptococci.

Table 1: Summary of the past work on vermicomposting in which more than one earthworm species was used simultaneously.

The significance of using mimosa as a substrate stems from the fact that the mimosa is an invasive plant, colonizing large tracts of land, particularly in the tropical and sub−tropical regions of the world.The commercial value of mimosa is less or nil. Hence, the ungoverned mimosa overrun other vegetation and causes a reduction in the biodiversity as well as agricultural productivity.By finding a possible way to utilize mimosa biomass in large quantities in the present study, an avenue has been opened to make the harvesting of mimosa, hence its control, remunerative.

The objective of the present study is to compare the three different epigeic earthworm species of E. eugeniae, E. fetida, and P. excavatus in vermicomposting mimosa in reactors with single species or combinations of two or three species.

Methodology

Vermireactors of 30 cm diameter, 9.7 cm depth and volume seven liters were employed.A 3 mm thick and moistened jute cloth served as vermibed. Leaves of mimosa were collected manually from places close to the authors' laboratories. They were washed to free them from adhering dirt, wiped with blotting paper and weighed. All the quantities reported in this study were adjusted so that the feed and vermicast weight represent dry weights accomplished by oven drying the substrate/vermicast to constant weight at 105° C. Except the weight of earthworms, which were weighed as live weight following the water washing to remove adhering material off the earthworm and kept them for few minutes on tissue paper to wipe off excess water. Each reactor, run in duplicate, was charged with 300 g dry weight of mimosa equivalent to about 1500 g of fresh weight of the weed and was seeded with 90 healthy, adult earthworms of chosen species randomly collected from cultures maintained on cow manure. The height of the substrate column was maintained at 5-6 cm as is required in the high-rate protocol. A required amount of water was sprinkled over the reactor content every day to keep about 60 % moisture. All the reactors were kept covered with wet gunny bag and nylon mesh. The reactor's operation was in the semi-continuous (pulse-feed) mode. Every 15 days once, the vermicast was harvested and quantified as described elsewhere in the thesis. One-way ANOVA was conducted to find if there was a significant difference among reactors with a different generation of earthworms.

Results and Discussion

The average vermicast output for each set of 15-day pulse-fed reactor operation over five months is presented in Table 2. As a function of time, the trends of vermicast recovery followed a consistent pattern in all the 14 reactors (Figure 1). A slow but steady increase in vermiconversion was noticed from the beginning until the third run. After that, a plateau was reached and was maintained for over three-and-a-half months, suggesting that the earthworms, which had been grown on cow dung before they were transferred to the experimental reactors, took the time to adapt to the mimosa feed and, after the initial lag phase, achieved a consistent rate of vermicast output (Figure 1). At the steady state, which was after 60 days of reactor operation, all the reactors were converting close to 40 % of the feed into vermicast per 15 days (Table 2) which translates to near 100 % conversion in 37.5 days. In contrast, conventional vermireactors take 90-100 days in effecting 100 % conversion of phytomass into vermicast, that, too, with the pre-requisites of composting and supplementation of cow dung. In the reactors presented in this study, the vermicast output can be increased additionally by employing higher earthworm density and not removing the juveniles that are generated, as has been recorded for reactors fed with paper waste wherein 100 % conversion was achieved in a solid retention time of just 10 days.

Run	Vermicast output %, (±SD) in reactors with earthworms						
(Days)	E fetida	E. eugeniae	P. excavatus	E. fetida	E. eugeniae	E. fetida	E. fetida + E.
of				+ E. eugeniae	+ P. excavatus	+ P. excavatus	eugeniae + P. excavatus
1 (15)	10.1 ± 1.9	9.9 ± 0.3	7.6 ± 0.7	10.6 ± 1.5	9.1 ± 2.9	9.7 ± 0.8	11.3 ± 1.2
2 (30)	16 ± 0.4	17.7 ± 0.8	13.7 ± 0.4	19.4 ± 1.4	15.8 ± 0.3	15.7 ± 0.8	15.6 ± 2
3 (45)	33.2 ± 0.8	33.1 ± 0.4	29.1 ± 0.4	38.5 ± 1.4	33.5 ± 0.4	31.8 ± 0.4	32.9 ± 0.6
4 (60)	42.5 ± 3.1	40.8 ± 1.5	35.4 ± 1	39.9 ± 1.2	40 ± 1.1	40.4 ± 1	42.7 ± 0.5

5 (75)	42.4 ± 2.1	40.1 ± 0.9	34.5 ± 2.5	42.1 ± 2.6	37.3 ± 2.1	39.4 ± 1.3	41 ± 1.1
6 (90)	43.8 ± 1.8	39.2 ± 0.3	36.4 ± 1.2	42.2 ± 0.8	38.4 ± 3.1	38.3 ± 1.6	40.6 ± 2.7
7 (105)	41.6 ± 2.1	40.9 ± 3.9	34.5 ± 1.8	44 ± 2.7	38.4 ± 0.3	37.8 ± 1.9	41.4 ± 3.9
8 (120)	42.3 ± 1.2	38.6 ± 2.2	37 ± 0.6	43.7 ± 0.3	36.4 ± 1.6	37.5 ± 1.8	42 ± 0.5
9 (135)	41.3 ± 1.2	38.7 ± 0.1	36.7 ± 1.3	44.2 ± 0.8	38.1 ± 1.6	37.1 ± 2.4	41.4 ± 2.2
10 (150)	43.1 ± 3.3	41.6 ± 1.4	35.9 ± 0.5	42.7 ± 1	36.3 ± 1.2	37.7 ± 1.4	40.8 ± 3.8

Table 2: Vermicast produced, as a percentage of mimosa feed mass in reactors with inter and intraspecific earthworm species of E. fetida, E. eugeniae, and P. excavatus

There was no mortality in any of the reactors. All the reactors observed to have the good growth of earthworms and reproduced well to the different degrees (Figure 2 and 3). No consistent trend was observed vis a vis zoomass gain, or juvenile or cocoon production. The zoomass gain followed the trend: E. fetida > (E. fetida + P. excavatus) > P. excavatus > (E. fetida + E. eugeniae + P. excavatus) > (E. fetida + E. eugeniae) > (E. eugeniae + P. excavatus) > E. eugeniae. The juvenile production had the trend: (E. eugeniae + P. excavatus) > P. excavatus > (E. fetida + E. eugeniae) > E. eugeniae > (E. fetida + P. excavatus) > (E. fetida + E. eugeniae + P. excavatus) > E. fetida (Figure 3).In cocoon production, the trend was P. excavatus > (E. eugeniae + P. excavatus) > (E. fetida + P. excavatus) > (E. fetida + E. eugeniae + P. excavatus) >E. eugeniae > (E. fetida + E. eugeniae) > E. fetida (Fig-3).These observations do confirm that all the three epigeic species explored by us (E. fetida, E. eugeniae, and P. excavatus) can be utilized, singly or in combination, to equal advantage for generating vermicompost from mimosa in the high-rate pulse-fed reactors.The earthworm zoomass decreased slightly during the first run (Figure 2) apparently because the earthworms took some time to acclimatize to the new feed. In the subsequent runs, the zoomass increased almost linearly with time and grew by an order of magnitude during the 5-month operation in all the reactors.

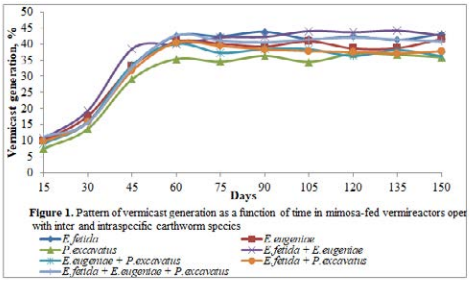

Figure 1: Pattern of vermicast generation as a function of time in mimosa-fed vermireactors operated with inter and intraspecific earthworm species

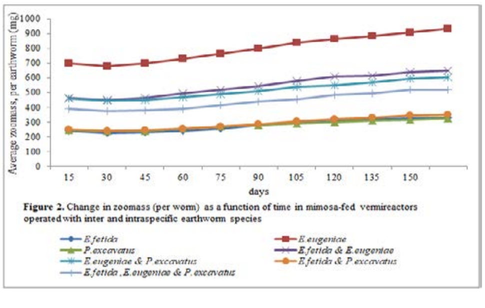

Figure 2: Change in zoomass (per worm) as a function of time in mimosa-fed vermireactors operated with inter and intraspecific earthworm species

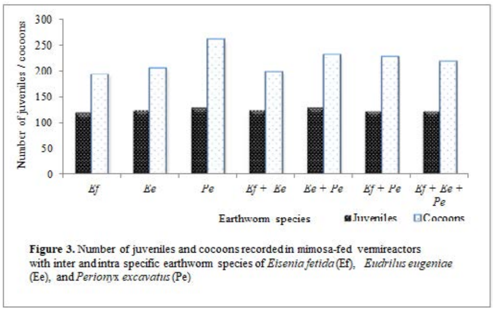

Figure 3: Number of juveniles and cocoons recorded in mimosa-fed vermireactors with inter and intra specific earthworm species of Eisenia fetida (Ef), Eudrilus eugeniae (Ee), and Perionyx excavatus (Pe)

Studies performed by these authors on the fertilizer value of mimosa vermicompost, as also completed studies on the vermicompost of other species of weeds by the authors' group, have shown that the process of direct vermicomposting of weeds based on high-rate vermireactors leads to vermicomposts of excellent fertilizer value even vermicomposts derived through this technology from weeds like lantana (Lantana camara) are plant-friendly in contrast to the parent substrate that possesses negative allelopathy and plant/ animal toxicity in other ways. Statistical analysis of the results of Table 2 reveals that there was no significant difference (F (6,133) =0.835 P=. 545) in the vermicast recovery among any set of three reactors, which either had a single species or that species in combination with one or two other species. Hence, use of two or three earthworm species instead of one has caused no beneficial (nor adverse) effect on vermicast production.

Summary and Conclusion

The effect of using two or three species of earthworms instead of one at the rate of vermicomposting of the terrestrial weed Mimosa (Mimosa pudica) was studied.In all cases, mimosa was directly vermicomposted without any pre–composting, supplementation of animal manure or any other form of pre–processing, utilizing the high–rate vermicomposting system. Over a long–term (150-day) pulse-fed operation, vermicomposting was seen to occur briskly in all the reactors, leading to consistently high vermicast output.There was no significant difference noted statistically in the reactor performance when two or three of the species were used together, and E. fetida achieved the most efficient vermicast production, closely followed by E. eugeniae.The results reveal that all the three earthworm species can be employed, singly or in combination, to efficiently vermicompost mimosa. The study demonstrates the fact that there were any obvious advantages in the performance of multispecies over single species.

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Competing Interests

All authors declare no competing interests.

Declarations

Funding

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Conflicts of interest/Competing interests: The authors have no conflict of interests with whatsoever concerned

Ethics approval

The work did not involve any human or animal and its related subject. Earthworm used in this study are not required ethical approval.

Consent to participate

The authors give their consent to participate in any intellectual conversation or work model to explain or illustrate

Consent for publication

The authors give consent to publish the paper entitled "Effect of Simultaneous Deployment of Two or Three Earthworm Species on Vermicomposting of the Terrestrial Weed Mimosa (Mimosa pudica)" in International Journal of Environmental Research.

Availability of data and material

The work was carried out at Pondicherry university as a part of the first author PhD research work subject to any plagiarism check involved.

Code availability

The work involved statistical tools such as ANOVA

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