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Biochemical Approaches for Accelerated Decomposition of Sericultural Wastes Using Microbial Consortia

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Abstract

Mulberry foliage is the sole food for silkworm, *Bombyx mori*. Farmers are adopted to whole shoot harvesting and feeding their leaves to silkworm. Silkworm rearing bed contains huge number of mulberry shoots, which needs to be a longer time to decompose. Farmers are dumping this seri-waste nearby roadsides or their mulberry garden and burning them. It is not reaching to their mulberry garden for recycling of organic and nutritive component present in them. Therefore, efforts have been made to identify microbes to hasten decomposing of seri-waste. The sericulture waste was treated with a combination of cow dung slurry, microbial consortia (Waste Decomposer), Farm yard manure (FYM) and *T. harzianum* and green manure. The treatments were maintained with proper moisture and frequent mixing up to 180 days. The samples for the estimation organic carbon and nitrogen were collected after the 90 days of initiation of treatment and upto 180 days with the 30 days. It was found that the treatment of Sericulture Waste treated with Cow dung slurry + *T. harzianum* shown a fast conversion of organic carbon followed by Sericulture Waste treated with Waste Decomposer and *T. harzianum*.

Keywords: sericulture wastes, waste decomposer, Trichoderma harzianum, cow dung slurry

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Introduction

Mulberry foliage is the sole food for the silkworm (*Bombyx mori*). Its cultivation demands huge amount of farm yard manure and chemical fertilizers because of its fast growing and high biomass producing nature. A hectare of mulberry garden with a potential yield 35 tons of leaf can generate 23 tons of stem material (fresh weight) and the rearing activity generates 5.25 tons of fecal matter (fresh weight). These residues approximately having 204 Kg nitrogen, 57.38 Kg phosphorus and 141 Kg potash contents [1]. It includes mulberry branches, leaf twigs, left over leaves, larval litter and weeds of mulberry garden. The amount of waste availability increases tremendously after adoption of new technology *i.e*., feeding a silkworm with whole branch compare to traditional leaf plucking methods by the farmers. The measurable amount of silkworm bed waste includes mulberry shoots, which takes longer time to decompose. The lignolytic amount present in the mulberry plant branches prolongs decomposition time. It is estimated that approximately 210-240 days required completing the decomposition. Farmers are dumping this huge amount of seri-waste adjacent to their mulberry garden and later burning them. Dumping nearby mulberry gardens leadings to secondary source for silkworm pathogen and burning the seri-waste in turn wasting a nutrient availability in them. Therefore, the microbial consortia may be used to hasten its decomposition and early availability of decomposed manure to mulberry garden. The present composting experiment was conduct by using waste decomposer (A "Waste Decomposer" developed by National Centre of Organic Farming, Ministry of Agriculture & Farmers Welfare, Govt. of India, Ghaziabad) [2], cow dung slurry, Farm Yard Manure (FYM) and *Trichoderma harzianum* to know the change in C:N ratio at the quickest time of seri-waste *i.e*., silkworm rearing bed wastes.

Materials and Methods

The sericulture wastes were collected from the silkworm rearing facility of Karnataka State Sericulture Research and Development Institute (KSSRDI), Bangalore. They were chopped to small pieces and placed in plastic trays. The cow dung slurry, microbial consortia (Waste Decomposer), Farm yard manure (FYM) and *T. harzianum* are applied to sericulture wastes and green manure. They were maintained in a 12 treatments i.e., T1 (Sericulture Waste), T2 (Sericulture Waste treated with Cow dung slurry), T3 (Sericulture Waste treated with Waste Decomposer), T4 (Sericulture Waste treated with FYM), T5 (Sericulture Waste treated with *T. harzianum*), T6 (Sericulture Waste treated with Cow dung slurry and Waste decomposer), T7 (Sericulture Waste treated with Cow dung slurry + FYM), T8

(Sericulture Waste treated with Cow dung slurry + *T. harzianum*), T9 (Sericulture Waste treated with Waste decomposer + FYM), T10 (Sericulture Waste treated with Waste Decomposer + *T. harzianum*), T11 (Sericulture Waste treated with *T. harzianum* + FYM) and T12 (Sericulture Waste and *Gliricidia* with FYM). The treatments samples were maintained with proper moisture and frequent mixing. The samples were collected after the 90 days of initiation of experiment. Later, the samples were collected 3 times at the interval of 30 days *i.e*., 120 days, 150 days and 180 days. The samples were grinded to fine powder and utilized for the quantification of organic carbon and nitrogen contents. The organic carbon was quantified by following a mass loss on ignition explained by Konare [3]. The nitrogen content was determined by macro-Kjeldahl method described by Subbaiah and Asija [4]. The results were subjected to statistical ANOVA analysis.

Results

The present experiment was conducted by using waste decomposer, cow dung slurry, farm yard manure (FYM) and *T. harzianum* to know the change in C:N ratio at the quickest time. The result indicated a variability Organic Carbon, Nitrogen content and C:N ratio among the treatments (**Table 1**). The variation in the organic carbon content in 120th day, 150th day and 180th day's samples were highly significant. On 120th day the maximum conversion of organic carbon was observed in T8 (Sericulture Waste treated with Cow dung slurry and *T. harzianum*) followed by T10, T5, T7, T3, T9, T6, T2, T12, T11, T4 and T1 compared to 90th day organic carbon content. On 150th day the organic carbon was decreased in T8 followed by T9, T1, T6, T7, T5, T4, T2, T3, T10, T12 and T11. Further, on 180th day after treatment, the organic carbon content degradation was maximum in T3 followed by T12, T2, T6, T4, T8, T5, T1, T9, T10, T1 and T7. It shows that seri waste treated with treated with Cow dung slurry and *T. harzianum* shown a fast reduction in organic carbon followed by Sericulture Waste treated with Waste Decomposer and *T. harzianum* (T10). Whereas, T1 (seri waste) taken a longer time *i.e*., 180 days.

Table 1 Evaluation of microbes and its consortia on carbon, nitrogen contents and C:N ratio in sericultural wastes

Treatments	90 days			120 days			150 days			180 days		
	C	N	C:N Ratio	C	N	C:N Ratio	C	N	C:N Ratio	C	N	C:N Ratio
T1	38.50	2.50	15.51	33.73	2.94	11.60	29.80	2.52	11.84	24.43	2.99	8.87
T2	87.33	2.61	34.07	50.77	3.10	16.41	26.33	2.47	10.74	29.17	3.03	9.62
T3	86.03	1.84	45.06	56.13	3.50	16.56	25.30	2.38	10.68	29.53	2.26	11.43
T4	49.47	2.47	20.03	42.80	2.66	16.16	26.90	2.66	10.18	25.87	2.89	9.05
T5	87.60	3.24	27.06	56.87	3.24	17.54	27.47	2.87	9.81	24.57	2.57	9.84
T6	88.50	2.61	33.93	54.10	2.75	20.53	29.57	2.57	11.55	26.23	2.94	9.03
T7	85.17	2.45	34.92	56.63	3.01	18.97	29.07	2.54	11.61	22.00	2.94	7.49
T8	88.53	3.31	26.73	65.97	3.06	21.60	56.83	2.73	21.26	25.17	2.52	10.14
T9	84.23	2.57	33.90	55.53	2.82	20.33	40.13	2.26	17.96	24.13	3.24	7.47
T10	43.97	2.89	16.45	61.23	2.36	26.09	25.07	2.33	10.91	23.53	2.61	9.04
T11	65.93	2.73	25.04	48.63	2.52	19.37	20.83	2.40	8.74	22.33	2.85	7.87
T12	91.47	2.33	39.90	49.30	3.29	15.02	24.47	2.31	10.84	29.27	2.73	11.17
Mean	74.73	2.63	29.38	52.64	2.94	18.35	30.15	2.50	12.18	30.15	2.80	9.25
SD±	19.67	0.50	9.76	8.55	0.42	4.24	9.38	0.34	3.86	9.38	0.45	1.86
F value	56.36	4.35	15.22	39.67	4.47	7.46	266.87	1.16	15.59	266.87	1.55	2.44
CD @.05	2.60	0.19	2.33	1.34	0.16	1.34	0.58	0.17	0.91	0.58	0.21	0.81
CD @.01	3.88	0.28	3.48	1.99	0.23	1.99	0.87	0.25	1.36	0.87	0.32	1.22
Significance	HS	HS	HS	HS	HS	HS	HS	NS	HS	HS	NS	NS

(C-Carbon, N-Nitrogen, T1-Sericulture Waste, T2-Cow dung slurry, T3-Waste Decomposer, T4-FYM, T5-*T. harzianum*, T6-Cow dung slurry and Waste decomposer, T7-Cow dung slurry and FYM, T8-Cow dung slurry and *T. harzianum*, T9-Waste decomposer and FYM, T10-Waste Decomposer and *T. harzianum*, T11-*T. harzianum* and FYM, and T12-*Gliricidia* and FYM)

The variation in the nitrogen content was highly significant in 120th day's sample and non-significant in 150th day and 180th day's samples. On 120th day the maximum conversion of Nitrogen was observed in T3 followed by T12, T5, T2, T8, T7, T1, T9, T6, T4, T11 and T10 compared to 90th day nitrogen content. On 150th day the Nitrogen was decreased in T5 followed by T8, T4, T6, T7, T1, T2, T11, T3, T10, T12 and T9. Further, on 180th day after treatment, the nitrogen content degradation was maximum in T9 followed by T2, T1, T6, T7, T4, T11, T12, T10, T5, T8 and T3. It shows that seri waste treated with treated with waste decomposer shown a fast accumulation of nitrogen. Whereas, T1 (seri waste) taken a longer time *i.e*., 180 days.

The C:N ratio is a quick way to evaluate the balance between two elements present in the soil that are both essential for crop growth and microbial health. The degradability rate of organic substances changes with C/N ratio [8]. The variation in the carbon:nitrogen ratio was highly significant in 120th day and 150th day and non-significant in 180th day's samples. On 120th day the maximum C:N ratio was observed in T10 followed by T8, T6, T9, T11, T7, T5, T3, T2, T4, T12 and T1 compared to 90th day. On 150th day the Nitrogen was decreased in T5 followed by T8 followed by T9, T1, T7, T6, T10, T12, T2, T3, T4, T5 and T11. Further, on 180th day after treatment, the Nitrogen content degradation was maximum in T3 followed by T12, T8, T5, T2, T4, T10, T6, T1, T11, T7 and T9. Carbon to nitrogen ratio (C\N) means the ratio of carbon element amount in organic matter to its content of nitrogen element amount. It is seen that, the best C\N ratio is 20-30 atoms of carbon for each atom of nitrogen (20-30 carbon atoms:1 nitrogen atom). C:N ratios also provide clues about the microbial population.

Discussion

The selection and optimization of compost amendments would allow to improve nutrient retention and organic matter degradation, including its effect on microbial community structure and metabolic function. The process of composting perfectly integrates into the desired circular economy context by promoting nutrient recycling and diminishing the demand for synthetic fertilizers supporting, at the same time, sustainable agriculture practices and long-term food security [5]. Optimizing composting efficiency requires the selection of specific microbial consortia. The diversity, composition, and functional roles of microbial communities during composting are strongly shaped by environmental factors and the physico-chemical properties of the feedstock, such as temperature, moisture, and the levels of organic carbon, nitrogen, and phosphorus. These elements regulate microbial activity and underscore the critical role of microbial interactions in driving the composting process [6]. *Trichoderma* spp. have been used to convert solid organic waste into compost-like substrates via solid-state fermentation on digestate-based blends, producing fungal biomass and enzymes, and in some cases gibberellins and oxylipins [7]. Manea [8] found that inoculating compost with *Trichoderma* spp. can accelerate Municipal Solid Waste (MSW) composting, producing nutrient-rich compost that can serve as an organic fertilizer for crops. Further, *Trichoderma* support strong potential for *Trichoderma*-based inoculants to accelerate rice straw decomposition, especially when applied below ground, though early fungal suppression and site-specific conditions should be considered [9]. An effort was made to know the fast decomposition of sericulture waste by using the microbial combinations. The *Trichoderma* sp., cow dung slurry and waste decomposer were used to know their role in fast decomposing of seri-waste. Cow dung harbors a diverse microbial community including bacteria, actinomycetes, fungi, and *Azospirillum*, with high colony-forming units on various selective media [10-12]. Composting with efficient lignocellulolytic (i.e. cellulose and lignin-degrading) microbes can speed up decomposition [12]. In the present study, T8 (Sericulture Waste treated with Cow dung slurry + *T. harzianum*), shown a fast conversion of organic carbon by 120th and 150th days followed by T10 (Sericulture Waste treated with Waste Decomposer + *T. harzianum*) by 120 days and T9 (Sericulture Waste treated with Waste decomposer + FYM) after 150 days. The C:N ratio was increased to maximum in T10 followed by T8 on 120th day compared to other treatments. The *Trichoderma* sp. and other microbes present in cow dung slurry and waste decomposer may have a role in fast decompose. Composting is a process of changing physical, chemical and biological characteristics of organic substance commonly known as biodegradation [13]. As decomposition progresses, the C:N ratio of residues generally decreases because microbes respire carbon as CO_2 more rapidly than they lose nitrogen. Consequently, the remaining substrate becomes relatively enriched in nitrogen, leading to a reduction in the C:N ratio until it reaches a stabilized, humus-like state typically around 10 to 25, depending on the material [14]. It is considered as a cost-effective biological treatment and stabilization method for recycling solid wastes [15]. The chemical composition of the natural fibers significantly influences the mechanical properties and biodegradability. Cellulose is the most abundant carbohydrate present in plant residues/organic matter in nature. When cellulose is associated with pentosans (eg. xylans & mannans) it undergoes rapid decomposition, but when associated with lignin, the rate of decomposition is very slow [16]. Mulberry stem having a 58.65 % of cellulose and 10.21 % of hemicelluloses followed by lignin (20.79 %), wax (0.56 %), moisture (6.45 %) and 3.34 % of ash [17]. Therefore, the biodegradation of mulberry stem prolongs because of its rich content in cellulose and lignin. Biological decomposition is the main and efficient decomposition method in which bacterial and fungal spores speed up the decomposition of waste under aerobic and anaerobic conditions. Microbial decomposition enhances nutrient content by nitrogen fixing, phosphorous solubilization, and cellulose decomposition of decomposed final product [18]. There are a variety of bio-decomposers such as bacteria, fungi, protozoa etc. and they are capable to degrade cellulose by depolymerizing cellulases which hydrolyze ligno-celluloses. In the present investigation it has been proved that the reduction in carbon content in T8 is fast compared to other treatments due to the usage of cow dung slurry and *T. harzianum*. Similar observation was made by Gautam [19], where *Humicola, Trichoderma*, and *Penicillium aspergillus* used to recycling of urban solid waste. Idham [20] confirmed the presence of microbial decomposers particularly *Lactobacillus, Actinomycetes* and *Aspergillus* sp. in cow manure. Therefore, the microbiota present in the cow dung slurry and *T. harzianum* may have a role in fast decomposition of seri-waste. In the present study the decomposition rate by waste decomposer takes a second place compare to cow dung slurry and *T. harzianum*. This may be due to the nature of organic wastes. This may be due to slight variation in the biochemical component of seri-wastes. Further, utilization of seriwaste as a compost improves the soil health, higher and quality yeild of mulberry leaves and ultimately better production of silkworm cocoon. This leads to generate additional income to the farmers and encouraging an organic farming for the sustainability of soil in mulberry plots.

Conclusion

Harvesting mulberry leaves along with their shoots and feeding to silkworm is an advanced technology compare to earlier individual leaf harvest. This enhances a availability enormous amount of seriwaste in silkworm rearing bed. Recycling such waste is prolonging process because of its lengthy decomposing time. To overcome this issue, efforts were made to hasten its decomposition with combination of cow dung slurry, microbial consortia (Waste Decomposer), Farm yard manure (FYM) and *T. harzianum* and green manure. The results proceed to recommend that treating a sericulture waste with combination of Cow dung slurry + *T. harzianum* more ideal. It is more effective compare to using a waste decomposer with a combination of FYM and *T. harzianum.* But, maintaining a proper moisture and frequent mixing is very much necessary to achieve fast decomposition of seri-waste. It would be more effective of allowing chopped small pieces of seri-waste instead of dumping a whole seri-waste in decomposition pits straight away from silkworm rearing bed.

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