International Journal of Plant & Soil Science

33(22): 117-125, 2021; Article no.IJPSS.75232
ISSN: 2320-7035

Comparative Study on Effectiveness of Various Compost Cultures on Composting of Farm Wastes

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2021/v33i2230689
Editor(s):
(1) Prof. Faruk Toklu, University of Çukurova, Turkey.
Reviewers:
(1) Kiran D A, Siddaganga Institute of Technology, India.
(2) Seyede Roghie Ghadirnezhad Shiade, Sari Agricultural Science and Natural Resources University, Iran.
(3) Surinder Singh Rana, CSK Himachal Pradesh Agriculture University, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/75232

Short Research Article

Received 12 August 2021
Accepted 25 October 2021
Published 02 November 2021

ABSTRACT

Aim: The aim of this study was to evaluate effectiveness of various microbial compost cultures for aerobic-composting of farm wastes.

Place of Study: Three trials were conducted on farmer's field and one at Krishi Vigyana Kendra (KVK) Ramanagara district.

Methodology: During the composting process, days to compost, maturity in terms of changes in temperature, pH and composting dynamics were studied. Compost quality parameters such as macro and micro-nutrients and C:N ratio and stability of the compost were recorded at different intervals.

Results: The results showed that the compost culture from IIHR and UASB had taken 90 and 105 days respectively, for complete stabilization; further had relatively higher temperature and pH during the initial phase and reached ambient condition at maturity stage, C:N ratio has showed gradual reduction from 39.65 to 15.98 and 39.75 to 13.66% respectively in IIHR and UASB cultures, they also had high macro, secondary and micro nutrients(IIHR-1.55% N, 0.93% P, 0.95% K, 4.39% Ca, 0.69% Mg, 0.19%S, 930 ppm Fe, 10ppm Cu, 305ppm Mn, 82ppm Zn, 26 ppm B UASB-1.59% N, 0.91% P, 0.97% K, 4.25%Ca, 0.88% Mg, 0.21%S, 948 ppm Fe, 9ppm Cu, 325ppm Mn, 93ppm Zn, 28ppm B) content and resulted in more compost production (3.3 and 2.8 t/year, respectively) with B:C ratio of 6.67 and 7.25 respectively when compared to NCOF (T_3) and farmers practice (T_4).

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Conclusion: Aerobic-composting of farm waste using microbial culture of UASB and IIHR proved to be an effective technology that aids to convert organic farm waste into valuable organic manure with an advantage of minimizing the environmental contamination associated with burning of residues.

Keywords: Microbial consortia; aerobic composting; C: N ratio; macro nutrients; micro nutrients.

1. INTRODUCTION

Low soil organic carbon (C) levels and macro, micro-nutrient deficiencies due to soil mismanagement and misuse are the major challenges for improving productivity in the semiarid tropics [1]. Soil organic Carbon is one of the most important parameters governing soil health through influencing soil chemical, physical and biological properties and thereby influencing crop yields [2]. In India, nearly 700 million tonnes of organic waste is generated annually, leading to challenges for its safe disposal, with the waste being either burned or land filled (3,4,5]. However, there are several naturally occurring microorganisms that are able to convert organic waste into valuable resources such as plant nutrients and reduce the C:N ratio to support soil productivity. These microorganisms are also important to maintain nutrient flow from one system to another and to minimize ecological imbalance [6,7].

Composting is a preferred and environmentally sound method whereby organic waste is reduced to organic manure and soil conditioners through biological processes [8,9]. The high organic carbon content and biological activity of compost make it effective for applications such as erosion control and revegetation [10]. Traditional composting (farmers' practices of heaping straw and dung) is time consuming and relatively less effective. In such case, using half decomposed compost/manure/plant residue creates many plant nutrient and pest-related problems, rather than benefits.

The composting process involves three phases, and uses diverse microflora such as bacteria, fungi and mesophilic (*Streptomyces rectus*) and thermophilic Actinomycetes (*Actinobifidachromogena*, *Thermomonospora fusca*, *Microbispora, Thermopolyspora. bispora, Thermomonospora curvata*, *Thermoactinomyces sp*.) eventually converting organic waste to humus [11-14]. During the first phase there is an increase in carbon dioxide along with the temperature. The substrate is reduced due to the degradation of sugar and proteins by the action of mesophilic organisms [15,13,6,14]. The second phase leads to an increase of the temperature in the compost piles from 45°C to approximately 70°C and the mesophiles are replaced by thermophiles [12,13]. Large numbers of pathogenic individuals are degraded during this time [6]. The third phase begins with the decrease of temperature in the compost pile.

The quality and stability of compost is entirely dependent on its raw materials [16,17,18]. During the composting process, various parameters including the C:N ratio, composting temperature, pH of the finished product, moisture content are used to assess the quality and stability of the compost [19-24]. In particular, this study focuses on the identification of suitable but cheap method, processes that use minimal energy and the selection of proper microbial culture to produce quality compost.

2. MATERIALS AND METHODS

On farm test on aerobic-composting of farm waste using various microbial consortium from different institute as per their recommendation (T_1 - 5kg Arka microbial consortium decomposer from IIHR per tonne of farm waste, T_2 - 1 kg Compost culture from UASB per tonne of farm waste, T_3 - 20 L Waste decomposer solution from NCOF per tonne of farm waste and T_4 - Farmers practice without microbial consortium) were evaluated for their efficacy in decomposing of farm wastes in farmers field at K.G. Hosahalli village, Ramanagara taluk and district during June 2018 to January 2019. Three trials were conducted on farmer's field and one at KVK farm. Farm wastes comprises of left over fodder, straw and cow dung from cowshed, weeds, dry leaves, green leaves in equal proportion.

2.1 Description of the Composting Site

K.G. Hosahalli village, Ramanagara taluk and district falls under agro-climatic zone *i.e.,* Eastern Dry Zone- Zone 5. The experimental field is located at 12°43' N latitude and 77°16' E latitude and 682 m above sea level. The average temperature ranging between min 24.7°C (76.5°F) and max 37.1°C (98.8°F). The site has a dry weather with humidity ranging from 63 to 77 %. The rainfall here is around 932 mm. The site has moderately deep loamy soils and deep red sandy loam soils [25].

2.1.1 Composting using microbial consortium/ compost culture

One tonne of farm waste (left over residues of ragi straw and cow dung from cowshed, weeds, green and dry leaves in equal proportion) was collected in a compost bag (8ft × 4ft × 2ft) and spread ragi straw at the base layer followed by grass weeds, broad leave weeds and dry leaves. Sprinkle slurry prepared using microbial consortium, cow dung, cow urine and water over each layer of farm waste. All the above steps were repeated in the stated sequence until the pit was filled 1-2 feet above the pit height. Finally, the pit was plastered with mud and cow dung slurry to maintain optimum moisture content inside the heap. To avoid entry of excess water due to rain, to protect from wind and to maintain the moisture and temperature, the pit was covered with shed made of coconut fronds. Water was sprayed timely over the pit to maintain 60-70% moisture. After 4 weeks of decomposition, the first turning was carried out. This composting process was conducted in three farmer's field, one at KVK farm and monitored for up to 4-5 months.

2.2 Waste Decomposer

Waste decomposer is a consortium of microorganism extracted from desi cow dung developed by National Centre of Organic Farming (NCOF), Ghaziabad. Jaggery (2kgs) and one bottle of waste decomposer containing 30g microbial consortium is added to 200 litres of water in a plastic drum. The content of the drum was stirred with a wooden stick twice every day. The drum was covered and stored under shade for five days. On 6^{th} day, 20 litres of waste decomposer solution from 200 litres was used for sprinkling on every layer of one tonne of farm wastes filled in a compost bag.

2.3 Sampling and Analysis

Representative samples (1kg each) were collected at day one of the composting process and every 30 days thereafter, shade dried, oven dries at 60^{o}C, crushed and screened through 0.5mm sieve. The samples collected were analysed for various parameters *viz.*, temperature, moisture content, pH, EC, organic carbon and nutrient content. At each sampling period, the pH was determined potentiometrically in 1:10 suspension, EC conductometrically and moisture content was calculated by the deduction of weight loss. The chemical composition of the collected samples were determined as per standard procedures.

Phosphorus, potassium, calcium, magnesium, iron, manganese, zinc, copper and boron content were determined by thediacid (HNO_3 +$HClO_4$ in 10:4) digestion method [27]. C:N Ratio was calculated by dividing the total organic carbon with total nitrogen.

3. RESULTS AND DISCUSSION

The present study was carried with an objective to utilize the farm waste more effectively by decomposition using appropriate microbial consortium. Analysis of all the physical and chemical parameters revealed that right quantity of the consortia decomposed the raw material within a very short time period. However, among the different consortia, decomposer of IIHR followed by compost culture of UASB decomposed rapidly to correlate between microbial colonization and rate of decomposition.

Sl no	Parameters	Methods	References
1	pH	Potentiometric method	[26]
2	ECdsm^{-1}	Conductivity bridge method	[26]
3	OC %	Walkley and Black, 1936, wet digestion method	[27]
4	Total N %	Micro kjeldahl distillation method	[27]
5	Total P %	Vanadomolybdate yellow colour method	[27]
6	Total K %	Flame photometer method	[27]
7	Total Ca and Mg %	Versenate titration method	[27]
8	Micronutrients- Fe, Mn, Zn and Cu ppm	Atomic Absorption Spectrophotometer with appropriate hallow cathode lamps	[28]
9	Boron ppm	Azomethine-H method	[29]

3.1 Physical Characteristics

During the composting process, gradual changes in the textures of the raw materials were observed after 30 days, followed by the appearance of a black coloured humus-like substance which developed after 80 days of decomposition. In this study, Farm waste treated with decomposer of IIHR took 90 days followed by compost culture of UASB in 105 days to stabilize the compost, whereas farm waste treated with waste decomposer of NCOF and farmers practice took 195 and180 days respectively. Moisture appeared to be a key influencing factor for microbial activity [10], as low moisture contents inhibit the growth of beneficial microorganisms [7], while excess moisture can create anaerobic conditions, leading to the production of unpleasant odours and toxic volatile substances [30]. So, the moisture content was maintained at 60% by sequential watering to replace any water loss. The composting process was monitored for up to 4 months and moisture content was allowed to reduce after 70 days except for farmers practice and NCOF waste decomposer where the process was monitored for up to 7 months and moisture allowed to reduce after 150 days. The study revealed that the quantity of NCOF waste decomposer (20L per tonne of farm waste) used for composting was not sufficient for efficient decomposition of farm waste. This may be due to less microbial counts in 20 litres of waste decomposer solution for effective decomposing of farm wastes.

The temperature was raised from 35^oC to $65^oC \cong 5$ on 60^{th} day of composting because of high microbial activity, thus indicating rapid decomposition, later there was drop in temperature to $35^oC \cong 4$ and reached the constant temperature (Fig.1f). Weight loss was observed during the compost formation process. The weight loss was calculated using a simple deduction method. The reduction in weight was more significant during the first 45 days, which is a similar result to those observed by Andrea *et al.* [31].

The weight loss of compost was 19.1% (T_1), 19.2 % (T_2), 24.8% (T_3), 24.6% (T_4) may be due to the loss of dry mass in terms of CO_2 [24] and mineralisation of organic matter during the compost process. We can produce more compost annually from decomposer of IIHR (3.3tonnes) and compost culture of UASB (2.8tonnes) when compared to waste decomposer of NCOF (1.4tonnes) and farmer's practice (1.5tonnes). When we calculate Benefit Cost ratio, decomposer of IIHR (B/C is 6.67) and compost culture of UASB (B/C is 7.25) benefit the farmers more than waste decomposer of NCOF (B/C is 5.17) and farmer's practice (B/C is 4.71) (Table.1).

3.2 Chemical Characteristics

3.2.1 pH, EC and organic carbon changes during composting

The changes in pH, EC and organic carbon during the composting process are shown in Fig. 1.The decreasing trend of pH, EC and organic carbon value was observed during decomposition period. The initial pH values were between 8.0 and 8.5. In the first 60 days of composting, drastic decrease in pH was observed for all the treatments. The pH decrease is the result of volatilization and microbial decomposition of organic acids, and the release of ammonia by microbial mineralization of organic nitrogen sources [32]. A similar pH drop was observed by Poincelot (1974), and White *et al.,*(1995) suggested that an alkaline pH could enhance the composting process, controlling pathogenic fungi that prefer acidic growth conditions [30]. The decomposition of organic wastes at pH values of 6.0 or below can slow down the decomposition process, while pH values above 8.0 can cause the release of unpleasant smells associated with ammonia. Earlier studies have identified that microbial activity enhanced the likelihood of achieving a suitable pH range of 5.5–9.0; while the composting process is most effective at pH values between 6.5 and 8.0 [33]. The pH value stabilized at 7.0 after 90 days of composting for the trial of decomposer of IIHR and 105 days for compost culture of UASB, whereas NCOF and farmers practice(Fig. 1a), which achieved a neutral pH after at 150 days.

The decreasing trend of EC from 1.6±0.3 dsm^{-1} to 0.8±0.1 dsm^{-1} was observed during the composting of farm waste. It is an indication of mineralisation of wastes [30]. The initial organic carbon content was relatively high at 35 ±1.5%, which reduced to 25±1.5% during composting as carbon loss as CO2 [7].

3.3 Nitrogen Content

The results recorded for total nitrogen content was found to be relatively higher, ranging from 1.10 to 1.59% and showed increasing trend with time in all the trials during composting (Fig.1d). The higher nutrient content in the compost was probably due to better decomposition, loss in initial weight of composting material [34] and the raw material used for composting.

Table 1. The days taken for composting, number of cycle, quantity produced, income, expenditure and B: C as influenced by different compost culture

Treatments	Days of composting	Volume reduction (%)	No cycle in a year	Quantity produced (Kg/year)	Gross Income/ year(Rs.)	Total Expenditure/ year (Rs.)	Benefit Cost ratio
T_1-IIHR	90	19.15	4.06	3282.97	6565.94	985	6.67
T_2-UASB	105	19.20	3.48	2809.22	5618.43	775	7.25
T_3-NCOF	195	24.83	1.87	1407.38	2814.75	545	5.17
T_4-FP	180	24.60	2.03	1529.31	3058.63	650	4.71
Sem	0.99	0.04	0.04	34.58	69.15	5.98	0.10
CD	3.18	0.12	0.13	110.61	221.23	19.13	0.32
CV	1.39	0.34	2.78	3.06	3.06	1.62	3.32

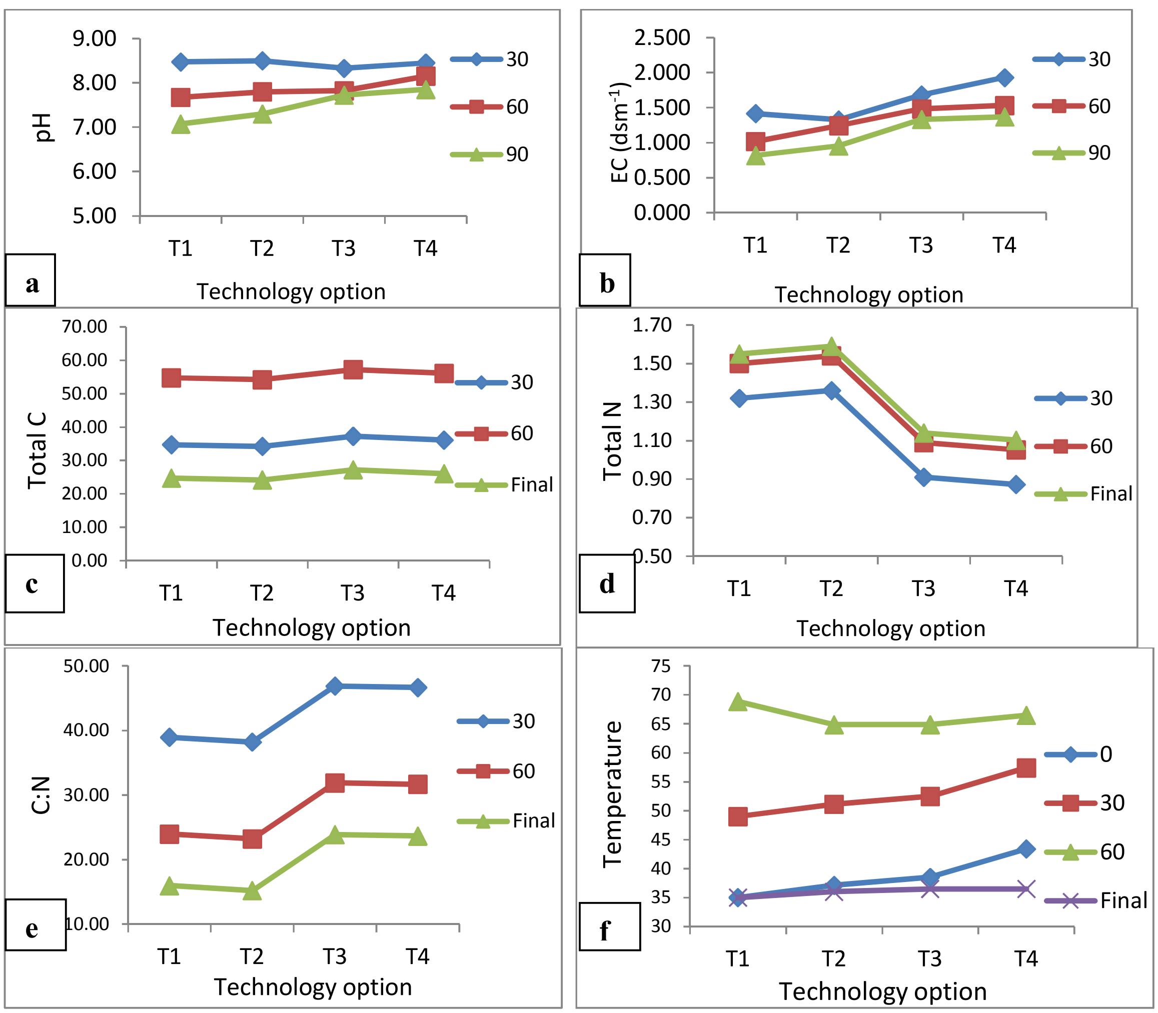

Fig. 1. Changes in pH(a), EC(b), total carbon(c), total nitrogen(d), C:N(e), temperature(f) during the decomposition of farm wastes

Table 2. Physico-chemical properties of matured farm waste aerobic-compost

Treatments	pH	EC(dSm^{-1})	total C%	total N%	CN
T_1-IIHR	7.08	0.83	24.75	1.55	15.98
T_2-UAS(B)	7.05	0.85	24.20	1.59	15.23
T_3-NCOF	7.36	0.92	27.25	1.14	23.91
T_4-FP	7.12	0.96	26.10	1.10	23.69
Sem	0.04	0.05	0.30	0.01	0.21
CD	0.12	NS	0.97	0.02	0.67
CV	1.07	10.80	2.36	0.77	2.12

Table 3. Macro and micronutrient concentrations in matured farm waste aerobic-compost

Treatments	P	K	Ca	Mg	S	Zn	Cu	Fe	Mn	B
			%					ppm		
T1-IIHR	0.93	0.95	4.39	0.69	0.19	82	10	930	305	26
T2-UAS(B)	0.91	0.97	4.25	0.88	0.21	93	9	948	325	28
T3-NCOF	0.68	0.80	3.38	0.59	0.17	78	8	850	287	21
T4-FP	0.51	0.82	3.50	0.46	0.15	67	8	810	210	23
Sem	0.01	0.01	0.01	0.01	0.00	0.88	0.69	1.09	1.01	0.81
CD	0.03	0.02	0.05	0.02	0.01	2.82	NS	3.48	3.22	2.58
CV	2.53	1.25	0.75	2.10	4.32	2.20	15.63	0.25	0.71	6.60

3.4 C/N Ratio

The initial organic carbon content was relatively high at 39.75%, which is consistent with the observations of Hadas and Portnoy (1994). The C: N ratio gradually decreased (Fig.1e). Atkinson *et al.* [35] reported that a reduction of 29% of the organic carbon content occurs during composting of organic waste; while a reduction of only 10% in the carbon content was estimated by Erickson *et al.,* [21] and Umsakul *et al.,*[7]. When the consortium of IIHR and UASB were used, the rate of decomposition was faster and the C:N ratio reduced to 15.98/15.23:1 at 90/105 days respectively, whereas the farmers practice and NCOF waste decomposer required more than 180 days for the decomposition (Fig.1e). Of the three consortium tested, compost culture UASB had a greatest increase in the rate of decomposition (Fig.1e).

The decrease in the C:N ratio can be explained by the transformation of organic carbon into carbon dioxide, followed by a reduction in the organic acid content [36-39,24]. Saidi *et al.,* [30] reported that a stable C:N ratio could be achieved after 90 days of decomposition. High C:N ratios can indicate the presence of unutilized complex nitrogen substrates [30,23].

3.5 Total Phosphorus Content (P)

Throughout the composting process, the total phosphorus varied between 0.51 and 0.93%, depending on the inoculum (Table.3). The lowest phosphate ion concentrations were measured for farmers practice and waste decomposer, while the maximum concentration was measured for decomposer IIHR and compost culture UASB, due to better decomposition resulted from higher microbial activity through added culture.

3.6 Other Plant Nutrients

Due to the decomposition of farm wastes, animal manure and weeds with microbial inoculant, potash (K) ion concentration of matured compost recorded from 0.80 to 0.97%. The exchangeable bases *i.e.* calcium (Ca - 3.38 to 4.39%), magnesium (Mg - 0.46 to 0.88%), sulphur (S - 0.15 to 0.21%) were also assessed in composting of farm wastes and found relatively high content of exchangeable bases (Table 3). Micronutrients concentration of matured compost recorded 810-945 ppm of iron (Fe), 210-325ppm manganese (Mn), 67-93ppm zinc (Zn), 8-10ppm copper (Cu), and 21-28ppm boron (B)respectively (Table3).

4. CONCLUSION

The microbial consortiums from various institutes were used as a starter culture in the composting of farm waste which efficiently decomposed all the substrates. The chemical composition of end products, even from the initial experimental stage, was consistent with national and international standards for composting. For successful composting, the selection and quantity of the most appropriate consortium of the inoculants is an important component [23] in hastening the compost process and the compost was stable after 90 days, with a pH value of 7.0 ± 0.2 and a C: N ratio close to 15:1. The experimental results indicate that the consortium is more effective in composting process. Thus the experiment reveals that microbial consortium from IIHR and UASB could be used to decompose the agricultural wastes efficiently.

The composts can be prepared by the farmers and utilized in integrated soil nutrient management. Farm wastes and available animal manures can be converted into organic manure within short duration by the farmers. Other benefits such as cleaning the environment and reducing the cost on fertilizer application could help to reduce the cost of production.

ETHICAL APPROVALS

We conducted our research after obtaining proper IEC approval.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/75232