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Comparative assessment of maturity indices during the compost formation of bagasse

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ABSTRACT

To overcome the problem of disposal of bagasse, a popular method of composting called NADEP method in its modified form was used in the study. The study was done by making brick-walled tanks and taking three types of treatments having different proportions of bagasse with cow dung, rice straw and soil. The study was done for 105 days on the basis of compost maturity parameters like temperature, C/N ratio, total microbial population, moisture content and pH. The treatment which contained bagasse with cow dung (B2) in the ratio of 1:2 achieved maturity comparatively fast with a sharp decrease in C/N ratio in 15 to 30 days. This reflects that cow dung itself is a good microbial inoculant. The compost so prepared can be used as a growing medium for crops. In this way NADEP method was standardized on small scale to be used individually by any farmer or person of low economic status.

KEYWORDS

Bagasse;
NADEP method;
Cow dung;
Rice straw;
C/N ratio;
Compost.

INTRODUCTION

In the wake of the Green Revolution, our agriculture has become heavily reliant on fertilizers and chemicals. Through their use, increased pollution of soil, water and environment has resulted in health hazards. Consequently, in Organic Farming, the use of fertilizers and chemicals is prohibited. Quality compost when incorporated into the soil would improve its physical characteristics and thus enhance chemical and biological activities leading to higher soil fertility [6, 7, 12]. The agricultural soil in the country is also gradually losing its productivity because of the irrational/uncontrolled use of chemical fertilizers[2, 18]. This has smashed the natural microbial flora in soil. This has caused a total loss of ecological poise and unless a solution is found in time, it may lead to an irremediable loss of soil fertility. The situation can be remedied effectively by means of organic fertilizers and insect repellants in place of chemical fertilizers and insecticides. Many farmers have realized this and are switching over to organic farming.

Composting is a dynamic process which will occur swiftly or gradually, depending upon the process used and the skill and technique with which it is executed. A neglected pile of organic waste will inevitably decompose, but slowly. This has been referred to as "passive composting" because little maintenance is performed. Fast or "active" composting can be accomplished in two to six weeks. This method requires three key activities: aeration, proper moisture content, and proper carbon to nitrogen (C/N) ratio. The composting process is currently viewed primarily as a waste management method to alleviate organic waste, such as manure, yard trimmings, municipal biosolids, and organic urban wastes. The stabilized end-product (compost) is widely used as a soil amendment to perk up soil structure, provide plant nutrients, and assist the revegetation of disturbed or eroded soil. Composts can assist in agricultural crop production by improving soil physical properties, such as by lowering bulk density and increasing water holding capacity[13].

Bagasse is a fibrous residue of Sugarcane stalks left over after the crushing and extraction of the juice. A sugar factory produces nearly 30% of bagasse out of its total crushing. Many research efforts have attempted to make use of bagasse as a renewable feedstock for power generation and for the production of bio-based materials. This by-product is commonly burnt or used by the sugar factories as a fuel for the boilers. The low calorific value of bagasse makes this a low efficiency process. Also, the sugar cane mill management encounters problems vis-à-vis convention of "clean air" from the Environmental Protection Agency, due to the eminence of the smoke released in the atmosphere. Presently 85% of bagasse production is burnt. Even so, the excess bagasse is deposited on empty fields altering the landscape which causes impairment to soil fertility and environment. Composting a natural biological process is the controlled decay of organic matter in a warm moist environment by action of bacteria, fungi and other organisms[22].

Bagasse is broken down slowly by the indigenous microorganisms originally present in it, even with the entire environmental conditions maintained at an optimum level, because of the unfavorable C/N ratio and the high content of lignocellulose. Bagasse may be used in composting if it is first shredded, enriched with other substances. Direct incorporation of raw agro-industrial waste into the soil may cause detrimental effects such as phytotoxicity and soil nitrogen immobilization. The main aim of this study was to study compost formation of Bagasse by NADEP method under various conditions; Physico-chemical analysis of bagasse (total organic carbon, total nitrogen, C/N ratio, moisture content and temperature); and to study the change in total microbial population during composting.

MATERIALS AND METHODS

Bagasse was collected from a sugar mill (Kichcha, Udham Singh Nagar, India), cow dung and surface soil from University farm, and rice straw from dairy farm (Nagla, University farm). Bagasse and rice straw were chopped into lengths of about 3-6 cm before mixing.

A tailored method of making compost called NADEP method was used in this study[4, 8, 10]. For this, four tanks of same size were prepared which were made up of bricks. The tanks were prepared in such a manner that the free air spaces should be there. The tanks were set aside in a Polyhouse in the College of Basic Sciences and Humanities (at G.B. Pant University of Agriculture and Technology, Pantnagar, India). Apt shadow and aeration was maintained there. At the bottom of each tank a 2.5 cm layer of slurry (cow dung+soil+water) was spread as bedding material followed by bagasse with other materials. The layering of bagasse with other materials i.e. rice straw, cow dung or soil was done in an appropriate manner. For this, the experiment was divided into different treatments depending on the different patterns of layering as shown in the TABLE. There were three treatments (B1, B2, and B3) and one control in the experiment. The total biomass taken in each treatment was 5 kg.

TABLE 1 : Treatment layout for composting

Treatments	Symbol	Compositon	Ratio
1	B1	Bagasse+Cowdung+Soil	1:2:1
2	B2	Bagasse+Cowdung	1:2
3	B3	Bagasse+Cowdung+Rice straw	1:2:1
Control	C	Cowdung+Rice straw+Soil	1:2:1

Composite samples were taken at five symmetrical locations in each pile. The sampling of treatments and control was made weekly for temperature and moisture content. Total organic carbon, total nitrogen, total microbial population, and pH were analyzed at every 15 days. Moisture content was estimated by drying the samples at 105^0C in an oven for 24 hrs[3]. The pH was determined on a water extract from compost using compost to water ratio of 1:5 by weight[16]. Temperature was recorded daily equally in the morning (9 A.M.) and evening (5 P.M.) at 10 cm depth in compost pile using thermometer specifically designed for measuring temperature and the data obtained are the means of both the values weekly. The organic matter (OM) content of compost sample was analyzed by weight loss on ignition at 430^{0}C for 24 h. For this, sample was kept in oven at 105^{0}C for 48 hrs. After this, the dry weight of sample was taken. Then sample was further kept in muffle furnace at 430^{0}C for 24 hrs. Then final dry weight was measured. Total organic carbon (TOC) was calculated from organic matter[19]. Total Nitrogen was estimated by the 'Micro-kjeldahl' method[3]. The C/N ratio of the compost sample was determined by estimating the values of total organic carbon (TOC) and total nitrogen and then dividing TOC by total nitrogen.

The total microbial population was estimated by Plate Count Method[24]. The media used in this experiment was Nutrient agar (Beef extract, 3.0 g; Peptone, 5.0 g; Agar, 20.0 g; distilled water, 1 litre [pH, 7.0]). The incubation temperatures were 37^{0}C for mesophilic growth and 65^{0}C for thermophilic growth. The incubation time was 24 h for both types of microorganisms. All the experiments were conducted in triplicates and data were stored in Microsoft Excel. Completely randomized design (CRD) with two or three factors was used. Data was statistically analyzed using programme Stpr2 and Stpr15.

RESULTS AND DISCUSSION

Evaluation of stability and maturity parameters

Variation in pH

Initially the pH was low (acidic) in all treatments due to acidic nature of bagasse. But as the experiment proceeded, pH increased slowly and after that it became neutral and then got stabilized (Figure 1). The reason behind this could be that in the early stages of the composting, organic acids were accumulated as a by-product of the digestion of organic matter by bacteria and fungi[14]. The resulting drop in pH encourages the growth of fungi, which are active in the decomposition of lignin and cellulose. Usually, the organic acids breakdown further during the composting process, and the pH rises. This may be caused by two processes that occurred during the thermophilic phase: decomposition and volatilization of organic acids and release of ammonia by microbes as they break proteins and other organic nitrogen sources. Later in the composting process, the pH became neutral as the ammonia was either lost to the atmosphere or incorporated into new microbial growth. Finished compost had a pH between 6 and 8[17].

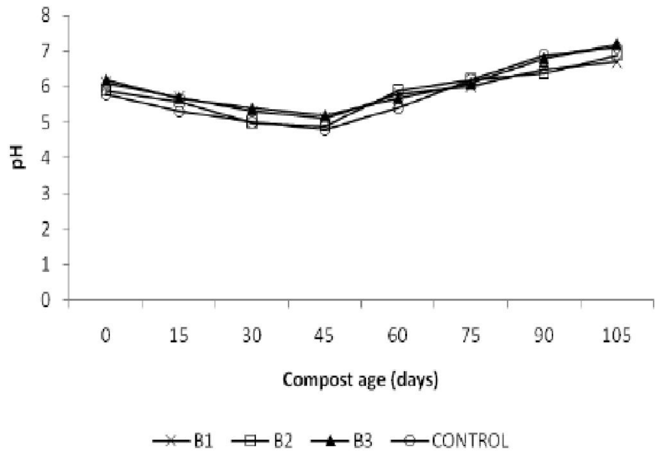

Figure 1 : Variation in pH of composting material over time

Temperature fluctuation during the experiment

Results show that there was a sudden increase in temperature (40 to 55^{0}C) in 7 to 35 days and after then temperature started decreasing slowly and reached to about 28-29^{0}C after 105 days (Figure 2). This sudden increase in temperature may be due to intense microbial activity[17]. Temperature is an important parameter indicating the rate of composting process and compost maturity[11]. Temperature profiles for different treatments attained the optimal temperature for effective composting of 50-60^{0}C[25]. The thermophilic phase started in the vicinity of the beginning of the composting process. The temperature of all treatments decreased speedily to <40^{0}C between 50 to 60 days and continued to decrease at a snail's pace to ambient at 90 days.

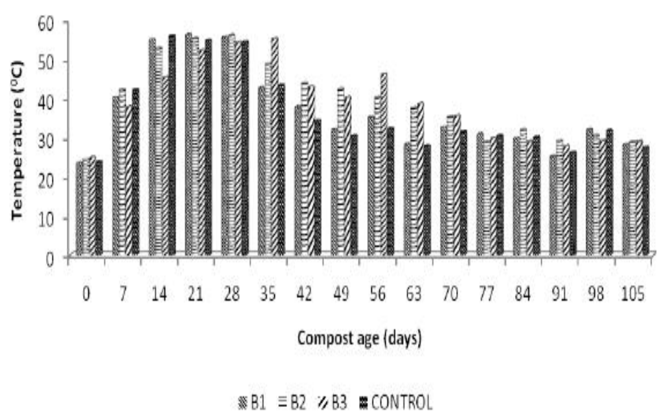

Figure 2 : Temperature fluctuation in compost matrix with time

No mixing and larger piles may have kept the temperature higher for a longer time.

Moisture content

Moisture content plays a crucial role in the process of composting[15]. There was a little difference in the moisture content between treatment B2 (bagasse+cowdung) and control throughout the experiment. But statistical analysis showed that at the end of the experiment, the moisture content of control was higher as compared to treatment B2 (Figure 3). Moisture content of all treatments at the outset was in the range of 65%, but as the composting process proceeded the moisture level decreased due to hasty microbial activity. To sustain it, water was strewn on samples to keep them moist[5].

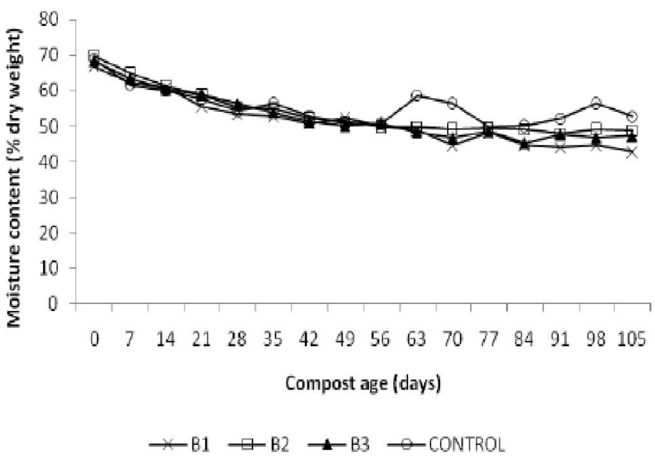

Figure 3 : Changes in moisture content in compost samples over time

Total Organic carbon

There was a variable decrease in organic carbon content of bagasse. The total organic carbon content of all treatments initially was >60%, but as the composting process proceeded, the total organic carbon content decreased. After sometime it became almost stable in the range of 27-30% (Figure 4). The lowest percentage of total organic carbon in treatment B2 shows that it had rapid composting and speedy decomposition of total organic carbon. This was may be due to mixing of more amount of cow dung to bagasse because in other treatments, cow dung was in low amount (by weight). Cow dung offers plenty amount of microbes as compared to other treatments which degraded the sample very fast and split more carbohydrate into CO_2, thus carbon content get decreased[20].

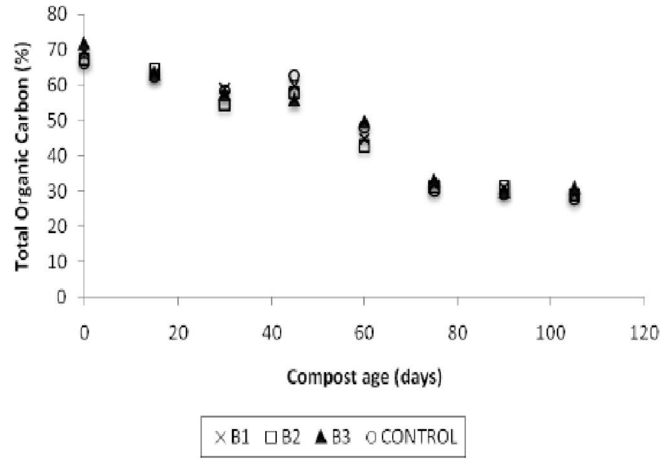

Figure 4 : Variation in Total organic carbon of composting material over time

Total nitrogen

In the process of composting, firstly the total nitrogen content was low depending on the constituents used. But as the composting process proceeded, micro organisms may have degraded carbon much faster than nitrogen. Most of the nitrogen was recycled into new micro organisms. This resulted a boost in total nitrogen content[17]. Total nitrogen content of all treatments initially was about 1%, but after then, it increased all of a sudden from 30 to 45 days and after then it increased very slowly (Figure 5). Nearly 50% of the carbon was lost but less than 20% of the nitrogen[16]. At the end of the experiment, total nitrogen content in treatment B2 was highest. This was may be due to higher microbial population in more amount of cow dung, more nitrogen was recycled into the micro organism.

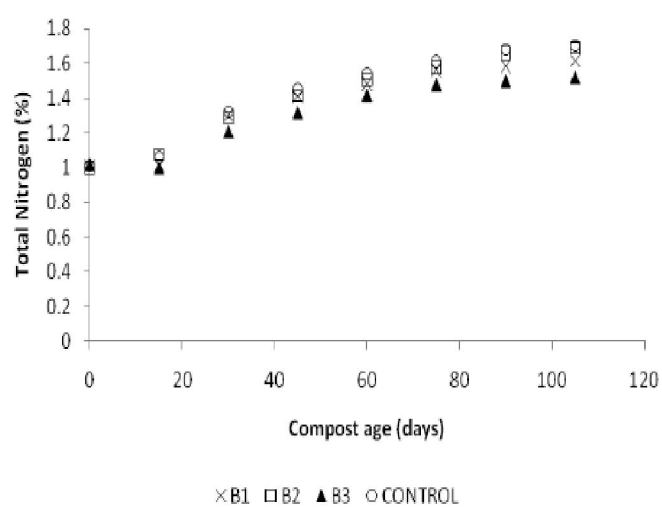

Figure 5 : Fluctuations in Total nitrogen of composting material with time

Change in C/N ratio

As there was a decrease in organic carbon day by day and an increase in total nitrogen, so the ratio of carbon and nitrogen (C/N ratio) decreased[11, 23]. Highest C/N ratio was in the treatment B3 may be because of mixtures of two main substances (rice straw and bagasse) which had already a high C/N ratio[1]. C/N ratio decreased sharply till 45 days due to high microbial activity. It was most likely due to greater loss of carbon than nitrogen during composting[16]. After 45 days, C/N ratio decreased slowly and at the end of the experiment, treatment B2 had lowest C/N ratio (Figure 6). Although the relative differences in C/N ratios between all treatments was not so much distinct, but lowest C/N ratio of treatment B2 reflects its higher amount of microbial biomass, high microbial activity and good proportion of substrates.

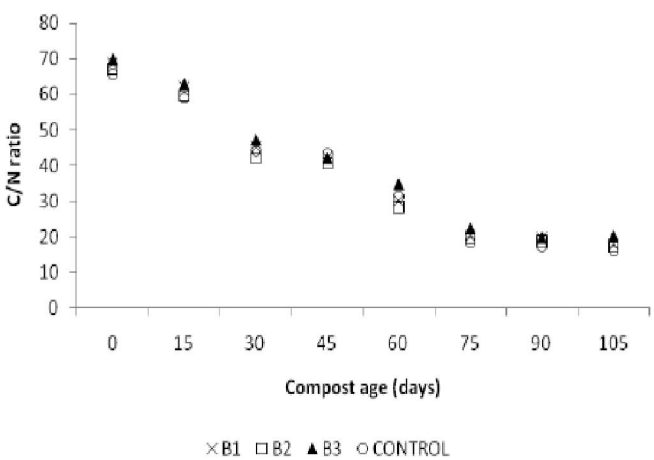

Figure 6 : C/N ratio of different compost samples with changing time

Total microbial growth

The growth of both the mesophilic and thermophilic microorganisms, at various stages of the composting process, was determined. The growth of the mesophilic microorganisms in the pile regularly increased with time and reached a maximal growth of approximately 10^{10}-10^{11} CFU g^{-1} after 30 days of composting. After that this number declined for some time and then became stable (Figure 7). Thermophilic microorganisms in pile grew rapidly, reaching CFU of approximately 10^{11}-10^{12} CFU g^{-1} between 30 to 60 days of decomposition and then slowly declined to 10^{7} CFU g^{-1} at the end of composting time (Figure 8). The growth rates of the mesophilic and thermophilic microorganisms in the treatments were mostly parallel to each other but resulted in overall lower cell counts. In the end the lowest microbial population was observed in treatment B2, which means, it may have decomposed faster than other treatments. During the decomposition, the temperature of the material was raised, which favors the growth of microorganisms during that particular stage of composting. The proliferation of the mesophilic and thermophilic microorganisms during composting is related to the mesophilic and thermophilic stages of the composting system. Microbial succession plays a key role in the composting process and in the appearance of certain microorganisms that reflect the quality of the maturing compost[9, 21].

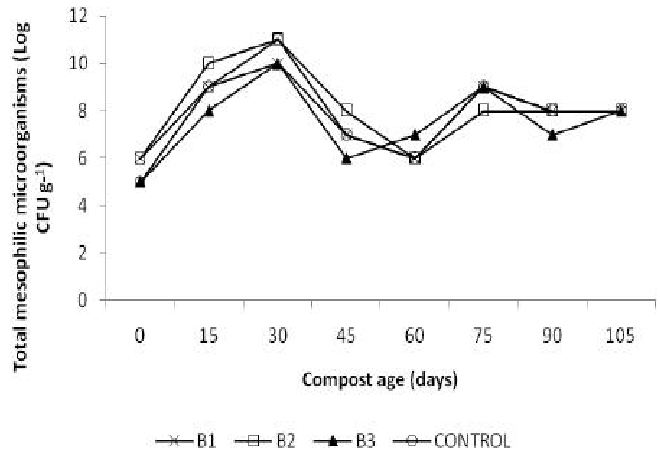

Figure 7 : Growth profile of mesophilic microorganisms over time.

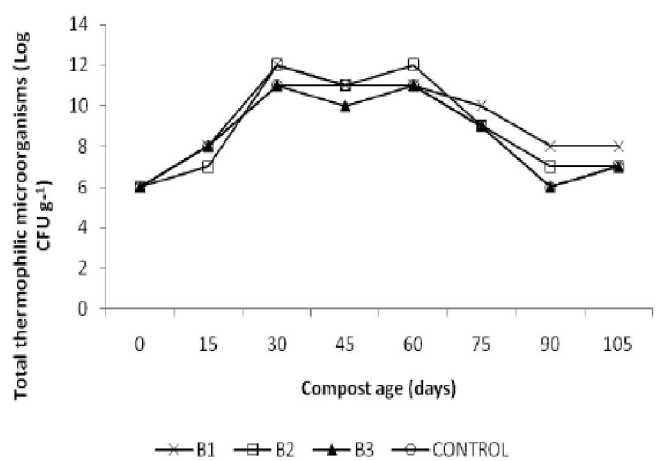

Figure 8 : Growth profile of thermophilic microorganisms over time

CONCLUSIONS

This investigation has revealed that the composting activities of all the three treatments are similar in temperature, pH, and moisture content. However, there was a slight difference in the number of microorganisms in both thermophilic and mesophilic stages in the treatments. Final C/N ratio was observed lowest in the treatment B2 showing better compost formation. Thus, it may be concluded from the present study that: (i) NADEP method of composting is really a suitable method for decomposition of agricultural residue in a short time i.e. 3 to 4 months as compared to other methods, (ii) This is a low cost technology, which can be practiced by farmers of different economic status, (iii) The compost so obtained is of good quality within short time. This method requires less effort but gives good quality compost, and (iv) Composting is one of the important methods of agricultural waste treatment. It not only provides a good bio-fertilizer which is used for making soil more fertile, but also cures the problem of solid waste disposal.

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