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Faizan M Malek
Department of Agronomy, College of Agriculture, Bharuch, Navsari Agricultural University, Gujarat, India

Divyesh D Patel
Department of Agronomy, College of Agriculture, Bharuch, Navsari Agricultural University, Gujarat, India

Tushar U Patel
Department of Agronomy, College of Agriculture, Bharuch, Navsari Agricultural University, Gujarat, India

Payal A Patel
Department of Agronomy, College of Agriculture, Bharuch, Navsari Agricultural University, Gujarat, India

Jay D Patoliya
Department of Agronomy, N. M. College of Agriculture, Navsari Agricultural University, Gujarat, India

Corresponding Author:
Faizan M Malek
Department of Agronomy, College of Agriculture, Bharuch, Navsari Agricultural University, Gujarat, India

Impact of pigeon pea substrate on physico-chemical properties of vermicompost

Faizan M Malek, Divyesh D Patel, Tushar U Patel, Payal A Patel and Jay D Patoliya

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Abstract
This study, conducted from May, 2023 to January, 2024 at Navsari Agricultural University, Bharuch, India, evaluated the physical properties of vermicomposting pigeon pea stalks using different ratios of cattle dung (CD) and pigeon pea stalk (PPS), supplemented with bacterial biodecomposer consortium (BBC) and earthworms (EE). At 120 and 150 days, lowest pH was recorded in the 50% CD + 50% PPS + 10 g BBC + EE (T8) treatment at 7.14. The significantly lower EC was noted in the treatment of 40% CD + 60% PPS + 10 g BBC (T6) which was 1.48, 1.29 and 1.19 dS/m at 90, 120 and 150 days, respectively. Whereas at 30 and 60 days, it was noted in the treatment of 50% CD + 50% PPS + EE (T2) which was 2.98, 2.67 and 2.14 dS/m, respectively. The total organic carbon content of the 60% CD + 40% PPS + 10 g BBC + EE (T7) treatment was significantly lower at 30, 60, 90, 120, and 150 days (40.20%, 36.80%, 31.50%, 31.00% and 30.30%), and it was found to be statistically comparable to the 50% CD + 50% PPS + 10 g BBC + EE (T8) treatment at 30, 60, 120, and 150 days. The significantly higher moisture content (77.58% at 30 days) was found in the treatment of 50% CD + 50% PPS + EE (T2) which was found statistically at par with the treatment of 60% CD + 40% PPS + EE (T1), 60% CD + 40% PPS + 10 g BBC (T4) and 60% CD + 40% PPS + 10 g BBC + EE (T7). Whereas, at 150 days, it was highest in the treatment of 60% CD + 40% PPS + 10 g BBC (T4) (41.81%) which was at par with the treatment of 60% CD + 40% PPS + EE (T1) and 60% CD + 40% PPS + 10 g BBC + EE (T7).

Keywords: Vermicompost, epigeic earthworm, pigeon pea stalks, physical properties, total organic carbon

Introduction
Pigeon pea (*Cajanus cajan* L. Millsp.), commonly known as red gram, arhar, or tur, is a major legume crop in the tropics, particularly in India. It is predominantly grown during the *kharif* season, both as a sole crop and as an intercrop, across diverse agroecological conditions. The seeds of pigeon pea contain 21% dietary protein (Sharma *et al*., 2015) [15] and are rich in essential minerals like phosphorus, magnesium, iron, calcium, sulphur, and potassium (Kunyanga *et al*., 2013). [9] India ranks first globally, contributing to 82% of the total area and 78% of the total production of pigeon pea. Among Indian states, Maharashtra leads in pigeon pea production with 7 lakh tonnes, followed by Uttar Pradesh, Madhya Pradesh, Karnataka, and Gujarat (Anonymous, 2017) [2]. Pigeon pea's deep root system and drought tolerance make it suitable for areas with low and erratic rainfall. As a leguminous plant, it plays a role in nitrogen fixation, enhancing soil fertility (Cardoen *et al*., 2015) [3]. However, the common practice of burning pigeon pea stalks for firewood not only affects the environment negatively but also degrades soil quality. Approximately 10.5 million tonnes of pigeon pea stalks could be efficiently utilized for producing organic manure like vermicompost (Sahoo *et al*., 2021) [14]. The green revolution led to intensive cropping systems that depleted soil organic matter, necessitating increased fertilizer use and resulting in the loss of beneficial soil microorganisms (Singh and Benbi, 2016) [17]. Vermicomposting has been recognized as a rapid, efficient, and cost-effective method to convert crop residues into organic manure. Earthworms act as mechanical mixers, breaking down organic matter, reducing the C:N ratio, and promoting microbial activity (Thakur *et al*., 2021) [20]. Vermicompost produced through this process contains plant growth regulators, high microbial activity, and pest-repellent properties, making it

an environmentally friendly alternative to chemical fertilizers.

Adopting vermicomposting techniques can help farmers manage agricultural costs and reduce reliance on chemical inputs, promoting a greener agricultural practice (Kaplan, 2016) [8]. Epigeic earthworm species, such as *Eisenia fetida*, are particularly suited for vermicomposting due to their surface activity and ability to decompose organic matter rapidly (Hartenstein and Bisesi, 1989; Viljoen and Reinecke, 1992) [6, 22]. This study, conducted at the College of Agriculture, Navsari Agricultural University, Bharuch, aims to evaluate the capacity of pigeon pea stalks for vermicomposting and assess physico-chemical properties like pH, EC, Total organic carbon and Moisture content.

Materials and Methods

The study "Impact of pigeon pea substrate on physico-chemical properties of vermicompost" was conducted from May, 2023 to January, 2024 at the College of Agriculture, Navsari Agricultural University, Bharuch, Gujarat, India. The experiment involved various treatments combining cattle dung (CD), pigeon pea stalk (PPS), bacterial biodecomposer consortium (BBC), and the earthworm species *Eisenia fetida*.

Location and Experimental Site: The study took place at Bharuch (21°42' N, 72°59' E, elevation 18m), specifically at the Farm Shed of the College of Agriculture.

Materials

Pigeon Pea Stalks and Cattle Dung were sourced from the college farm, dried, chopped, and analyzed for chemical properties. Plastic tubs (50 cm diameter, 30 cm height) were used as vermireactors. Each reactor was layered with cattle dung as bedding, topped with a mix of cattle dung and pigeon pea stalks, reaching a total of 6 kg. *Eisenia fetida* were collected from vermicomposting unit, college farm. Liquid BBC was bought from Pathology Lab, NMCA, Navsari Agricultural University.

Treatments

T1	60% CD + 40% PPS + EE
T2	50% CD + 50% PPS + EE
T3	40% CD + 60% PPS + EE
T4	60% CD + 40% PPS + 10 g BBC
T5	50% CD + 50% PPS + 10 g BBC
T6	40% CD + 60% PPS + 10 g BBC
T7	60% CD + 40% PPS + 10 g BBC + EE
T8	50% CD + 50% PPS + 10 g BBC + EE
T9	40% CD + 60% PPS + 10 g BBC + EE

Where, CD = Cattle dung, PPS =Pigeon pea stalks, BBC = Bacterial biodecomposer consortium and EE = Epigeic earthworm

Experimental Procedure

Once the substrate temperature fell below 35 C, 50 adult earthworms were introduced in each of 6 out of 9 treatments. 10 gm/l BBC was applied in each of 6 out of 9 treatments as per experiment. Optimal moisture (70-80%) was maintained, and the reactors were covered with wet jute bags. Manual turning was performed every 15 days, and watering was adjusted to maintain 60-70% moisture after the first month. After 150 days, vermicompost was harvested by stopping watering and separating earthworms. The compost was then sieved and stored. Initial chemical properties of the materials were measured, including pH, EC, organic carbon, CN ratio, and nutrient content as displayed in Table 1. Quality of water used in the experiment was also analyzed as shown in Table 2.

Table 1: Analysis of chemical properties of pigeon pea stalk and cattle dung

Sr. No.	Chemical parameters	CD	PPS
1	pH (1:10)	7.94	7.67
2	EC (1:10)	2.74	1.98
3	Organic carbon (%)	47.8	58.2
4	C:N ratio	65.5	70.7
5	Total nitrogen (%)	0.73	0.82
6	Total phosphorous (%)	0.45	0.76
7	Total potassium (%)	0.48	0.35
8	Total Fe (ppm)	0.17	0.31
9	Total Mn (ppm)	464	379
10	Total Zn (ppm)	126	96
11	Total Cu (ppm)	42	47

Table 2: Details of quality of water used in experiment

Sr. No.	Parameters	Value
1.	pH	7.61
2.	EC (dS/m)	1.91
3.	Carbonate (me/1)	3.20
4	Bicarbonate (me/1)	6.80
5.	Chloride (me/1)	9.70
6.	Ca + Mg (me/1)	5.00
7.	Sodium (me/1)	10.1
8.	RSC (me/1)	5.00
9.	SAR	11.38

Results and Discussion

Changes in Physico-Chemical Properties

1. pH

The pH ranged from 8.24 to 7.14, with the lowest pH observed in the 50% CD + 50% PPS + 10 g BBC + EE (T8) treatment at both 120 and 150 days. As depicted in figure 1, the highest pH was recorded in the 60% CD + 40% PPS + 10 g BBC (T4) treatment at 30 and 60 days. The decline in pH over time is attributed to the breakdown of organic compounds and the release of humic acids, along with the mineralization of nitrogen and phosphorus into nitrates and orthophosphates. Microbial metabolism likely produced CO2 and organic acids, further lowering the pH, as supported by Haimi and Huhta (1986), Albanell *et al.*, (1988) [1] Elvira *et al.*, (1998) [4]. Furthermore, the pH of feedstocks may have decreased as a result of the bioconversion of organic material into organic acids and intermediates reported by Ndegwa and Thompson (2001) [10] and Patel (2023) [12]. During vermicomposting earthworms maintain the pH in the neutral range by secretion of intestinal calcium and ammonia which neutralizes carboxylic and phenolic groups of humic acids produced during the process reported by Pramanik *et al.* (2007) [13]. Reduced pH may also result from the addition of H+ ions by microorganisms during the transformation of NH4+-N into NO --N in waste mixtures. (Rai and Suthar, 2020) [19].

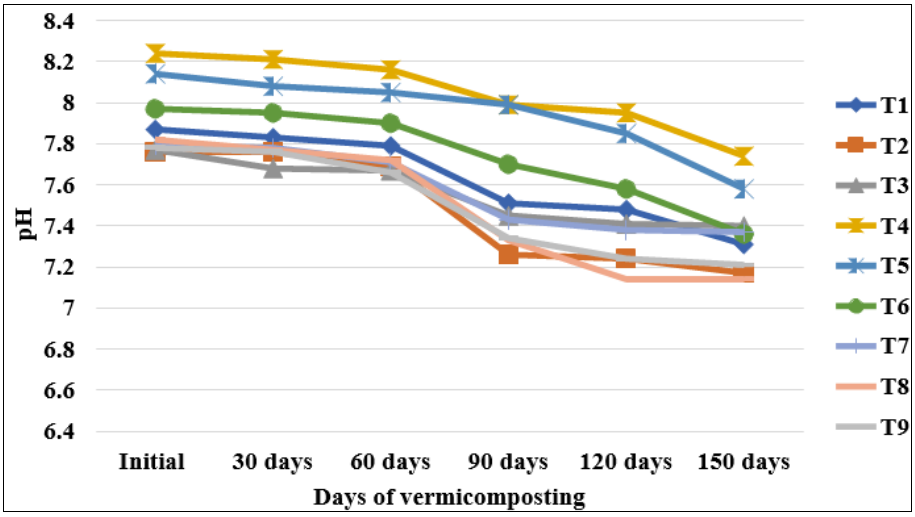

Fig 1: Periodical changes in pH during vermicomposting influenced by different treatments

2. EC

As shown in figure 2, changes in electrical conductivity (EC) of vermicompost varied among treatments, showing a general decrease from the initial substrate. The lowest EC values were observed in the 40% CD + 60% PPS + 10 g BBC (T6) treatment, reaching 1.19 dS/m at 150 days, while the highest was noted in the 60% CD + 40% PPS + 10 g BBC + EE (T7) at 30 days, measuring 3.44 dS/m. The reduction in EC indicates decreased salinity, making the vermicompost safer for agricultural use. According to Lim *et al.* (2012) [10], the precipitation of dissolved salts and the synthesis of soluble metabolites like ammonium (NH +) were the primary causes of the decrease in electrical conductivity. The initial salt content in the wastes was reduced by vermicomposting, when soluble elements were leached out by the excess of water applied reported by Fernández-Gómez *et al.* (2013) [5]. Similar results were also reported by using bio-sludge from a beverage industry by Singh *et al.* (2010) [16] and by using cotton stalk residues by Patel (2023) [12]. In the present experiment, all the treatment showed lowest EC from the threshold value of safer application for soil which was 3.0 dS/m (Soumare *et al.*, 2002) [18].

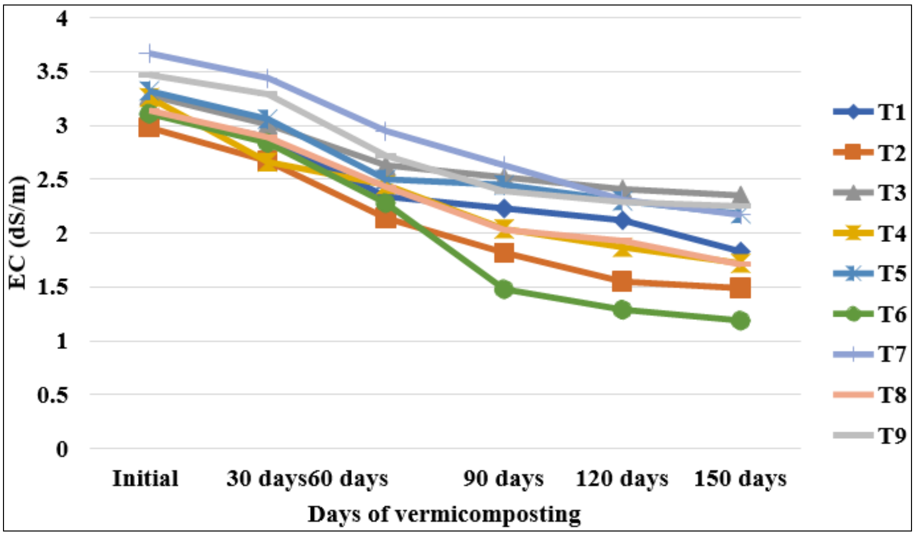

Fig 2: Periodical changes in EC during vermicomposting as influenced by different treatments

3. TOC

Total organic carbon (TOC) content decreased over time, ranging from 48.13% to 30.28%, as depicted in figure 3. The most significant reduction occurred in the 60% CD + 40% PPS + 10 g BBC + EE (T7) treatment, which decreased to 30.28% at 150 days. The reduction in TOC suggests extensive mineralization of the organic matter, CO2 release, and conversion into more stable humic substances. These findings align with previous research by Viji and Neelanarayanan (2015) [21] on the role of earthworms in enhancing organic matter decomposition. The differences in amount of carbon loss may be attributed to rapid respiration rate of microbes as stated by Suthar (2008) [19].

4. Moisture content

Moisture content varied significantly across treatments, influenced by the frequency of watering and the physical activity of earthworms. It is demonstrated in figure 4 that higher moisture content was recorded during the initial stages (30 and 60 days) due to more frequent watering, with levels ranging from 77.94% to 34.68%. The 50% CD + 50% PPS + EE (T2) treatment had the highest moisture content at 30 days, while the lowest was in the 40% CD + 60% PPS + 10 g BBC (T6) treatment at 150 days. Reduced moisture content over time is linked to decreased watering frequency as the compost stabilized. Hossen *et al.* (2022) [7] stated that cattle manure containing 70% initial moisture would be a good option for vermicomposting.

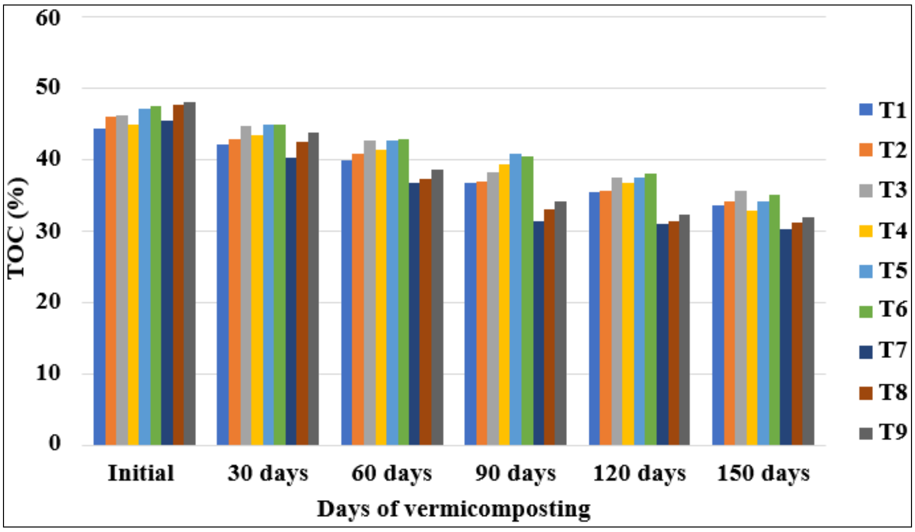

Fig 3: Periodical changes in total organic carbon (TOC) during vermicomposting influenced as by different treatments

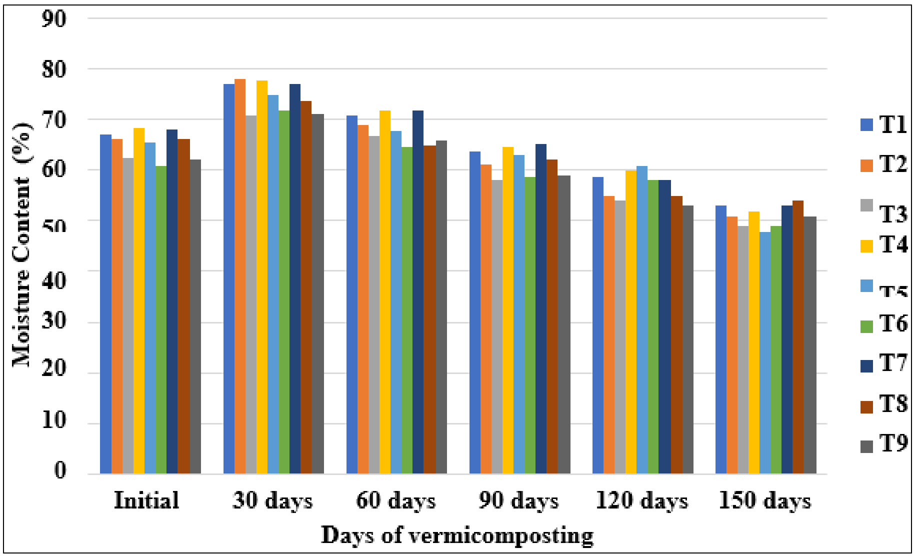

Fig 4: Periodical changes in Moisture content (%) during vermicomposting influenced as by different treatments

Conclusion

The study demonstrated that the treatment of 60% CD + 40% PPS + 10 g BBC + EE (T7) significantly improved the organic carbon reduction and maintained favorable moisture levels, reflecting its effectiveness in the vermicomposting process. At 150 days, the lowest electrical conductivity was achieved in the 40% CD + 60% PPS + 10 g BBC (T6) treatment, while the 50% CD + 50% PPS + 10 g BBC + EE (T8) treatment exhibited the lowest pH. The findings indicate that incorporating bacterial biodecomposer consortium and earthworms into specific ratios of cattle dung and pigeon pea stalks enhances the quality and stability of vermicompost. This approach holds promise for sustainable waste management and improved soil amendment practices.

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