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Chemical and microbiological characterization of organic supplements and compost used in agriculture

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Abstract

Excessive use of chemical fertilizers in agriculture enhances crop production but it may pose a risk to food quality and soil environment. One alternative to agrochemicals is the natural make organic supplements to supply essential nutrients for crop growth and promote healthy soil function. Therefore, an experimental study was performed to analyze the chemical and microbiological properties of locally produced supplements based on cow dung, such as vermicompost, farmyard manure, *Beejamrit*, *Jeevamrit*, and *Ghanjeevarmrit*. The *Jeevamrit* and farmyard manure had the lowest pH (4.93) and electrical conductivity (1.73 dS m^{-1}), whereas *Ghanjeevamrit* and *Jeevamrit* observed highest values (7.80 and 3.62 dS m^{-1}). Vermicompost had the highest concentrations of total N (1.76%), P (0.77%), K (0.81 %), Fe (398 mg kg^{-1}), Mn (65.9 mg kg^{-1}), Cu (15.5 mg kg^{-1}), and Zn (18.2 mg kg^{-1}). Under *Ghanjeevamrit*, 35.9 % of the total carbon was found, followed by farmyard manure (34.5 %) and vermicompost (24.1%). The counts of soil heterotrophic bacteria, fungi, actinomycetes, and beneficial microbial diversity such as P solubilizer, and nitrogen (N) fixer were found highest in vermicompost. However, in *Jeevamrit* there was no growth of actinomycetes and N-fixing bacteria whereas, in *Beejamrit* preparation except actinomycetes all other microbial growth was visible. Organic supplements such as farmyard manure had the lowest indole acetic acid production (1.66 µg ml^{-1}), while *Ghanjeevamrit* showed the highest (6.38 µg ml^{-1}). The liquid formulation (*Beejamrit* and *Jeevamrit*) indicated more levels of indole acetic acid than the farmyard manure (2.18 and 1.87 times more, respectively). The application of organic supplements had a great role in supplying available nutrients and modulating microbial diversity and plant growth hormone production.

Keywords beejamrit, farmyard manure, ghanjeevamrit, vermicompost

Introduction

The Indus Valley civilization in India was the origin of agricultural farming within the country, which then spread to other regions, including the southern section of India. Vedic documents and shlokas documented a number of innovations in crop production since that period, which evidently offered the art and science of agricultural practices at that time. Traditional crop cultivation methods that was prevalent in ancient India placed more attention on the health of the soil and the plants as well as how these factors affected agriculture, ecology, and the environment as a whole [1]. It is very essential to derive a robust, viable, and adoptable nutrient management module through organic inputs for different crop varieties on the basis of scientific knowledge, local environments, and economic viability. Native cattle species are different and distinct species in terms of both appearance and traits. In Indian agriculture, the cow is the backbone that supports the rural economy and livelihood upliftment. Cow urine is a good source of plant nutrients and has antifungal qualities as well as numerous other beneficial roles [2]. It has been used in crop production since ages. Many inputs and formulations based on traditional approaches and experiences have been documented in Indian agriculture [3-5].

Indigenous Technical Knowledge (ITK) refers to these formulations, which include *Panchagavya*, *Sasyagavya*, *Jeevamrit*, *Ghanjeevamrit*, *Beejamrit*, and several more that mainly include local availability of farm inputs. Recently, the use of these cost-effective formulations has been restored and regained its importance in modern agriculture scenarios, specifically in biodynamic, organic, and chemical free natural farming. In India, in the present scenario, low-cost formulations have now established a foundation to foster sustainable agriculture in natural farming [4]. Likewise, the current research indicates that most of these unique formulations are microbial-based concoctions. Therefore, by promoting healthy plant-microbe interactions, the application of these formulations in agricultural fields is an important component of soil health restoration [6-8]. The use of liquid organic formations like *Beejamrit*, *Jeevamrit*, and others (*Ghanjeevamrit*) in the natural system of farming has received greater attention in recent years. Devakumar et al., [2] and Sreenivasa et al., [9] observed the presence of several beneficial microflora *viz*., N fixers, P solubilizers, actinobacteria, fungi, and also numerous growth stimulators in this type of organic formulations.

Palekar [10] reported that the *Jeevamrit*, *Ghanjeevamrit*, and *Beejamrit* indigenous components/supplements have a greater load of microorganisms, which helps in the mineralization of essential macro and micronutrients elements that aid in plant availability and uptake. These formulations is incredibly rich in microorganisms, that proliferate in the soil easily and helps in boosting the microbial processes and their activity. Indian farmers belonging to small and marginal categories generally use available local resources or inputs for farming with the indigenous cow (*Bos indicus*) urine and dung, lime, pulse flour, and a palm of chemical-free soil which is used as foliar application following fermentation process. Many indigenous formulations or decoctions, like the cow dung and urine-based *Beejamrit*, *Jeevamrit*, and *Ghanjeevamrit*, have proved their positive impacts on soil chemical and biological characteristics. These substances possess a lot of microbial characteristics, which boost the soil microflora and produce a significant increase of different soil enzymes [9, 11]. Sreenivasa et al., [9] confirmed that the final formulations such as *Beejamrit*, *Jeevamrit*, and *Ghanjeevamrit* made from cow-based products that have rich in beneficial microorganisms such as *Azospirillum*, *Azotobacter*, P solubilizing bacteria, *Pseudomonas*, lacto-bacteria and *Methylotrophs* and several other microflorae.

However, there aren't plenty of scientific research or additional sources of data to back up this kind of traditional practice. The bulk of individual investigations have been documented, however, the literature on chemical and microbiological studies is not comprehensive. Therefore, the characterization of the chemical and microbiological properties of organic supplements are the focus of the present study.

Methodology

Preparation of indigenous and organic supplements

The farm-yard manure (FYM) was made by utilizing cattle dung and urine, farm biomass residue and straw whereas, vermicompost (VC) was prepared by using efficient earthworm species namely *Eisenia fetida* and *Eudrilus eugeniae*. The organic supplements preparation such as *Beejamrit*, *Jeevamrit*, and *Ghanjeevamrit* were prepared by using the standard method [10] as follows:

(1) Beejamrit

The *Beejamrit* was prepared by blending the indigenous cow dung and urine and the lime in a certain amount. Taking 5 L of cow urine and 5 kg of cow dung were added in a plastic drum containing 20 L of water and the minute was then thoroughly mixed with 50 g of lime and a fist of local soil. This was directly used for seed or seedling treatment.

(2) Jeevamrit

This preparation includes 10 kg of fresh cow dung and 5-10 L of cow urine, 2 kg of jaggery, 2 kg of pulse flour, and the palm of soil (150 gm) from a chemical-free area were added and thoroughly mixed in 200 L of water in a container. The mixture was kept in the shade for approximately 48 hours for fermentation purposes and this was ready for application on 9th day and could be applied up to the 12th day from its preparation.

(3) Ghanjeevamrit

The Ghanjeevamrit includes indigenous cow dung (100 kg, air dried for 4-5 days), cow urine (3 liters), jaggary (1 kg), pulse flour (1 kg) and 250 gm of soil from the uncultivated area or forest or tree cover. 10 days later of its preparation, this could be used directly as a field application.

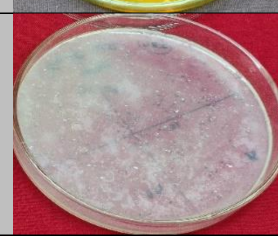
Chemical characterization of the organic preparations

All the preparations were assessed for various properties like pH, electrical conductivity (EC), total organic carbon (TOC), total N, P, K, and total micronutrient elements such as Fe, Mn, Cu, and Zn followed by standard protocols. The soil pH and EC (1:2.5 formulation: water) were determined by pH meter and EC conductivity meter, respectively [12]. The total carbon of solid manure such as farmyard manure (FYM), vermicompost (VC), and *Ghanjeevamrit* was estimated by the dry combustion method using a Muffle furnace. The total carbon in liquid formulations such as *Beejamrit* and *Jeevamrit* were estimated by a TOC analyzer [13]. The total content of macronutrients like N, P, and K were analyzed by standard protocol [14]. The N was digested by taking a sample (1 g solid and 10 ml liquid) in a 150 ml conical flask, added 10 ml of concentrated hydrochloric acid (HCl) kept overnight, and after that, added 10 ml of di-acid (HNO_3:$HClO_4$; 9:4). For P and K, took the same amount of sample as N but added only di-acid, and placed on a hot plate until the color changed to pure transparent white. The micronutrient (Fe, Mn, Cu, and Zn) was also measured in the digested sample by using atomic absorption spectrophotometry [15].

Microbial characterization of organic supplements

The samples collected for microbial studies were always stored at 4°C in the refrigerator. The culturable microbial population was counted by the dilution plate count method [16] for total microflorae such as bacteria, fungi, actinomycetes, P solubilizing bacteria, and N fixing bacteria on nutrient based agar, Martin's Rose-Bengal, Kenknight-Munaier's, Pikovskaya's agar, and Jenson's medium, respectively. The compost (10 g) and liquid (10 ml) formulations in 90 ml of sterilized water blank, and mixed uniformly to make 10^{-1}. The series of dilutions was followed up to 10^{-6}. The 0.1 ml of required dilution was transferred into a pored petri plate (around 25-30 ml of respective media were poured into the Petri plate within the aseptic environment of the laminar airflow chamber). After spreading, the plates were kept in an incubator at 28°C to develop colonies of the microorganism on the media. During the incubation period (for bacteria and fungus, after 48 hours; for actinomycetes, 3 to 7 days; for PSB and N-fixing bacteria, 5 to 6 days), the growth was examined, and the number of identifiable colonies were manually counted (Table 1).

Table 1. Characteristics of different colonies on representative agar plates

Organism	Characteristics	Colonies of organisms
Bacteria	On nutrient agar medium supplemented with cycloheximide @10mg/l medium, colonies of various shapes, with and without pigment visible after 48 hours of incubation were counted	
Fungus	On Martine Rose Bengal agar supplemented with streptomycin @ 50 mg/l of medium, fungal colonies appeared as cottony white hyphae with powdery spores, upon longer incubation.	
Actinomycetes	Slow growers (require 3 to 7 days after incubation), leathery or tough textured bright white, grey, or pigmented colony (subsurface mycelium) having a powdery, coating. The typical earthy smell comes from the Petri plates upon opening the lid.	
P-solubilizing bacteria	After plating for 48 hours, there was a clear halo zone surrounding the colony as a sign of P solubilization (add 1-2 drops of bromothymol blue dye to the media for a light blue color). Then, a clear yellowish colony growth was seen.	
N-fixing bacteria	After 48 to 72 hours, the Jensen's agar medium exhibits a transparent, watery shiny, or creamy white, round, or irregularly shaped growth.	

Analysis of indole 3-acetic acid (IAA) production

The IAA compound measured in compost or supplements was assessed quantitively, as reported by Salkowski [17]. Orthophosphoric acid (H_3PO_3) was added in two drops to the 2 ml supernatant of each sample that was obtained in a test tube. After that, it had further 30-minute incubation at room temperature (25°C) with Salkowski's reagent (0.5 M FeCl3 in 35% $HClO_4$). It is an important step that with the addition of Salkowski's reagent, the final solution's golden yellow color changed to varying shades of pink with respect to the amount of IAA. At a wavelength of 530 nm, the color intensity was evaluated in comparison to a blank solution made up of Salkowski's reagent and 4 ml of sterile distilled water along with the standard IAA concentrations.

Results and Discussion

Chemical properties of the formulation

The data related to chemical parameters *viz*. pH, EC, TOC, and total macro and micro-nutrient content are depicted in Table 2. Among all the manure or formulations, the maximum pH (Figure 1) was observed under *Ghanjeevamrit* (7.80), and the trend was observed in decreasing order *Beejamrit* (7.59) > FYM (7.54) > vermicompost (6.88) > *Jeevamrit* (4.93). Whereas, the electrical conductivity (EC) was showing maximum to minimum (Figure 2) *Jeevamrit* (3.62 dS m^{-1}) > *Beejamrit* (3.15 dS m^{-1}) > *Ghanjeevamrit* (3.01 dS m^{-1}) > vermicompost (2.29 dS m^{-1}) > FYM (1.96 dS m^{-1}).

Table 2. Nutrient content (macro and micro) under different organic supplements (± represent standard error of mean)

Supplements	Macronutrients (%)			Micronutrients (mg kg^{-1})			
	N	P	K	Fe	Mn	Cu	Zn
Jeevamrit	0.35±0.01	0.08±0.00	0.57±0.02	7.71±1.06	0.98±0.14	0.16±0.12	1.32±0.20
Beejamrit	0.16±0.02	0.12±0.01	0.59±0.02	18.5±0.72	3.19±0.15	0.48±0.09	0.54±0.14
Ghanjeevamrit	1.04±0.03	0.50±0.02	1.01±0.06	226±10.30	39.2±3.73	12.7±1.26	14.6±4.51
FYM	0.71±0.02	0.38±0.02	0.49±0.02	180±19.74	35.9±2.09	4.48±0.19	14.3±0.39
Vermicompost	1.76±0.02	0.77±0.03	0.81±0.02	398±14.29	65.9±7.62	15.5±1.81	18.2±1.23

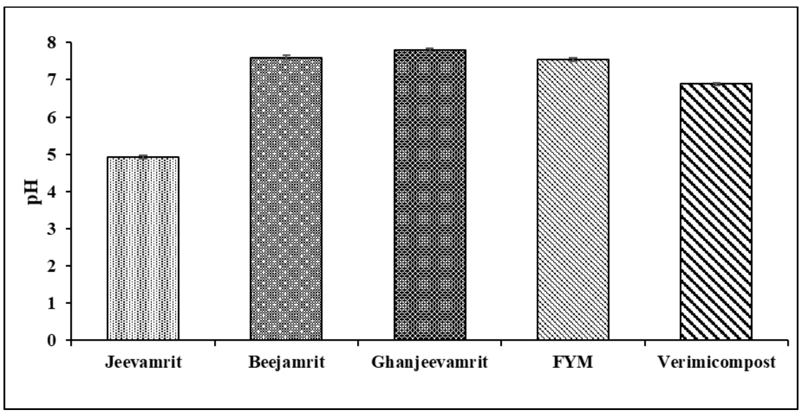


Figure 1. pH under different organic supplements
(Error bars represent ± standard error of the mean)

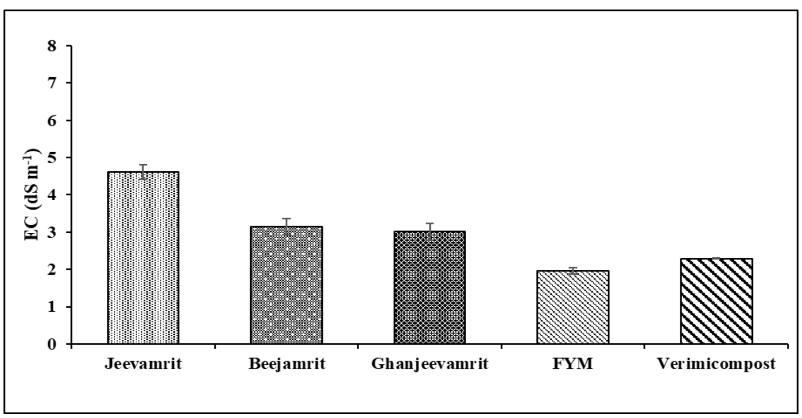


Figure 2. Electrical conductivity (EC) under different organic supplements
(Error bars represent ± standard error of the mean)

The pH and EC regulated the availability of nutrients and when it was applied to the soil, the pH, and EC were close to near the neutral [18]. The higher pH value was observed in *Ghanjeevamrit* because it was solid whereas least was observed in *Jeevamrit* due to its liquid nature and highly fermented. The *Ghanjeevamrit* had found maximum 35.9% TOC (Figure 3) among all the manure/formulation, followed by FYM (34.5%), VC (24.1%), *Jeevamrit* (0.13%) and *Beejamrit* (0.10%). In *Ghanjeevamrit* and FYM the TOC content recorded about 33% and 30% more than that of vermicompost, respectively. In vermicompost, the total N, P, and K content was found highest at 1.76%, 0.77%, and 0.81%, respectively (Table 2). The *Jeevamrit* showed very low content of nutrients 0.35 % N, 0.08 % P and 0.57 % K. Whereas, this concentration declined for N (0.16%) and increased for P (0.12%) and K (0.59%) under the *Beejamrit*. All the micronutrient (Fe, Mn, Cu, and Zn) was found to be maximum under the vermicompost (Table 2). The order of Fe content recorded as vermicompost (398 mg kg^{-1}) > *Ghanjeevamrit* (226 mg kg^{-1}) >, FYM (180 mg kg^{-1}) > *Beejamrit* (18.5 mg kg^{-1}) > *Jeevamrit* (7.71 mg kg^{-1}). Whereas Mn content followed the same trend as Fe, but for Cu and Zn followed the vermicompost (15.5 and 18.2) > *Ghanjeevamrit* (12.7 and 14.6 mg kg^{-1}) > FYM (4.5 and 14.3 mg kg^{-1}) > *Jeevamrit* (0.16 and 1.32 mg kg^{-1}) > *Beejamrit* (0.48 and 0.54 mg kg^{-1}). The higher total macro- and micro-nutrient contents were in vermicompost than FYM and other formulations, possibly owing to a decline in organic carbon and the acquisition of N by the earthworm's species in their nutrient-rich excretory substances, mucus, growth-promoting hormones, rhizobium and enzymes [19-20]. The nutrient contents enrichments occurred because of organic residue decomposition and mineralization resulted in the concentration of the composting material [21]. The nutrient contents vary highly from sample to sample, as per Singh and Ganguly's [22] review, which was supported by other investigations.

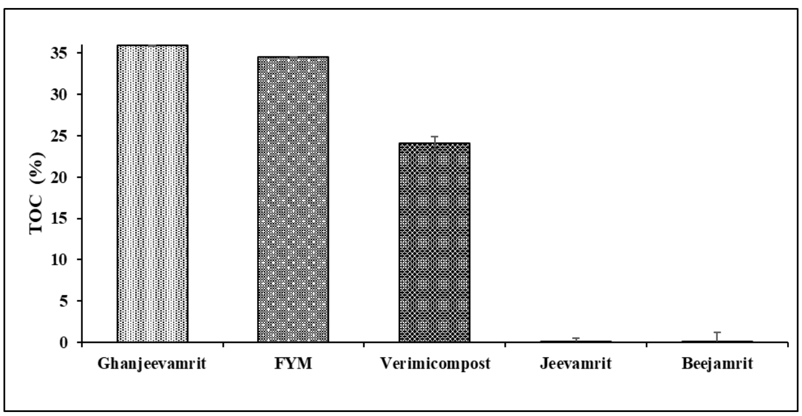


Figure 3. Total organic carbon (TOC) under different organic supplements
(Error bars represent ± standard error of the mean)

This may be brought on by differences in the raw materials utilized, climatic conditions, composting type and process, and moisture content at application time. The availability of macro and micronutrients can be increased via vermicomposting and FYM, which also have several advantages [23-25]. The macro-nutrients N (1.45%), P (0.46%), and K (0.55%) were present in vermicompost, and the DTPA extractable micro-nutrients were 17.8 mg kg^{-1}, Fe, 24.6 mg kg^{-1}, Mn, 19.2 mg kg^{-1}, Zn, and 7.6 mg kg^{-1} Cu [23]. Whereas, FYM are usually considered as the strongest and most reliable materials in organic systems [26]. Since FYM are the main sources of nitrogen (N) for crops, using them continuously as a substitute for N (0.5%) contributes to the accumulation of phosphorus in the soil [27]. Gangmei et al., [28] reported that the nutrient content of FYM is about 0.47% N, 0.37% P, and 0.62% K on a 70% moisture basis, while *Beejamrit* had nutrient contents of 2.26: 0.12: 0.46, *Jeevamrit* had nutrient contents of 1.93: 0.16: 2.6, and *Ghanjeevamrit* had nutrient contents of 1.33:

0.84: 0.73 in terms of N:P: K. Choudhary et al., [29] studied that among all the organic amendments, the highest major nutrients (N, P, and K) was found in Ghanjeevamrit (1.05%, 0.87% and 0.68%) followed by *Beejamrit* (0.72%, 0.14%, and 0.23%), *Jeevamrit* (0.25%, 0.13%, and 0.16%). Sharma and Thakur [30] reported that the organic preparations such as *Jeevamrit*, *Ghanjeevamrit*, Farmyard manure and vermicompost had higher available nutrients contents *viz*., total N (0.12, 0.69, 0.50, 1.38 %), total P (0.36, 0.58, 0.22 and 0.73 %), total K (0.15, 0.67, 0.48 and 1.13 %), respectively.

Microbial analysis

The microbial population such as total bacteria, fungi, actinomycetes, nitrogen-fixing bacteria (N-fixers), and phosphorus solubilizing bacteria (PSB) are counted after appropriate periods of incubation and expressed as colony forming units (cfu) in the different organic preparation (Table 3). The highest total bacteria were recorded in VC (167 × 10^7 cfu g^{-1}), followed by FYM (191 × 10^6 cfu g^{-1}), *Ghanjeevamrit* (122 × 10^6 cfu g^{-1}), *Beejamrit* (56 × 10^6 cfu ml^{-1}), and *Jeevamrit* (49 × 10^6 cfu ml^{-1}). Whereas, the maximum fungi observed in VC (106 × 10^3 cfu g^{-1}) > FYM (89 × 10^3 cfu g^{-1}) > *Jeevamrit* (62 × 10^3 cfu ml^{-1}) > *Ghanjeeevamrit* (8 × 10^3 cfu g^{-1})> *Beejamrit* (40 × 10^2 cfu ml^{-1}). In the case of actinomycetes, there is no count observed under the liquid formulations *Jeevamrit* and *Beejamrit*, but solid organic manure follows the trends of VC (112 × 10^5 cfu g^{-1}), FYM (64 × 10^5 cfu g^{-1}), and *Ghanjeevamrit* (48 × 10^5 cfu g^{-1}). The PSB had the highest VC, followed by FYM, *Ghanjeevamrit*, *Beejmrit*, and *Jeevamrit*. In contrast, the N-fixing bacteria followed the same pattern as the PSB, but no count was found under the *Jeevamrit*. The presence of a higher amount of beneficial microflora such as bacteria, fungi, actinomycetes, phosphorus solubilizing bacteria, and nitrogen-fixing bacteria in solid (VC, FYM, and *Ghanjeevamrit*) and liquid (*Jeevamrit* and *Beejamrit*) organic preparation could be mostly due to their ingredients such as cow-dung and urine, pulse-flour, and jaggery, which contain plant available nutrients, vitamins, essential amino acids, growth stimulating substances like indole 3-acetic acid (IAA), gibberellic acid (GA_3), and beneficial microflora [10, 31-32]. According to several researchers, lime has antifungal properties; hence there was no microbial development under the *Beejamrit* [33-34]. Cow urine has been shown to have antifungal properties previously [35].

Table 3. Microbial enumeration (cfu g^{-1} and cfu ml^{-1}) of culturable total bacteria, fungi, actinomycetes, P-solubilizer, and N-fixers under different organic supplements (± represent standard error of the mean)

Supplements	Total bacteria	Fungi	Actinomycetes	P solubilizer	N-fixers
Jeevamrit	49±10.11 × 10^6	62±4.10 × 10^3	Nil	41±4.16 × 10^4	Nil
Beejamrit	56±6.66 × 10^6	40±0.58 × 10^2	Nil	52±8.95 × 10^4	7±1.20 × 10^4
Ghanjeevamrit	122±15.45 × 10^6	8±3.79 × 10^3	48±7.77 × 10^5	63±3.76 × 10^4	27±3.18 × 10^4
FYM	191±10.84 × 10^6	89±13.57 × 10^3	64±9.29 × 10^5	116±17.46 × 10^4	112±18.15 × 10^4
Vermicompost	167±5.51 × 10^7	106±11.72 × 10^3	112±10.79 × 10^5	137±8.65 × 10^4	120±13.54 × 10^4

For *Jeevamrit* and *Ghanjeevamrit*, a small amount of soil was taken from the area where these preparations would be utilized, and it was also added as they were being prepared. An initial inoculum of fungi, bacteria, actinomycetes, P-solubilizes, and N-fixers would be provided by this. Besides boosting microbial environments, they also act as catalysts with a positive impact on beneficial microflora. Bindushree et al., [36] revealed that the heterotrophic microbial population and beneficial microorganism was highest under the *Beejamrit* and *Jeevamrit*. In the presence of organic matter, these bacteria secrete proteins, organic acids, and antioxidants that they then convert into energy [36]. Cow-based preparation was mainly enriched microbial sources, including many plant rhizobacteria that help in producing plant growth substances [9]. This changes the soil microbiota abundance from a disease-inducing soil to a disease-suppressing soil [37]. All organic formulations contain beneficial microorganisms that transform the nutrients in accessible form into dissolved form. Microbes in indigenous cow dung with cow urine supply sufficient nutrients including N and C and increase microbial activity. The cultural diversity of *Ghanjeevamrit*, with respect to total bacteria, fungi, actinomycetes, N-fixers, and P-solubilizers were found to be 183 × 10^5, 20 × 10^4, 56 × 10^3, 42 × 10^4, 28 × 10^4 cfu g^{-1}, respectively [31]. The actinomycetes, which are present in large numbers in cow dung, are thought to be responsible for the unpleasant smells, aromas, and colors. *Nocardia spp*., one of the specialized forms of actinomycetes, are primarily found in the microflora of cow dung [38]. The total culturable microbial counts in bioorganic preparation such as *Jeevamurth*, *Ghanjeevamurth*, FYM, and VC were recorded 68.7 × 10^6, 81.7 × 10^7, 40 × 10^6, and 101 × 10^6 cfu g^{-1}, respectively [30]. These formulations may have a unique ability to create an environment that is congenial for microbial growth particularly beneficial bacteria, fungus, and actinomycetes, which might be responsible for the significant growth in these beneficial microflorae in the formulations [29, 31]. Ram et al., [39] reported that the organic amendment such as cow pat pit (a fermented mixture of fresh cow dung, crushed eggshell powder and basalt/bentonite) contained maximum bacteria (16.7 × 10^8 cfu g^{-1}), fungi (8.30 × 10^5 cfu g^{-1}), actinomycetes (12.7 × 10^6 cfu g^{-1}) and P-solubilizers (8.30 × 10^5 cfu g^{-1}). Another study by Ram et al., [40], reported that the fungi population was highest in Jeevamrit (1.20 × 10^7 cfu ml^{-1}) whereas actinomycetes (3.10 × 10^6 cfu ml^{-1}) and total bacteria (324 × 10^7 cfu ml^{-1}) lower as compared to biodynamic preparations after 9^{th} day of preparation. Further, the application of organic amendment with biodynamic formulation (BD-500 and BD-501) improved the yield and fruit quality of mango [41].

Indole 3-acetic acid (IAA) production

The IAA production recorded highest under the *Ghanjeevamrit* (6.38 μg ml^{-1}) and liquid formulations such as *Beejamrit* (5.28 μg ml^{-1}), *Jeevamrit* (4.77 μg ml^{-1}). Farmyard manure (FYM) and vermicompost (VC) had lower amounts of IAA which is 1.66 and 1.85 μg ml^{-1} respectively (Figure 4). The *Ghanjeevamrit* had recorded 2.84 times more IAA production, followed by *Beejamrit* (2.18), *Jeevamrit* (1.87), and vermicompost (0.11) as compared to FYM. Likewise, we observed that *Beejamrit* and *Jeevamrit* constituted a strong source of IAA, a well-reported plant growth regulator. Based on this investigation, *Jeevamrit* and *Bejaamrit* showed efficient bio-stimulants that could be utilized for stimulating plant growth [38]. FYM, vermicompost, and *Ghanjeeevamrit* are efficient sources of essential nutrients and energy for beneficial microbes that mineralize the unavailable soil nutrients [29, 42-43].

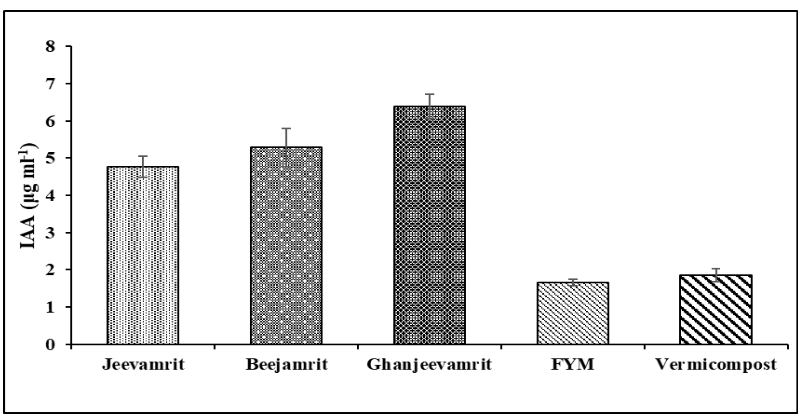


Figure 4. Indore acetic acid (IAA) production under different organic supplements
(Error bars represent ± standard error)

Conclusion

Beejamrit, *Jeevamrit*, *Ghanjeevamrit*, farmyard manure, and vermicompost were environmental-friendly organic supplements prepared from locally available cow-based products. These organic forms are mainly included cow dung and urine, pulse flour, jaggary, and a fist of chemical-free soil. They contain macro and micro-nutrients, vitamins, amino acids, and growth-promoting substances.

In the present study, the Beejamrit, a microbial combination of plant-beneficial bacteria, which includes free-living N-fixers and P-solubilizers, was described. Our study offers a scientific comprehension of the *Beejamrit* and *Jeevamrit* formulations, its dynamic plant-rhizobacterial network acts as a seed priming agent. All of these preparations include cow dung as a necessary ingredient, which also acts as an energy source of helpful microbes for inoculation. The occurrence of naturally existing beneficial microbes, particularly bacteria, actinomycetes, N-fixers, phosphate solubilizers, and fungi, was brought about by the addition of cow-based formulations including *Jeevamrit*, *Ghanajeevamrit*, and *Beejamrit* as well as farm yard manure and vermicompost. In comparison to FYM and Vermicompost, the indole acetic acid concentrations in the *Ghanjeevamrit*, *Beejamrit*, and *Beejamrit* were greater. This compound is essential for seed germination and plant growth. Overall, this result indicated that the application of these low-cost, natural organic preparations formed by cows was quite successful in improving soil health. Further field research was required to establish the relationship and efficacy of organic supplements with growth and crop yields and soil health sustainability.

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References

[1] S. K. Patel, A. Sharma and G. S. Singh **(2020)**. Traditional agricultural practices in India: an approach for environmental sustainability and food security. Energy Ecol. Environ., **5:** 253-271.
[2] N. Devakumar, S. Shubha, S. B. Gouder and G. G. E. Rao **(2014)**. Microbial analytical studies of traditional organic preparations beejamrutha and jeevamrutha. *In*: Proceedings of the 4th ISOFAR Scientific Conference. 'Building Organic Bridges', at the Organic World Congress 2014, 13-15 Oct., Istanbul, Turkey (eprint ID 23621), pp639-642.
[3] M. Barooah and A. Pathak **(2009)**. Indigenous knowledge and practices of Thengal Kachari women in sustainable management of bari system of farming. Indian J. Tradit. Knowl., **8:** 35-40.
[4] Z. P. Bharucha S. Mitjans and J. Pretty **(2020)**. Towards redesign at scale through zero budget natural farming in Andhra Pradesh, India. Int. J. Agric. Sustain., **18:** 1-20.
[5] A. Khadse and P. M. Rosset **(2019)**. Zero budget natural farming in India–from inception to institutionalization. Agroecol. Sustain. Food Syst., **43:** 848-871.
[6] S. Chadha, Rameshwar, Ashlesha, J. P. Saini and Y. S. Paul **(2012)**. Vedic Krishi: Sustainable livelihood option for small and marginal farmers. Indian J. Tradit. Know., **11:** 480–486.
[7] I. P. Sharma, C. Kanta, T. Dwivedi and R. Rani **(2020)**. Indigenous agricultural practices: A supreme key to maintaining biodiversity. In: R. Goel, R. Soni, D. Suyal (eds) Microbiological advancements for higher altitude agro-ecosystems & sustainability. Rhizosphere Biology. Springer, Singapore. pp91-112. doi: 10.1007/978-981-15-1902-4_6.
[8] D. Jain, P. Jain, A. A. Bhojiya, R. K. Jain, R. Choudharya, S. K. Sharma and S. K. Yadav et al., **(2021)**. Microbiological and enzymatic properties of diverse Jaivik Krishi inputs used in organic farming. Indian J. Tradit. Know., **20:** 237–243.
[9] M. N. Sreenivasa, M. N. Nagaraj and S. N. Bhat **(2009)**. Beneficial traits of microbial isolates of organic liquid manures. First Asian PGPR Congress for sustainable agriculture, 21-24 June, ANGRAU, Hyderabad.
[10] S. Palekar **(2006)**. Text book on Shoonya Bandovalada naisargika Krushi, published by Swamy Anand, Agri Prakashana, Bangalore.
[11] K. Gangadhar, N. Devakumar, Vishwajith and G. Lavanya **(2020)**. Influence of different sources of organic manures and decomposers on enzymatic activity and microbial dynamics of rhizosphere soil of Chilli (*Capsicum annum* L.). Int. J. Curr. Microbiol. App. Sci., **9:** 542-555.

[12] M. L. Jackson **(1973)**. Soil chemical analysis. Prentice- Hall Inc, N.J., USA.
[13] D. W. Nelson and L. E. Sommers (1982). Total carbon, organic carbon and organic matter. *In*: A. L. Page, R. H. Miller, D. R. Keeney (Eds.), methods of soil analysis: Part II (2nd edn.), Chemical and Microbiological Properties-Agronomy Monograph No. 9, American Soc. Agronomy, Soil Sci. Soc. America, Madison, WI, USA (1982), pp539-579.
[14] G. Estefan, R. Sommer and J. Ryan **(2013)**. Methods of soil, plant, and water analysis. A manual for the West Asia and North Africa region. 3rd edn. ICARDA, West Asia.
[15] W. L. Lindsay and W. A. Norvell **(1978)**. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Sci. Soc. Amer. J., **42:** 421-428.
[16] P. K. Chhonkar, S. Bhardararaj, A. K. Patra and T. J. Pudukayastha **(2007)**. Enumeration of soil biota. *In*: Experiment in Soil Biology and Biochemistry. Westrile Publishing House, New Delhi.
[17] E. Salkowski **(1885)**. Uber das verhalten der skatolcarbonsaure im organismus. Z Physiol. Chem., 9: 23-33.
[18] Q. Jin and M. F. Kirk **(2018)**. pH as a primary control in environmental microbiology: 1. Thermodynamic Perspective. Front. Environ. Sci., **6:** 21. doi: 10.3389/fenvs.2018.00021.
[19] G. Tripathi and P. Bhardwaj **(2004)**. Decomposition of kitchen waste amended with cow manure using an epigeic species (*Eisenia fetida*) and an anecic species (*Lampito mauritii*). Bioresour. Technol., **92:** 215-218.
[20] M. M. R. Malik, M. J. Akhtar, I. Ahmad and M. Khalid **(2014)**. Synergistic use of rhizobium, compost and nitrogen to improve growth and yield of mung bean (*Vigna radiate*). Pak. J. Agric. Sci., **51:** 393-398.
[21] K. Sharma and V. K. Garg **(2017)**. Vermimodification of ruminant excreta using Eisenia fetida. Environ. Sci. Pollut. Res., **24:** 19938-19945.
[22] A. B. Singh and T. K. Ganguly **(2005)**. Quality comparison of conventional compost, vermicompost and chemically enriched compost. J. Indian Soc. Soil Sci., **53:** 352-355.
[23] S. K. Singh, M. Kumar, R. P. Singh, J. S. Bohra, J. P. Srivastava, S. P. Singh and Y. V. Singh **(2018)**. Conjoint application of organic and inorganic sources of nutrients on yield, nutrient uptake and soil fertility under Rice (*Oryza sativa*)-Wheat (*Triticum aestivum*) system. J. Indian Soc. Soil Sci., **66:** 287-294.
[24] P. H. Shinde, R. L. Naik, R. B. Nazikar, S. K. Kadam and V. M. Khare **(1992)**. Evaluation of vermicompost. Proceedings of National Seminar on Organic Farming, MPKV, Pune.
[25] Z. Aslam, A. Ahmad, M. Ibrahim, N. Iqbal, M. Idrees, A. Ali and I. Ahmad et al., **(2021)**. Microbial enrichment of vermicompost through earthworm *Eisenia fetida* (Savigny, 1926) for agricultural waste management and development of useful organic fertilizer. Pak. J. Agric. Sci., **58:** 851-861.
[26] T. Rao Nagendra **(2009)**. Phosphorus and Potassium nutrient management options for organic production systems. Efficient use of on-Farm and Off-Farm Resources in Organic Farming. IISS, Bhopal., pp82-91.
[27] A. Sowjanya, M. Rekha Sree and V. R. K. Murthy **(2017)**. Effect of integrated nitrogen management on growth components, yield and nutrient uptake of rice. The Andhra Agric. J., **64:** 753-756.
[28] T. P. Gangmei, N. Kaur, A. Thakur, S. Baghla, K. K. Sahu, A. Kumar and S. Manuja **(2022)**. Studies on irrigation scheduling and nutrient management on wheat growth and productivity. Himachal J. Agric. Res., **48:** 48-55.
[29] R. Choudhary, R. Kumar, G. D. Sharma R. P. Sharma, N. Rana and P. Dev **(2022)**. Effect of natural farming on yield performances, soil health and nutrient uptake in wheat + gram inter cropping system in sub-temperate regions of Himachal Pradesh. J. Crop Weed., **18:** 01-08.
[30] R. Sharma and I. Thakur **(2022)**. Impact of bioorganic nutrients and chemical fertilizers on sustainable production of French bean and soil health. J. Environ. Biol., **43:** 430-439.
[31] S. Mukherjee, S. Sain, M. N. Ali, R. Goswami, A. Chakraborty, K. Ray and R. Bhattacharjee et al., **(2022)**. Microbiological properties of Beejamrit, an ancient Indian traditional knowledge, uncover

a dynamic plant beneficial microbial network. World J. Microbiol. Biotechnol., **38:** 111. doi: 10.1007/s11274-022-03296-3.

[32] N. Gore and M. N. Sreenivasa **(2011)**. Influence of liquid organic manures on growth, nutrient content and yield of tomato (*Lycopersicon esculentum*) in the sterilized soil. Karnataka J. Agric. Sci., **24:** 153-157.

[33] M. Leharwan, M. Gupta, and S. Leharwan **(2020)**. *In-vitro* evaluation of six bio-product against coriander stem gall disease. Bhartiya Krishi Anusandhan Patrika., **35:** 33-38.

[34] P. Dev, S. S. Paliyal and N. Rana **(2022)**. Subhash palekar natural farming-scope, efficacy and critics. Environ. Conserv. J., **23:** 99-106.

[35] A. B. Basak and M. W. Lee **(2001)**. Efficacy of cow dung in controlling root rot and Fusarium wilt of cucumber plants. Abstract published *In*: Korean Society of Plant Pathology annual meeting and International conference, held on 25-30 th October, 2001, Kyongju TEMF hotel, Korea, pp49.

[36] C. Bindushree, R. N. Lakshmipathi, M. C. Nagaraju and M. Siddu **(2023)**. Effect of different farming practices on total beneficial microorganisms in direct seeded rice. The Pharma Innov., **12:** 2412-2420.

[37] M. N. Sreenivasa, M. N. Nagaraj and S. N. Bhat **(2010)**. Beejamruth: A source for beneficial bacteria. Karnataka J. Agric. Sci., **17:** 72-77.

[38] E. Somasundaram, N. Sankaranan, S. Meena, T. M. Thiyagarajan, K. Chandaragiri and S. Pannerselvam **(2003)**. Response of green gram to varied levels of Panchagavya (organic nutrition) foliar spray. Madras Agric. J., **90:** 169-172.

[39] R. A. Ram, A. Singha and A. Kumar **(2019a)**. Microbial characterization of cow pat pit and biodynamic preparations used in biodynamic agriculture. Indian J. Agric. Sci., **89:** 210-214.

[40] R. A. Ram, A. Singha and S. Vaish **(2018b)**. Microbial characterization of on-farm produced bio-enhancers used in organic farming. Indian J. Agrc. Sci., **88:** 35-40.

[41] R. A. Ram, A. Singha and V. K. Singh **(2019)**. Improvement in yield and fruit quality of mango (*Mangifera indica*) with organic amendments. Indian Journal of Agricultural Sciences., **89:** 1429-1433.

[42] L. Goswami, A. Nath, S. Sutradhar, S. S. Bhattacharya, A. Kalamdhad, K. Vellingiri and K. H. Kim **(2017)**. Application of drum compost and vermicompost to improve soil health, growth, and yield parameters for tomato and cabbage plants. J. Environ. Manag., **200:** 243-252.

[43] K. Sharma and V. K. Garg **(2019)**. Vermicomposting of waste: a zero-waste approach for waste management. *In*: Sustainable resource recovery and zero waste approaches, Elsevier., pp133-164.