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Nutritional Assessment of Organic Liquid Formulations of *Capralac extractum* (Goat) and *Bubaluslac extractum* (Buffalo), along with Panchagavya Formulation for Sustainable Agriculture

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ABSTRACT

Keywords

Panchagavya (PG), *Capralac Extractum* (CE), *Bubaluslac Extractum* (BE), Sustainable Agriculture

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Effective improvements in sustainable agriculture and forestry are necessary to cope with the detrimental consequences of the excessive application of synthetic fertilizers on the environment and human health. This study has resulted in a novel idea of using two organic liquid formulations consisting of *Capralac Extractum* (CE) and *Bubaluslac Extractum* (BE), based on Indigenous agricultural techniques used in ancient India i.e., "Panchagavya." The study aims to provide both innovative formulations alongside panchagavya in different formulations prepared in glass jars and earthen pots with dung, milk, urine, curd, and ghee of goat, buffalo, and cow in the ratio of 1:7:2:3:3. Nutrient analysis conducted using CHNS and ICP-MS indicated that the nutritional level was highest in glass jars, except for iron, when compared to earthen pots. The intriguing aspect was that the maximum level of nutrients was detected in the *Capralac Extractum* and Panchagavya glass jars. The study further revealed that PG-G formulations contained a good amount of Mn, Zn, K, P, and Ag. In the case of the CE-G formulation, higher concentrations of Mg, P, B, Cu, and N, followed by the highest values of K and Ca, were detected. A Study of pot culture assay revealed a significant effect of CE-G on vegetative growth of wheat plants. Therefore, this study offers two novel formulations that could open new opportunities for scientific research to better understand their effects on plants, soil, and crops, which could lead to improved agricultural practices and provide substitute formulations for agricultural sustainability.

Introduction

The present world scenario emphasizes the need of eco-friendly practices for sustainable agriculture. Excessive use of chemical fertilizers has caused significant environmental damage in the form of air, water, and soil pollution, leading to various deadly diseases in humans, animals, and plants. In recent years, the utilization of liquid fertilizers has surged owing to their effortless mixing with water, allowing plants to absorb them more effectively (Souri and Sooraki, 2019). These fertilizers are often applied by spraying them directly onto crops, ensuring the rapid availability of nutrients. Thus, becomes extremely useful for plants' development, if nutrition is not available through their roots.

Panchagavya (PG), a vedic formulation, used in agriculture by farmers with certain modifications have shown effective crop yields, better quality, and less pest infestation. According to the Sushruta Samhita, the term 'Gavya' pertains specifically to the cow. Therefore, panchagavya represents a distinct and unadulterated bioformulation exclusively derived from cow-derived products, including dung, urine, milk, curd, and ghee. Panchagavya has shown promising potential as an organic fertilizer and biopesticide (Raju *et al.,* 2022). Panchagavya contains five animal products, and after fermentation, these organic substances break down into simpler forms and act as nutritional supplements for plants. Therefore, panchagavya significantly contributes to pest and disease resistance, increasing overall yields (Kuamar and Singh, 2020). According to Khanna *et al.,* (2025), 3% solution of Panchagavya is found to be most effective for plants growth and development. Generally, ammonium and nitrates are crucial inorganic compounds that are beneficiary nutrients for direct plant growth and developments. The nitrogen cycle in an ecosystem depends on nitrates, which are naturally occurring forms of nitrogen (Gent, 2003). However, high nitrate accumulation harm plant growth and subsequently to human health (Anjana & Iqbal, 2007; Ikemoto *et al.,* 2002; Ishiwata *et al.,* 2002). In addition to panchagavya, there are other eco-friendly organic formulations, such as jeevamruth, beejamruth, and sasyamrutha, which are derived from cow products and have shown promising results in agricultural production (Sudheer *et al.,* 2025; Chakraborty & Sarkar, 2019). The application of panchagavya (PG) containing beneficial microbes promotes crop productivity to a large extent. The quality of liquid fertilizer is determined by the content of chemical substances such as growth regulators, organic acids, nutrient elements, and other chemical factors such as pH and E.C. (Sunaryo *et al.,* 2018; Arancon *et al.,* 2006; Campitelli *et al.,* 2012). Organic farming may result in a reduction in quantity, but it often leads to an enhancement in plant yield quality. The decrease in yield quantity can be attributed to the relatively lower content of macronutrient in organic fertilizers (Chanda *et al.,* 2011; Joshi R *et al.,* 2013). Organic fertilizers effectively promote environmental sustainability and plant growth after long-term use. However, previous studies have focused primarily on conventional solid organic fertilizer products, such as straw and manure (Sun *et al.,* 2014; Atiyeh *et al.,* 2001). Similarly, EC indirectly indicates the strength of the nutrient (hydroponic) solution, higher E.C. ($\geq$2.5 dS/m) hinders nutrient absorption due to increased osmotic pressure, whereas a lower E.C. may severely affect plant health and yield (Samarakoon *et al.,* 2006). Moreover, chitin, humic, and fulvic acids, among other biopolymers found in liquid organic nutrients, can act as bio-stimulants for plants (Canellas *et al.,* 2015; Tang *et al.,* 2013). Humic acid is an active component of soil and aquatic organic matter and is essential for agriculture (Mac Carthy *et al.,* 1990). Chen and Aviad (1990) reported that the optimum application of humic acid for plant growth ranged from 50 to 350 ppm.

Historically, cow-based panchagavya has been outlined in scriptures and employed in agricultural practice. However, there is no historical mention or documentation of using other domestic animals, such as goats or buffaloes, in the creation of panchagavya-like formulations. Therefore, investigating other animal-based formulations is of great interest because of different dietary and physiological habits. Introducing additional formulations that include materials from different sources warrants the creation of distinct nomenclature for each of these formulations, aligning with the requirement to distinguish them from traditional concepts. However, it's worth noting that Khanna *et al.,* (2025) restrict the inclusion of products from other domestic animals, primarily buffalo, in the Panchagavya formulation. Therefore, in present study the nomenclature for goat-based bio formulation abbreviated as *Capralac Extractum* (CE), which is based on the Latin word *Capraeae* means goat, *lac* word for milk-based component, and *extractum* is an extract. Similarly, the buffalo-based bioformulation is abbreviated as *Bubaluslac Extractum* (BE), in which *Bubalus* means buffalo (zoological name). All the raw components of PG, CE, and BE were obtained from the local cow, buffalo, and goat breeds of Madhya Pradesh. In this study, we tested the contents of nitrate, phosphate, sulphate, iron, manganese, sodium, potassium, and humic acid, along with pH, and E.C. Additionally, an attempt was made to verify the effect of containers, such as earthen pots and glass jars, on the quality of the formulations.

Materials and Methods

Experimental Design

Panchagavya mainly consists of 5 products of cow: dung, urine, milk, curd & ghee. Jaggery, banana, toddy, coconut water, and yeast powder are optional. Therefore, in this study, we prepared all three bioenhancers in the same manner using jaggery and other major 5 ingredients in glass jars and earthen pots for the comparison of nutrient quality analysis. All analytical quality reagents (HIMEDIA, CHD, Loba Chemie, Fisher Scientific, RANKEM, and EMPLURA) were used.

Preparation of Formulations

The raw materials of all three animals were collected from the nearby villages of Sagar Madhya Pradesh, India, and the same general procedure or method of panchagavya preparation was followed as per the method described elsewhere (Funde *et al.,* 2024). All raw materials for the preparation of PG, CE, and BE were used in the ratio of 1:7:2:3:3 (Ono & Trebat-Leder, 2016) i.e. Ghee 1 kg, dung 7 kg, curd 2 kg, urine 3 L, and milk 3 L. In this study, an earthen pots and glass jars were used to analyze the quality comparison of the fermenter on fermentation process. Minor modifications were made to the ingredients and methodology for preparing the goat dung formulation, managing the same consistency as for cow and buffalo dung formulations. Each formulation was placed in a glass jar and earthen pot for fermentation in three separate incubators at 32˚C ± 2 for 20 days.

Extraction of Formulations

After 20 days of fermentation, each formulation was diluted to 5 % using ddH_2O. Afterwards, the solutions were heated in a water bath at 55 ± 2 ˚C for 1 hour and allowed to cool for complete debris precipitation. Later, the mixture was centrifuged at 1600–1800 rpm for 45 min. The supernatant was carefully collected. The supernatant of all mixtures was stored in a refrigerator at 4–6 °C until further analysis.

Nutrient Analysis of Formulations

Nitrate and sulfate were analyzed using the method proposed by Mussa *et al.,* (2009). PDA acid solution (25% w/v; Art no. PDA 130911) for nitrate, and conditioning reagents (SULC1130911) for sulphate were purchased from Envirnotech Quality Research India (EQR India). Humic acid was purchased from HUMIGROW-95 CLSL, India, and analyzed using the method of Faithfull (2002). Phosphate was analyzed using the methods of Mussa *et al.,* (2009) and Kumar *et al.,* (2007), and absorbance was measured at 800, 830, and 860 nm using a spectrophotometer (SN1510-04 157C) Vantaa Finland. Iron was analyzed using the 1:10 phenanthroline method (Cuttitta, 1952). Hydroxylamine hydrochloride solution (IR 010213) and 1:10 phenanthroline solution (IR 010213) was purchased from EQR India. For manganese determination, we followed the method used by (Madhavi and Saraswathi. 2013). Special reagent art no. 210160 for Mn analysis was purchased from EQR India. All other chemicals were of AR grade in chemical analysis. All absorbance values were recorded using a CYBER ELISA R01 microplate reader (Salo Terrace, Millbury, MA01527, USA). A multiparameter HANNA HI98194 Chemistry Department DHSGU Sagar was used for pH and EC analysis. Na and K were determined using a flame photometer microprocessor (ESICO model- 1385).

The components of the formulations are a complex blend of organic and inorganic elements. Iron (Fe), Magnesium (Mn), Calcium (Ca), Potassium (K), and Sodium (Na) are some of the principal inorganic components of formulations, and organic compound as humic acid helps regulate their physicochemical properties of the formulations. For macro-micro nutrients analysis, the following instruments were used to evaluate the quality of the formulations: i) CHNS, and ii) ICP-MS, whose methods were adopted by Raj *et al.,* (2024). CHNS analysis, the facility was availed at IIT Mumbai, and for elemental analysis, and the ICP-MS facility was availed at IIT Delhi.

Plant Growth Assay Test

The pot culture test was design and conducted in the Department of Botany during the month of January using different formulations with respect to Sprint GR, Market-based Organic Fertilizer (MOF) of PRISM Crop Care Pvt Ltd. Hyderabad. A homogeneous mixture of partially sandy black soil was collected from the botanical garden of the department. The plastic pots of equal size (15 cm diameter × 7 cm height) were filled with homogenous soil at the rate of 500g per pot with 1% of all the dry formulations and 1 % of MOF (Market-based Organic Fertilizer) along with control pot. To compare the quality of the organic formulations with the MOF, a 1% mixture of the formulation with the MOF was also tested on plants growth. Ten wheat seeds were sown in each pot with sufficient space for optimal growth. All pots were maintained in triplicate for 25 days before the growth assessment was conducted.

Measurement of Vegetative Attributes

Fresh and dry weights were determined 25 days after sowing (DAS). Five plants from each treatment were harvested to determine the fresh and dry weights and the remaining plant samples were used for chloroplast analysis to determine the growth of plants.

Estimation of Chlorophyll

The total chlorophyll a, b, and carotenoid + xanthophyll contents were estimated by the method suggested by (Richardson *et al.,* 2002). The optical density (OD) of the solution was read at 645 and 663 nm for chlorophyll estimation and at 470 nm for carotenoid estimation.

Statistical Analysis

The data obtained from the experiments were analyzed using Origin Pro-2021 software and Microsoft Excel. Statistical graphs using Tukey's and Pearson correlation matrices were analyzed to assess the physicochemical variations across all the formulations.

Results and Discussion

Analysis of Nutritional Values of Formulations

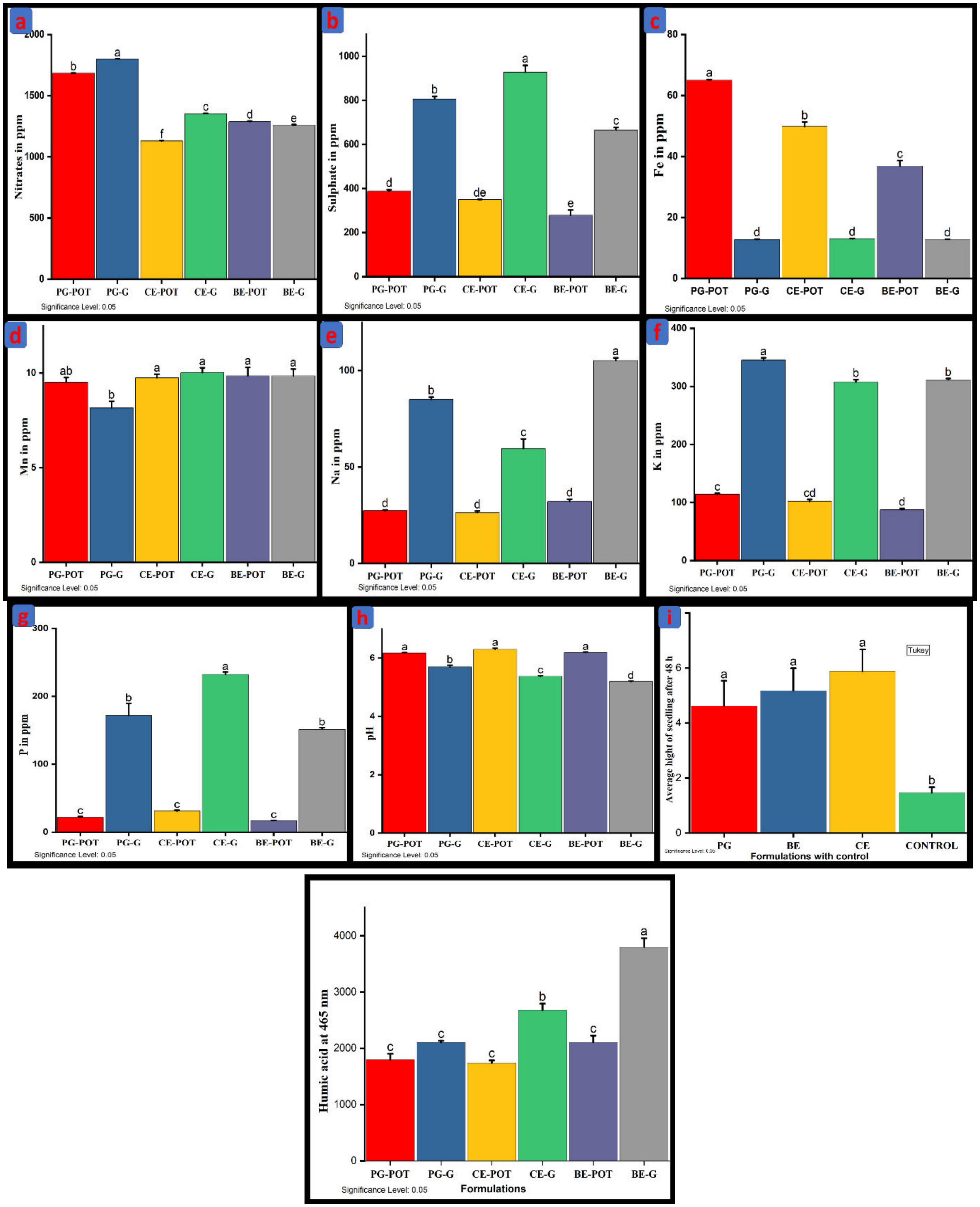
Ten distinct nutrient parameters were measured, including pH, EC, and TDS. All of these, which are necessary for plant growth and development, were tested in different formulations (Table 1). Before analyzing the nutrient levels in the formulations, each formulation was first diluted at 5% with dd H_2O. The amounts of nutrients in PG, CE, and BE had different nutritional levels, with significant differences between the pot and glass container (Table 1). According to the National Bureau of Agricultural Commodity and Food Standards, Ministry of Agriculture and Cooperatives (2005), the ideal pH of fertilizer is between 5.5 and 8.5, and the EC value should be less than 12 ds/m. Our results demonstrate that BE-G had the highest value of EC i.e., 9.8. followed by 9.6 and 9.1 in CE-G, and PG-G respectively (Table 1). Likewise, the pH of the samples was significantly different among the formulations ($p < 0.05$) (Fig 1h). The pH of the glass jars was found to be lower than that of the earthen pots due to the seepage of water from the earthen pots. The highest pH value was observed at 6.3 in CE-P, while the lowest value was observed in BE-G i.e. 5.19. These values were followed by the National Bureau of Agricultural Commodity and Food Standards, Ministry of Agriculture and Cooperatives (2005). A pH of 3.5 to 5.5 permits the solubility of the cations, whereas a pH higher than 5.5 causes the cations to react with the hydroxides and precipitate the elements (Li *et al.,* 2018). After 30 days of fermentation, the panchagavya pH decreased to 4.5, which could be due to the presence of *Lactobacillus* bacteria in panchagavya, which might produce more organic acids during the fermentation process (Funde *et al.,* 2024). Other nutrient results were estimated in terms of availability, dissolved or ionic form, and not in the form of total nutrients. However, the total nutrients were also analyzed using ICP-MS and CHNS to understand the nutrient composition of the formulations. The nitrate content in the observed formulations was found to be almost equal to that in other liquid chemical fertilizers, as shown by Phibunwatthanawong and Riddech (2019). It was noteworthy to mentioned that all Glass Jar formulations PG-G (1800 ppm) had a higher nitrate level, whereas Earthen Pot CE-P (1129 ppm) had a lower nitrate level. There was a significant difference ($p<0.05$) in the amount of nitrate in the glass and pot, as depicted in Fig 1(a). In the case of sulphate, a higher amount of sulphate was found in CE-G (928 ppm), whereas a lower amount of sulphate was found in BE-P (278 ppm). No significant difference was observed in PG-P and CE-P; however, all glass jar values were significantly different (Fig 1 b). The results of comparing these values at lower and higher ratios are presented in Table 1. All nutritional values were examined at a 5% concentration. Whereas it was observed that the nutritional values of glass jars were significantly higher than those of the pot values, except for Fe. The highest Fe content was found in PG-P (65 ppm) and was lower in both PG-G and BE-G (12.71 ppm and 12.75 ppm, respectively). However, no significant difference was observed with lower amounts of Fe in the glass jar formulations (Fig 1C). However, a significantly higher amount of Fe was found in the earthen pot's formulations. Seemingly, Mn content in PG-G was found 8.29 ppm and 10.05 ppm in CE-G, with no significant difference between and among the formulations (Fig 1d). A higher concentration of Na was found in BE-G (105 ppm), and a lower concentration was observed in CE-P (26.31 ppm). Results were showed a significant difference among all the values of remaining formulations with BE-G (Fig 1 e). The highest K value (345.2 ppm) was noted in PG-G, and the lowest was reported in BE-P (87.53 ppm). All formulations differed significantly in the PG-G for K level at $p<0.05$ (Fig 1f). The phosphate (P) content was also significantly higher than that of the pot values at $p<0.05$, as shown in Fig 1(g). BE-P had a lower value of 16.86 ppm for P, whereas CE-G had the highest P levels (232 ppm) (Table 1). Bhatt and Maheshwari (2020) conducted a chemical examination of fresh, non-fermented cow dung and found that, in February, when the cow had access to locally grown green grass and agricultural residues, cow dung had a pH of 7.1, following the values of EC was 0.97, N% was 0.9, P% was 0.2, and the K% was 1.02, respectively. This implies that higher-quality fodder results in higher-quality formulations.

Thirteen different nutrients were also analyzed using ICP-MS and CHNS. All these nutrients are essential for overall plant growth and development. For nutrient analysis, formulations were first dried in an oven at 45°C and were made to fine powder. Later on, this powder was analyzed for nutritional levels in various formulations using ICP-MS for P, K, Mg, Mn, Na, Fe, B, Ca, Zn, Cu, and Ag and CHNS was used for the analysis of carbon (C) and nitrogen (N). All the nutrient levels under different formulations are shown in Fig 2, 3, and 4.

The variation in the nutrient levels among different formulations PG, CE, and BE can be explained because of using different containers like glass jars (G) and earthen pots (P) which somehow regulate the seepage of nutrients. We found that nutrition values are greater in the case of CE-G. However, the highest concentration of N of 2%, was found in CE-G followed by 1.64 % in CE-P. The total N content was somewhere similar for PG-G, BE-P, and BE-G, which was 1.29, 1.23, and 1.36 % respectively as shown in Fig 2, with only 0.9 % N found in PG-P. The highest level of P was also found in CE-G (3013 mg/kg), followed by 2132 mg/kg in PG-G and 1988 mg/kg, 1333 mg/kg, 1159 mg/kg in BE-G, BE-P, and PG-P respectively. However, the lowest P content was found in CE-P (971 mg/kg) (Fig 3). In a comparative study on Sanjivani (SV) and PG the biochemical revealed that in PG and SV, N content was 1.4%, 1.03%, followed by 0.08%, & 0.04% for P and 0.5% & 0.5% for K, at pH 5.6, & 7.8, with EC 4.6, & 3.5, respectively (Chakraborty & Sarkar, 2019).

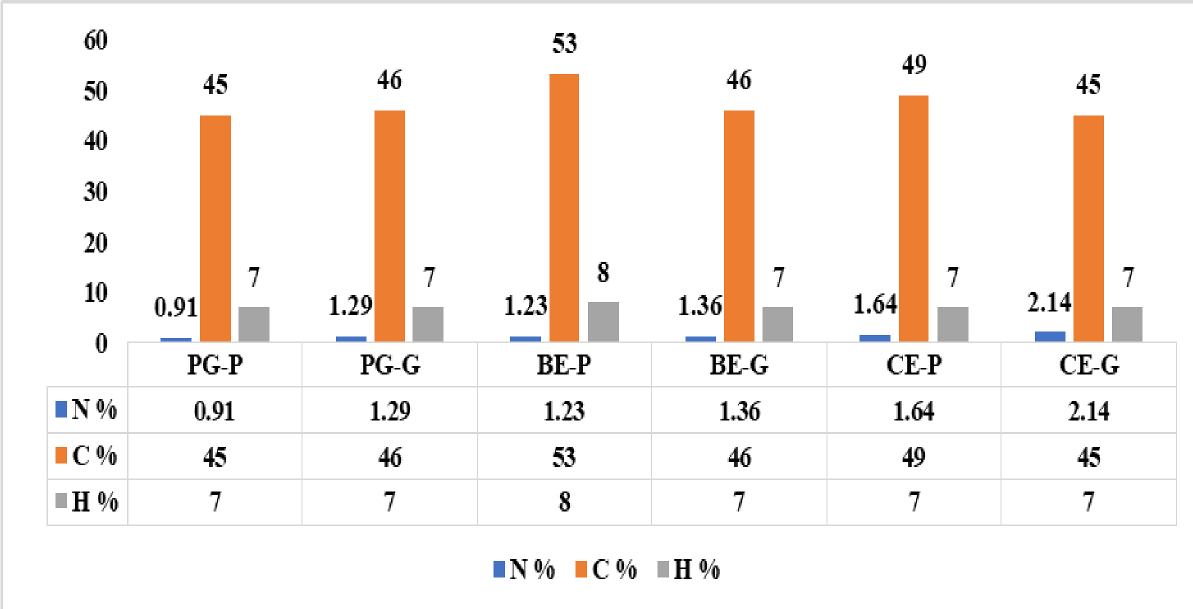
The highest K content was found in PG-G (17170 mg), followed by CE-G (15020 mg/kg), afterward BE-G (14735 mg/kg), PG-P (7832 mg/kg), CE-POT (5932 mg/kg), and lower K was found in BE-P (5932 mg/kg). The higher value of Na was found in BE-G (2425 mg/kg), followed by PG-G (1495 mg/kg), BE-P (698 mg/kg), PG-P (567 mg/kg), CE-G (255 mg/kg), and the lower Na value was found in CE-G (77mg/kg). The highest Mg was found (2957mg/kg) in CE-G, and the lowest in BE-P (547 mg/kg) (Fig 3). However, in the case of other formulations, 1450 mg/kg in BE-G, 1397 mg/kg PG-G, 1193 mg/kg CE-POT, and 989 mg/kg were found in PG-P. Similarly, the Ca values in descending order in formulations are 3616, 2475, 1413, 1052, 730, and 611 mg/kg were found in CE-P, CE-G, PG-POT, BE-POT, BE-G, and PG-G respectively. Mn was found at 443, 306, 218,113, 86, and 57 in PG-G, PG-P, BE-P, CE-P, CE-G, and lowest found in BE-G respectively. The highest Fe was found in PG-P (2219 mg/kg) followed by in CE-P (2057 mg/kg), and the lowest was found in PG-G (369 mg/kg), and 1339 mg/kg, 693 mg/kg, 422 mg/kg respectively in BE-P, CE-G, and BE-G (Fig 3). Some other essential micronutrients were also found in the formulations. Highest Boron (B) were found in CE-G (17 mg/kg) followed by CE-P (12 mg/kg), while 4.7 mg/kg, 3.9 mg/kg, 3.6 mg/kg, 2.2 mg/kg, respectively were found in PG-G, PG-P, BE-G, and BE-P. Higher Cu were found in CE-P (28 mg/kg) followed by PG-G (24 mg/kg), while17.7 mg/kg, 14.5 mg/kg, 13.9 mg/kg, and 10 mg/kg respectively were found in BE-P, PG-P, CE-G, and BE-G. The highest Zn was found in PG-G (55 mg/kg), followed by PG-POT (37.9 mg/kg), and the lowest was found in BE-P (25 mg/kg), then 31 mg/kg, 30.9 mg/kg, 26.4 mg/kg in CE-G, CE-P, and BE-G respectively (Fig 4). Jakubus and Michalak (2022) worked on vermicompost and its nutrient composition and found that in vermicompost N- 1.6 to 1.8 %, P- 4-6 g/kg, K- 18-24 g/kg, Ca- 34-44 g/kg, Mg- 8.7 -13.5 g/kg, S- 3.5-4.6 g/kg, Fe- 273-333 mg/kg, Mn- 71.5-102 mg/kg, Zn- 4.3-5.4 g/kg, Na- 1.6-2.1 g/kg, Cu- 16-18 mg/kg. In this series, Sunaryo *et al.,* (2018) also work. if we compare the nutritional value with Jakubus and Michalak (2022) found in vermicompost, then we found N, and P match with CE-G, K from PG-G, and Fe, Mn, and Cu match with all PG, CE, and BE values, Na only matches with the value of BE-G and PG-G.

Fig.1 Represents the concentration of Nitrates (a), Sulphate (b), Fe (c), Mn (d), Na (e), K (f), Phosphate (g)



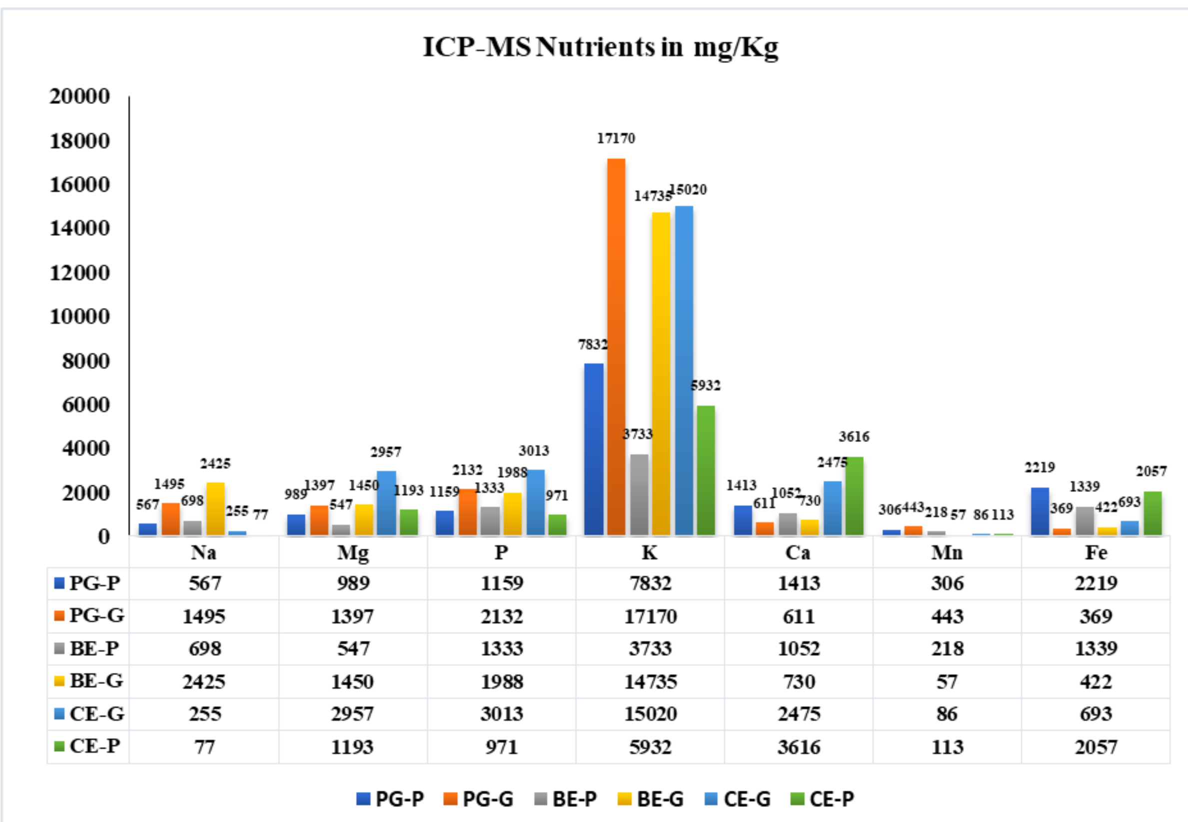
The values of pH (h), Seed germination with 20% PG, CE, and BE formulations concerning control (i), and Humic acid at 465 nm was also observed. All the data were evaluated for their significant differences using Tukey's test.

Fig.2 Nitrogen, Carbon, and Hydrogen elements level in percent in formulations based on CHNS.



	PG-P	PG-G	BE-P	BE-G	CE-P	CE-G
N %	0.91	1.29	1.23	1.36	1.64	2.14
C %	45	46	53	46	49	45
H %	7	7	8	7	7	7

Fig.3 Macro/ Micronutrients (P, K, Mg, Na, Ca, Mn, Fe) in formulations based on ICP-MS results (nutrients in mg/kg).



	Na	Mg	P	K	Ca	Mn	Fe
PG-P	567	989	1159	7832	1413	306	2219
PG-G	1495	1397	2132	17170	611	443	369
BE-P	698	547	1333	3733	1052	218	1339
BE-G	2425	1450	1988	14735	730	57	422
CE-G	255	2957	3013	15020	2475	86	693
CE-P	77	1193	971	5932	3616	113	2057

Fig.4 Micronutrients (B, Cu, Zn in mg/kg) level in formulations based on ICP-MS.

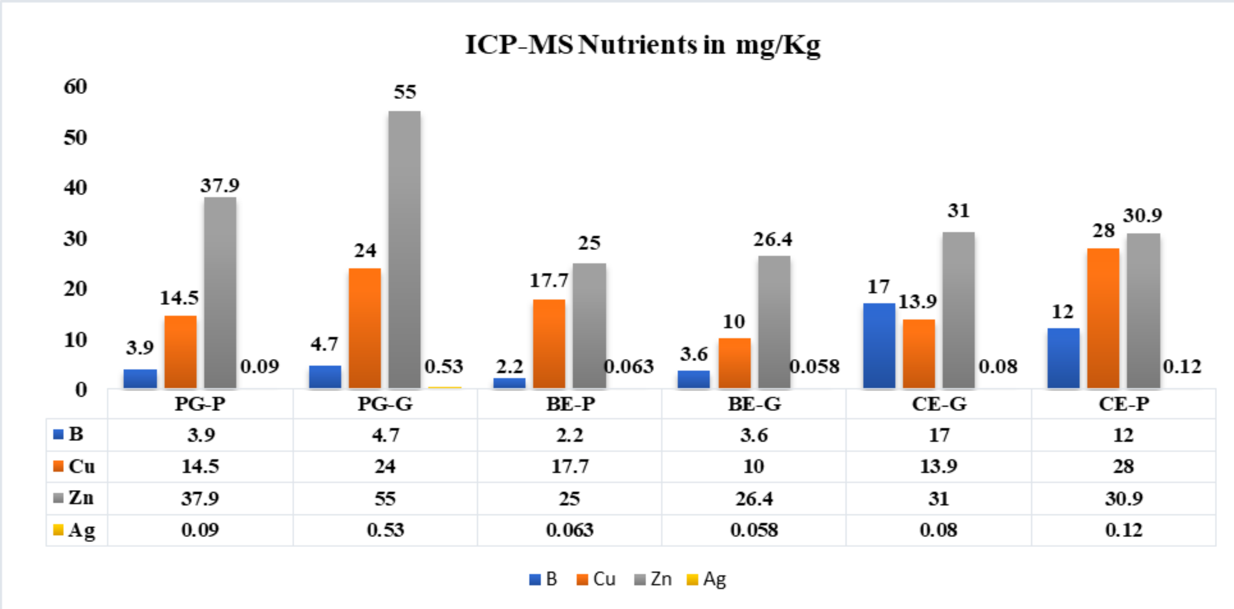


Fig.5 Effect of different formulations PG-G 1%, PG-P 1%, CE-G 1%, CE-P 1%, BE-G 1%, BE-P 1%, MOF 1%, and control on concentration on (a) chlorophyll a, (b) chlorophyll b, (c) carotene + xanthophyll, and (d) total concentration of chlorophyll, (e) Seed germination in each pot of formulations, (f) Effect of different formulations PG-G 1%, PG-P 1%, CE-G 1%, CE-P 1%, BE-G 1%, BE-P 1%, and MOF 1% on fresh and dry weight.

GROWTH IMPACT ON PLANT OF PG, CE, AND BE BASED ON PIGMENTS CONCNETRATION

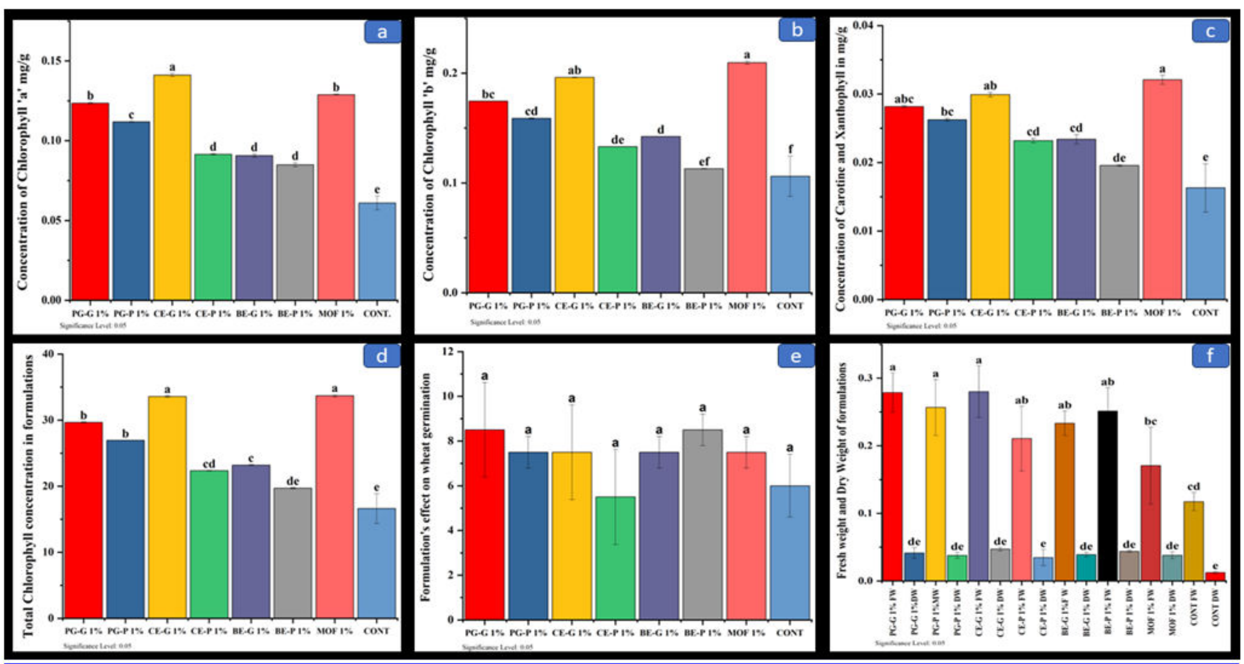


Fig.6 Pearson pairwise Correlation coefficient Matrix of P.G., C.E., and B.E. formulations along with Glass jar and Earthen pot based on test parameters

CORRELATION COEIFICIENT MATRIX AMONG THE FORMULATIONS BASED ON CONCENTRATION OF NUTIRENTS

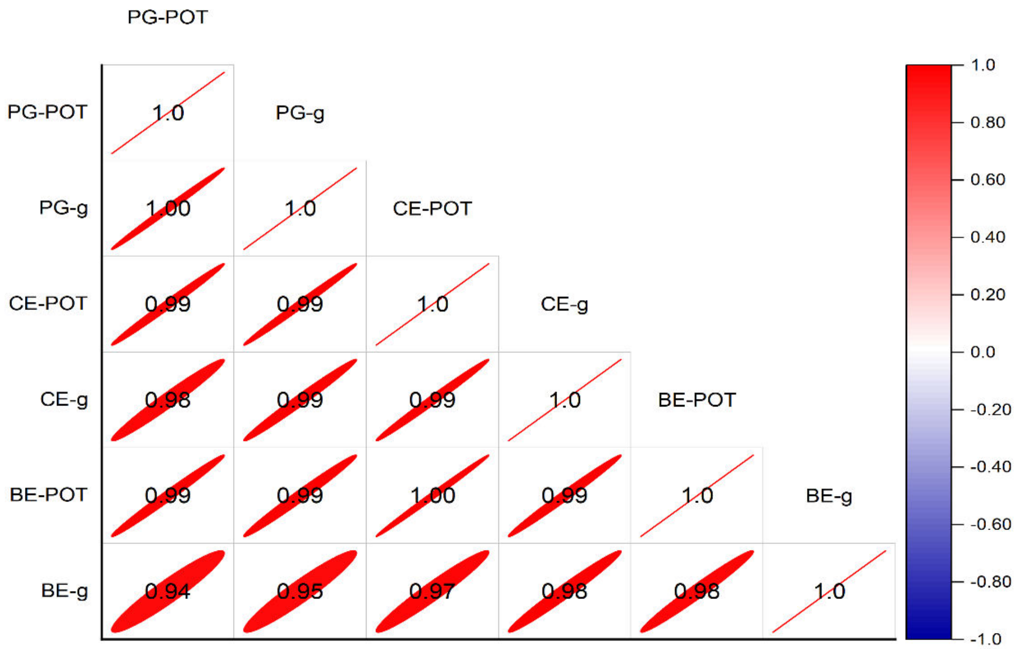


Fig.7 Pearson pairwise Correlation coefficient Matrix in all physio-chemical parameters

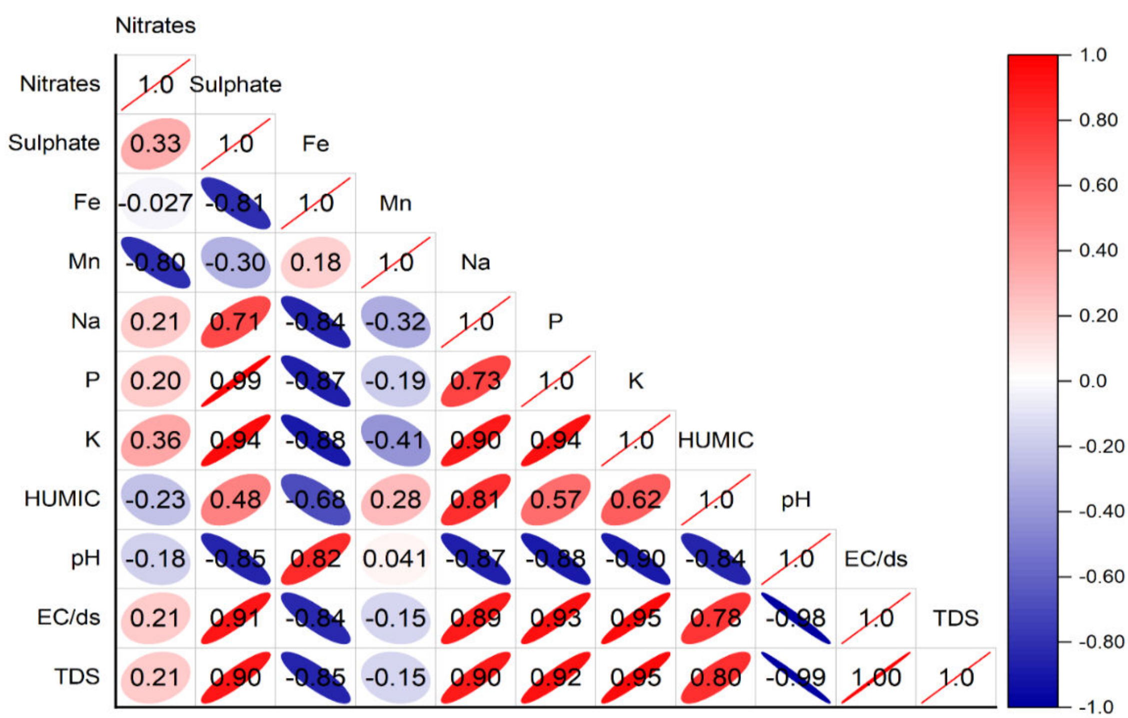


Table.1 Physio-chemical characterization of PG, CE, and BE with earthen pot (P) and glass pot (G) comparisons.

Parameter	PG-P	PG-G	CE-P	CE-G	BE-P	BE-G
Nitrate (NO_3^-) ppm	1683±4.08	1800±2.1	1129±5.40	1353±5.74	1258±9.8	1288±7.8
Sulphate (SO_4^{2-}) ppm	387± 12.83	806.2±21.03	349.7±2.2	928±53.3	278.7±42.2	665.9±21
Iron (Fe^{2+}) ppm	65±0.3	12.71±0.3	49.86±2.4	13±0.16	36.9±3	12.75±0.16
Mn (Mn^{2+}) ppm	9.57±0.44	8.29±0.60	9.74±0.3	10.05±0.44	9.98±0.7	9.85±0.6
Sodium (Na^+) ppm	27.4±0.73	85.07±2	26.31±1.5	59.5±8.7	32.2±1.8	105.2±2.4
Potassium ppm	114±3.5	345.2±6.8	101.9±5.3	307±7.7	87.53±4	311.2±4.2
Phosphate (PO_4^{3-}) ppm	21.9±2.4	171.9±30.4	31.06±2.3	232±6.2	16.86±1	151.2±4.4
pH	6.17±0.3	5.69±0.10	6.3±0.07	5.37±0.04	6.18±0.03	5.19±0.02
EC-ds/m	7.7	9.1	7.3	9.6	7.2	9.8
TDS	3880	4570	3650	4800	3700	4930

All the values are the arithmetic mean of three replicate observations with ± SD

Additionally, in various liquid organic fertilizers, García *et al.,* (2021) noted 630 to 6270 ppm K_2O, 100 to 850 ppm Na, 400 to 1278 ppm Mn, 300 to 740 ppm Fe, 3.7 to 5.1 EC, and pH 4 to 5.5 which is similar or somewhere greater than of these values in case of all PG, CE, and BE nutrient composition. In the study of micro and macro-nutrients, Ag is also detected in a small amount in all the formulations, which is also good for plant growth and protection. Silver in ionic or nanoparticle forms has a high antimicrobial activity and is widely used for various sterilization purposes. Similarly, relatively few studies have shown the applicability of silver to control plant diseases (Jo *et al.,* 2009). Small silver and micromolar doses (1 to 10 µM) can suppress bacterial growth in water (Liu *et al.,* 1994). Sang *et al.,* (2012) worked on More than 10 plant diseases caused by 18 different plant pathogenic fungi and found that 100 ppm of AgNPs effectively inhibits all fungal pathogens. The highest amount of Ag was found in PG-G (0.53 mg/kg), followed by CE-P (0.12 mg/kg) after then 0.09, 0.08, 0.063, and the lowest was 0.058 mg/kg, respectively in PG-P, CE-G, BE-P, and BE-G.

Additionally, based on the research conducted thus far on panchagavya (PG), Jeevumrutha (JM), and Sasyamrutha (SM) by Chakraborty and Sarkar, (2019), the values of N were 2366, 658, & 742 ppm, followed by P (187, 195, & 96 ppm), K (1354, 821 & 323 ppm), Mn (0.287, 0.394 & 0.238 ppm), Fe (9.17, 42.44 & 14.74 ppm) and S (485, 564 & 503 ppm), respectively in PG, JM, & SM. In an additional review study conducted by Khanna *et al.,* (2025), the chemical composition of PG represented a pH of 5.45, with EC of 10.22 dSm2, following the content of N, P, K, and Na 229 ppm, 209 ppm, 232 ppm, and 90 ppm was discovered). All numbers, however, roughly correlate with the nutritional values of a different study by Chakraborty & Sarkar (2019); and García *et al.,* (2021), when nutritional values are converted from 5% to 100%. The National Centre for Organic & Natural Farming, Ministry of Agriculture & Farmers Welfare, Govt. of India order 1985 (2023), which specifies that the total NPK percentage in liquid organic fermented manure should not be less than 1.2 %, is also in line with the PG-G and CE-G values of the formulations. Research showed that soil urease, sucrase, and phosphatase activities, total nitrogen, available nitrogen, total phosphorus, available phosphorus, total potassium, available potassium, and the amount of organic matter all increased the effect of humic acid on increasing crop yield and quality (Jindo *et al.,* 2012; Li *et al.,* 2019).

The only element that was found to be lower was phosphate. This discovery might be explained by the simple composition of PG, CE, and BE, which only had five main components. Use Chakraborty & Sarkar, (2019); instead of banana, yeast extract, molasses, sugarcane juice, and coconut water in other formulations (Khanna *et al.,* 2025). 20% diluted formulations were also tested for 100 germination seeds on *Vigna radiata* with control and found CE has the highest potential for seed germination of *Vigna radiata*. Fig 1 (i) shows CE promotes a higher seed germination rate but also insignificant difference from PG, & BE at the level of 0.05 p-value. This means all three formulations have good potential for seed germination. Autoclave water was also tested as a control and found to lower seed germination.

Correlation Coefficient Matrix

The correlation matrix shows mutuality in two variables based on positive, and negative correlation. The correlation between all formulations was depicted in Fig 6. Correlation coefficient matrix analysis revealed strong positive relationship among all the tested formulations. The relationship of humic acid with nitrates (-0.23) was weakly negative, and with Fe (-0.68) moderately negative (Fig 7). But in the case of sulfate (0.48) and Mn (0.28) was weakly positive; with P (0.57), and K (0.62) was moderately positive, and with Na (0.81), it was strongly positive. The positive relationship of humic acid with P, K, Na, sulfate, TDS, and Mn explains the direct contribution of the composition of humic acid somewhere (Allard, 2006; Li *et al.,* 2014). Other research also says that in humic acid, humates are composed of different metal salts formed by the reaction of COOH and OH groups with various metallic cations like Fe++, Mn++, Ca^{++}, and Zn^{++} (Tsutsuki and Kuwatsuka, 1979). Correlation with the pH of humic acid is strongly negative (-0.84), which clearly explains that a high concentration of humic acid will increase the formulation's acidic nature (decrease pH value). This means humic acid is inversely proportional to pH value.

Chlorophyll Content in Test Plants

We performed a plant test of formulations with respect to MOF (Market-based Organic Fertilizer) and found a significant increase in the content of chlorophyll "a" in CE-G 1%, PG-G 1%, and MOF 1% respectively (Fig 5a). Similarly, Chlorophyll "b" was found to be more abundant in CE-G 1%, MOF 1%, and PG-G 1% (Fig 5b). MOF 1% had a greater concentration of carotene + xanthophyll, followed by CE-G 1% and PG-G 1% in Fig 5 (c). Additionally, CE-G 1% and MOF 1% had a higher concentration of total chlorophyll, followed by both PG-G 1% and PG-P 1% in Fig 5 (d). However, in Fig 5 (f) PG-G 1%, PG-P 1%, and CE-G 1% had the highest fresh weight (FW) and dry weight (DW) findings. On the other hand, no discernible variation in seed germination was discovered in Fig 5 (e). Accordingly, the plant growth study indicates that 1% CE-G promotes overall plant growth since it contains more macro-micronutrients. In contrast to PG-G 1% and MOF 1%, CE-G 1% increases the concentration of chlorophyll a, b, and total chlorophyll content.

In the present study also noticed that higher concentrations of chlorophyll a and b, carotene + xanthophyll, and total chlorophyll were found in the glass jar-based formulations as compared to pot-based formulations. Additionally, the prior nutrient data also indicate that glass jars contain larger amounts of nutrients for the overall growth of plants, and higher nutrient concentrations are effective.

In conclusion, effective improvements for sustainability in agriculture are necessary to cope detrimental consequences of excessive application of synthetic fertilizers on the environment and human health. This study resulted in a novel idea of using two organic liquid formulations consisting of Capralac Extractum (CE) and Bubaluslac Extractum (BE), based on indigenous agricultural techniques used in ancient India. "Panchagavya." The study aims to provide both innovative formulations alongside panchagavya in different formulations prepared in Glass jars and earthen pots with dung, milk, urine, curd, and ghee of goat, buffalo, and cow in the ration of 1:7:2:3; 3 based on their nutrient analysis.

The highest concentrations of sulphate (928 ppm), manganese (10.05 ppm), and phosphate (232 ppm) were found in CE-G followed by the concentrations of nitrate (1353 ppm), iron (49.86 ppm) and humic acid (2676 ppm) was observed higher in CE-P. The high ranking of CE-G's qualitative results clearly explains its efficiency. Conversely, PG has the highest concentrations of nitrate (1800 ppm), iron (65 ppm), and potassium (345 ppm), and the concentrations of sulphate (806 ppm), Na (85 ppm), and phosphate (171.9 ppm) also in good amount.

CE-G and PG-G preserve portions of the standard nutrition value and both formulations can be used as the best organic supplements for agriculture. Additionally, based on the CHNS and ICP-MS analysis, it can be easily concluded that PG-G formulations have a good amount of Mn, Zn, K, P, and Ag and can be useful in agricultural practices either through hydroponics or field trials. In the case of CE, higher concentrations of Mg, P, B, Cu, and N, followed by the highest value of K and Ca are more effective in sustainable agriculture. Thus, both PG and CE are complementary. The comparative study of nutritional value in a glass jar and an earthen pot makes it clear that a glass jar is more effective in protecting nutrients from seepage than an earthen pot.

Higher Fe content was found in PG-G in both treatments. Higher Na was found in BE-G under both methods of testing.

Ag in ionic or nanoparticle forms has a high antimicrobial activity and is widely used for various sterilization purposes. The small amount of Ag at micromolar doses (1 to 10 µM) is sufficient to suppress bacterial growth. If the values are converted in µM, then the highest amount of 'Ag' was found in PG-G (4.9 µM), followed by the highest recorded in CE-P (1.11 µM).

Based on our results, we conclude that the number of nutrients present in the different formulations was in the order of CE-G>PG-G>CE-P. We have also evaluated the impact of formulation on plant vegetative growth and found that both CE-G 1% and MOF 1% are almost similar in the pigments test except in fresh weight and dry weight. While PG-G 1% is a good competitor of CE-G and MOF. Yet both formulations (CE-G, and PG-G) also contain other plant-protecting biochemicals and plant growth-promoting microflora that can boost the plant growth and defense mechanism. Hence, these formulations can be used for carrying out sustainable agriculture in a capricious environment.

Authors Contributions

Dr. Raj Kumar Mehra - Conceived the original idea, designed the methodology, performed experimental work and wrote the manuscript; Ankita Jain - Performed experimental work, computational framework and analysed the data. Wrote the manuscript; Dr. Poonam Dehariya – Supervision; Mukesh Kumar Kanwar – Supervision.

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Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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