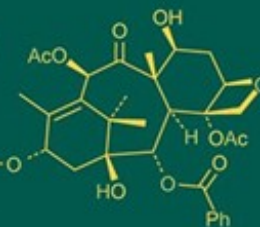
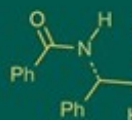
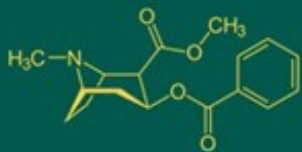


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Effect of liquid organic manures on growth, yield and quality of Kalmegh (*Andrographis paniculata* Burm F Nees) under Malnad region of Karnataka

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ABSTRACT

A field experiment was conducted during 2025-2026 at Agricultural and Horticultural Research Station, Thirthahalli, Shivamogga, to evaluate the "Effect of liquid organic manures on growth, yield and quality of Kalmegh (*Andrographis paniculata* Burm. F Nees) under Malnad region of Karnataka". The experiment was laid out in Randomized Complete Block Design (RCBD) comprising of ten treatments with three replications. The treatments consist of Jeevamrutha at 10 % and 20 %, Panchagavya at 5 % and 10 %, Vermiwash at 10 % and 20 % and their combinations. The recommended dose of fertilizers (RDF) was applied uniformly to all the treatments except T₁₀. Drenching of applications was carried out at 25, 50 and 75 days after transplanting. Among the different treatments, results revealed that treatment T₉ (Jeevamrutha 20 % + Panchagavya 10 % + Vermiwash 20 %) recorded the highest plant height (46.53 cm), primary branches per plant (22.07), secondary branches per plant (20.27), Number of leaves per plant (190.40), Leaf area per plant (1653.27 cm²), Number of days taken for maturity (100.67), Fresh herbage yield (43.33 g/plant), Dry herbage yield (14.03 g/plant) and andrographolide content (1.98%). The next best treatment was T₈ (Jeevamrutha 10 % + Panchagavya 5 % + Vermiwash 10 %, with 44.53 cm plant height, 21.13 primary branches per plant, 19.27 secondary branches, 179.73 number of leaves, 1426.60 cm² leaf area per plant, 97.13 number of days taken for maturity, 40.18 g/plant fresh herbage yield, 12.18 g/plant dry herbage yield, 1.76% andrographolide content. Overall, the combined application of jeevamrutha, panchagavya and vermiwash proved effective in enhancing the growth, yield and quality of Kalmegh and was found to be a promising organic nutrient management practice for its cultivation under Malnad region of Karnataka.

Keywords: Kalmegh, Andrographolide, Jeevamrutha, Panchagavya, Vermiwash

1. Introduction

Kalmegh (*Andrographis paniculata* Burm. F Nees) is a very important medicinal herb of family Acanthaceae and well known for its therapeutic properties. It is widely regarded as the "King of Bitters" because of its characteristic bitter flavor and is often employed in traditional systems of treatment (Anon., 2021) [1]. The plant is known for its varied pharmacological actions such as hepatoprotective, antioxidant, anti-inflammatory, antibacterial and immunomodulatory activity. Kalmegh is used for therapeutic purposes owing to its bioactive diterpene lactones, mainly andrographolide, which is one of its principal quality defining ingredients. The demand of kalmegh as raw material for herbal formulations and medicinal preparations has expanded tremendously creating a need for effective production procedures that ensures higher biomass output along with improved accumulation of bioactive ingredients (Chakravarti et al., 1952; Moktader et al., 1939) [2, 3]. Nutrient management is one of the primary elements that determine plant development, yield and phytochemical quality. The common methods of nutrient management are mostly based on chemical fertilizers, but their excessive and continuous application can negatively influence the health of the soil and its biological activity. Thus, there is a growing interest in sustainable nutrient-management strategies that enhance crop output without compromising soil quality.

Liquid organic manures and bioformulations like jeevamrutha, panchagavya and vermiwash are increasing importance in sustainable crop development. These formulations comprise various nutrients, beneficial microbes and physiologically active chemicals that may be helpful in increasing nutrient availability, microbial activity and plant growth (Maity et al., 2020) [4]. Jeevamrutha is a fermented microbial preparation used as a stimulant of biological activity and nitrogen cycling in soil. Panchagavya is created from cow generated products and contains nutrients and growth boosting substances which may enhance the vegetative growth and physiological activities. Vermiwash derived from vermicomposting system contains soluble nutrients,

beneficial microbes and other physiologically active chemicals which might help to increased plant growth and production.

Hence, present investigation was carried out to evaluate the effect of bioformulations on growth, yield and quality of Kalmegh (*Andrographis paniculata* Burm. F. Nees). The study was conducted to evaluate the effect of different concentrations and combinations of jeevamrutha, panchagavya and vermiwash on growth and yield parameters, andrographolide content. The present study aims to find out a suitable approach of nutrient management using liquid organic manures for improvement of productivity and quality of Kalmegh under sustainable agricultural techniques.

II. Materials and Methods

The present investigation was conducted to study the response of Kalmegh (*Andrographis paniculata* Burm. F. Nees) to different liquid organic manures with respect to growth, yield and quality attributes. The experiment was conducted during 2025-2026 at AHRS, Thirthahalli. The experimental site was characterized by red soil and the initial soil properties of the experimental field were determined before planting. Healthy and uniform planting material of kalmegh was used for the experiment. The crop was established at a spacing of 30 cm × 15 cm. Standard agronomic practices recommended for kalmegh cultivation were followed throughout the experimental period, except for the treatments under investigation. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Ten treatments comprising recommended dose of fertilizers and different concentrations and combinations of liquid organic bioformulations were evaluated.

Treatments	Treatment Details
T ₁	RDF (FYM-15 t/ha + NPK-75 :75 :50 kg/ha)
T ₂	Jeevamrutha (10 %)
T ₃	Jeevamrutha (20 %)
T ₄	Panchagavya (5 %)
T ₅	Panchagavya (10 %)
T ₆	Vermiwash (10 %)
T ₇	Vermiwash (20 %)
T ₈	Jeevamrutha (10 %) + Panchagavya (5 %) + Vermiwash (10 %)
T ₉	Jeevamrutha (20 %) + Panchagavya (10 %) + Vermiwash (20 %)
T ₁₀	FYM (15 t/ha) + Jeevamrutha (20 %) + Panchagavya (10 %) + Vermiwash (20 %)

Note: RDF (T₁) is common for all the treatments except T₁₀

Preparation and application of bioformulations

Jeevamrutha, panchagavya and vermiwash was prepared using standard procedures.

Liquid jeevamrutha was prepared by mixing 10 kg of fresh desi cow dung, 10 litres of desi cow urine, 2 kg of jaggery, 2 kg of pulse flour and a handful of soil collected from the field in a 200-litre capacity plastic drum. Water was added to the mixture to bring the total volume up to 200 litres and the contents were thoroughly mixed. The mixture was stirred three times a day in a clockwise direction using a wooden stick to ensure uniformity. The drum was kept in a shaded area and covered with a wet gunny bag. The mixture was left to ferment for seven days to encourage microbial growth and was subsequently used according to the prescribed treatments (Palekar, 2006) [5].

Preparation of panchagavya was followed according to the procedure given by Swaminathan *et al.* (2008) [6]. The raw materials used were cow dung (0.50 kg), urine (0.45 litre), milk (0.168 litre), curd (0.172 litre) and ghee (0.195 kg). Wide mouthed containers were used for preparation of panchagavya. The measured amount of cow dung and ghee were added first into the container and kept for about three days for fermentation. On fourth day the remaining products were added to the container and kept it for fermentation for about seven days. The contents were stirred for 20 minutes continued till 10 days both in the morning as well as in the evening to facilitate aerobic microbial activity.

Vermiwash is a liquid extract produced from vermicompost, which is prepared by feeding earthworms with raw materials like leaf litter or cow dung or other organic materials. It comprises a massive bacterial count, mucus, vitamins, different bioavailable minerals, hormones, enzymes and different antimicrobial peptides (Gudeta *et al.*, 2021) [7]. The required quantity of each bioformulation was diluted with water to obtain the desired concentration before application. The prepared formulations were applied to the crop as soil drenching at 25, 50 and 75 days after transplanting.

Crop management

The experimental field was prepared thoroughly before planting. The specified quantity of well decomposed FYM was applied to individual plots according to treatments and mixed thoroughly with the soil fifteen days prior to transplanting. The recommended dosage of nutrients (75:75:50 kg of N: P₂O₅: K₂O ha⁻¹), 50 per cent of nitrogen as urea and full dose of P₂O₅ as rock phosphate and K₂O as murate of potash (MOP) were applied as basal dose and mixed thoroughly into the soil at the time of transplanting and remaining 50 per cent of nitrogen was applied as a top dressing at 30 days after transplanting. Thirty days old seedlings were transplanted at a spacing of 30 cm x 15 cm apart during January 2026. Irrigation was provided immediately after transplanting of seedlings. The crop was irrigated daily till the establishment. After establishment of the crop irrigation was given at 4 -5 days interval till the maturity of the crop.

Biochemical analysis

The chlorophyll content in leaves was estimated at different stages of crop growth by following Dimethyl sulfoxide (DMSO) method given by Shoaf *et al.* (1976) [8]. Fresh and fully matured leaves from the plant were brought to laboratory in ice box from the field. A known weight of sample (100 mg) was cut into small pieces and incubated in 7.0 ml of dimethyl sulfoxide for 12 hours in dark. After the incubation period, supernatant was collected and volume was made up to 10 ml using dimethyl sulfoxide. The absorbance of the extract was measured at 645 nm and 663 nm using dimethyl sulfoxide as blank in spectrophotometer.

Quality analysis

The analysis was carried out using shimadzu LC-10A HPLC system equipped with C18 column (symmetry, 4.6 mm × 250 mm) in isocratic mode with the mobile phase acetonitrile and water in the ratio 7:3 with the RP-HPLC C-18 column at a flow rate of 1 ml/min. The standard andrographolide with the concentration 0.4/1 mL.

Sample preparation: One gram of foliage powder was macerated using methanol extract and dried at room temperature, after drying extract was dissolved in 10 ml mobile phase (1 mg/ml) 20 µL was injected and the elution was monitored at 230 nm. The amount of andrographolide present in the sample was estimated using the formula.

××

$$\text{Andrographolide (mg/g)} = \frac{\text{Sample area}}{\text{Standard amount}} \times \frac{\text{Dilution}}{\text{Sample area}}$$

Sample area Standard amount Dilution

Andrographolide (mg/g) =

Standard area Dilution of standard Sample

$$\text{Andrographolide (\%)} = \frac{\text{Andrographolide (mg/g)}}{10}$$

Microbial analysis

General microflora in soil: Ten grams of pooled soil (treatment wise) was mixed in 90 ml sterile water blank to give 10^{-1} dilution. Subsequent dilutions up to 10^{-6} were made by transferring serially 1 ml of the dilution to 9 ml of sterile water blanks. The populations of bacteria, fungi and actinomycetes were estimated by transferring 1 ml of 10^{-5} , 10^{-3} and 10^{-4} dilutions respectively to a sterile petridish and approximately 20 ml of media viz., Soil Extract Agar, Martins Rose Bengal Agar and Kusters Agar for soil bacteria, fungi and actinomycetes, respectively was poured into plates. The plates were rotated twice in clockwise and anticlockwise direction for uniform distribution of the inoculums. After solidification of the media, plates were kept for incubation in an inverted position at 30 ± 1 °C for a week time and emerged colonies were counted (Tate, 1995) [9].

Beneficial microflora in soil: The population of beneficial microflora was determined by serial dilution plate count technique. Soil sample of each treatment was collected replication wise and pooled. Ten grams of pooled soil was used for population estimation. The popula-

tion of *Azotobacter sp.*, *Bacillus sp.* was estimated by transferring 1 ml of 10^{-3} and 10^{-4} dilutions respectively to sterile petri dishes. Approximately 20 ml of Waksman 77 medium for *Azotobacter chroococcum*, Pikovskaya's medium for PSB and Aleksandrov's agar medium for KSB were poured into the plates and kept for incubation in an inverted position at 30 ± 1 °C for a week time and emerged colonies were counted (Tate, 1995) [9].

III. Results and Discussion

Growth Parameters: Growth is an irreversible increase in size and shape of the plant and it is affected by the complex interaction between environmental factors and physiological processes which are influenced by external inputs like water and nutrients. In the present field experiment, it was recorded that the growth parameters viz., plant height, number of primary branches, number of secondary branches, number of leaves, leaf area and number of days taken to maturity differed significantly among the treatments due to the application of liquid organic manures. The five uniform plants were selected and tagged in each treatment for recording the observations on various growth parameters.

Table 1. Effect of liquid organic manures on growth parameters of kalmegh (*Andrographis paniculata* Burm. F Nees) at harvest stage.

Treatments	Plant height (cm)	Number of primary branches	Number of Secondary branches	Number of leaves	Leaf area (cm ²)	No. of days taken for maturity
T ₁	29.83	16.47	15.60	95.53	506.47	89.27
T ₂	33.13	17.93	16.47	107.47	581.87	90.40
T ₃	34.60	18.13	16.80	119.40	772.53	91.73
T ₄	35.63	17.27	17.27	115.67	665.13	92.93
T ₅	37.47	18.13	18.13	140.87	968.53	95.13
T ₆	35.03	17.60	16.40	123.13	718.40	90.20
T ₇	36.53	17.47	18.20	134.60	874.47	91.93
T ₈	44.53	21.13	19.27	179.73	1426.60	97.13
T ₉	46.53	22.07	20.27	190.40	1635.27	100.67
T ₁₀	39.40	19.80	18.87	168.20	1176.60	94.93
S. Em ±	1.02	0.50	0.74	1.90	11.80	1.80
CD @ 5%	3.02	1.54	2.20	5.70	35.10	5.50

Note: T₁ (RDF) is common for all the treatments except T₁₀

The data pertaining to growth and maturity parameters of kalmegh as influenced by different organic nutrient treatments are presented in Table 1. Plant height was significantly higher in T₉ (46.53 cm), followed by T₈ (44.53 cm), whereas the lowest plant height was recorded in T₁ (29.83 cm). The number of primary branches was significantly higher in T₉ (22.07), followed by T₈ (21.13), while the lowest number was recorded in T₁ (16.47). Similarly, the number of secondary branches was significantly higher in T₉ (20.27), followed by T₈ (19.27), whereas the lowest was recorded in T₁ (15.60). The number of leaves per plant was significantly higher in T₉ (190.40), followed by T₈ (179.73) and T₁₀ (168.20), while T₁ recorded the lowest number of leaves (95.53). Leaf area was also significantly higher in T₉ (1635.27 cm²), followed by T₈ (1426.60 cm²), whereas the minimum leaf area was recorded in T₁ (506.47 cm²). The number of days taken for maturity differed significantly among the treatments. T₉ took the maximum number of days for maturity (100.67 days), followed by T₈ (97.13 days), while T₁ recorded the minimum number of days (89.27 days).

The increase in plant height may be attributed to the combined effect of jeevamrutha, panchagavya and vermiwash, which supply readily available macro and micronutrients, beneficial microorganisms, enzymes, amino acids, vitamins and naturally occurring plant growth regulators. These organic formulations improve soil microbial activity, enhance nutrient mineralization and uptake, stimulate cell division

and cell elongation, increase chlorophyll synthesis and photosynthetic efficiency and promote the synthesis and translocation of photosynthates, thereby resulting in increased vegetative growth and plant height, similar results were also reported by Sanjutha *et al.* (2008) [10] and Prabhu *et al.* (2009) [11] in kalmegh, Chaudary *et al.* (2017) [12] in ashwagandha, Kumbar *et al.* (2016) [13] in french bean and Gowda *et al.* (2025) [14] in kalmegh.

The increased number of primary branches may be attributed to the balanced supply of nutrients and bioactive compounds present in jeevamrutha, panchagavya and vermiwash, which promoted early establishment and vigorous vegetative growth. The presence of naturally occurring cytokinins in these organic formulations might have enhanced the initiation and development of axillary buds, thereby increasing branching. In addition, improved carbohydrate production and its efficient partitioning towards actively growing shoots may have favoured the emergence of more primary branches. The combined action of beneficial microorganisms and organic metabolites also improved the overall physiological status of the plant, resulting in better canopy development and increased branching. Similar results were observed by Parashar *et al.* (2011) [15] and Himabindu *et al.* (2017) [16] in kalmegh, Basavaraj *et al.* (2014) [17] and Kumar *et al.* (2016) [18] in French bean, Pansuriya *et al.* (2024) [19] in chrysanthemum and Gowda *et al.* (2025) [14] in kalmegh.

The increased production of secondary branches under the combined application of jeevamrutha, panchagavya and vermiwash may be attributed to the creation of a favourable rhizosphere environment that enhanced root proliferation and metabolic activity. A well-developed root system improves the absorption efficiency of water and essential nutrients, ensuring a continuous nutrient supply during the active vegetative phase. The presence of beneficial micro-organisms in jeevamrutha also stimulates the production of microbial metabolites, including vitamins, organic acids and growth-promoting substances, which improve root-soil interactions and nutrient assimilation. Furthermore, panchagavya enhances endogenous hormonal balance, particularly by maintaining a favourable cytokinin-to-auxin ratio, which encourages the activation of dormant axillary buds and their subsequent development into secondary branches. Vermiwash contributes bioactive compounds such as humic substances, enzymes and soluble nutrients that enhance chloroplast development and photosynthetic capacity, thereby increasing assimilate production. The greater availability of carbohydrates and metabolites supports the initiation and sustained growth of lateral shoots, ultimately resulting in a higher number of secondary branches throughout the crop growth period. These findings are in accordance with the results obtained by Kumar *et al.* (2016) [18] in kalmegh. Similar findings were also reported by Patil *et al.* (2012) [20] in onion and Gowda *et al.* (2025) [14] in kalmegh.

The higher number of leaves in T₉ may be attributed to the synergistic effect of jeevamrutha, panchagavya and vermiwash, which enhanced soil biological activity and ensured a continuous supply of readily available nutrients throughout the crop growth period. Jeevamrutha promotes the multiplication of beneficial micro-organisms, resulting in rapid nutrient mineralization and improved nutrient availability. Panchagavya contains naturally occurring plant growth regulators such as auxins, gibberellins and cytokinins, which stimulate cell division, leaf initiation and expansion. Vermiwash provides readily available macro and micronutrients, amino acids, vitamins and enzymes that improve root growth, chlorophyll synthesis and photosynthetic efficiency. The combined application of these liquid organic manures enhances carbohydrate production and efficient translocation of photosynthates to developing shoots, thereby promoting continuous leaf initiation, expansion and retention which ultimately resulted in a greater number of leaves per plant. These findings are in accordance with the results obtained by Prabhu *et al.* (2009) [11] in kalmegh. Similar results were obtained by Gowda *et al.* (2025) [14] in kalmegh, Harshavardhan *et al.* (2016) [21] in China aster, Fazeel *et al.* (2019) [22] in okra and Chaithra *et al.* (2021) [23] in sunflower.

The increased leaf area under T₉ could be attributed to the synergistic action of FYM and liquid organic manures, which improved soil fertility, microbial activity and nutrient availability, thereby promoting better nutrient uptake and sustained vegetative growth. Jeevamrutha enhanced microbial proliferation and nutrient mineralization, panchagavya supplied naturally occurring plant growth regulators such as auxins, gibberellins and cytokinins that promoted cell division and leaf expansion, while vermiwash provided readily available nutrients, enzymes and bioactive compounds that improved photosynthetic efficiency and assimilate production. The combined effect of these organic inputs resulted in vigorous vegetative growth, enhanced leaf expansion and ultimately greater leaf area per plant. Similar findings were reported by Sanjutha *et al.* (2008) [10], Prabhu *et al.* (2009) [11], Gowda *et al.* (2025) [14] in kalmegh.

The prolonged maturity period observed under the combined application of jeevamrutha, panchagavya and vermiwash could be attributed to the sustained availability of nutrients and continuous stimulation of physiological and metabolic activities throughout the crop growth period. Jeevamrutha enhances microbial proliferation and nutrient mineralization, ensuring a steady supply of essential nutrients, while panchagavya provides naturally occurring plant growth regulators such as auxins, gibberellins and cytokinins that promote prolonged vegetative growth and delay senescence. Vermiwash further supplies readily available nutrients, enzymes and bioactive compounds that improve chlorophyll synthesis, photosynthetic efficiency and assimilate pro-

duction. The integrated application of these organic inputs maintains higher metabolic activity and delay leaf senescence, thereby extending the vegetative phase and increasing the duration required for physiological maturity. Similar findings were reported by Sanjutha *et al.* (2008) [10], Prabhu *et al.* (2009) [11], Gowda *et al.* (2025) [14] in kalmegh.

Yield parameters

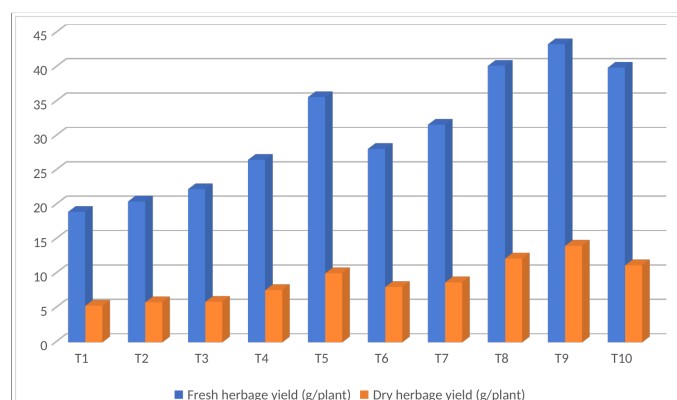


Figure 1. Effect of liquid organic manures on fresh and dry herbage yield (g/plant) in kalmegh (*Andrographis paniculata* Burm. F Nees) at harvest stage.

Among the different treatments, the maximum fresh herbage yield per plant (43.33 g), dry herbage yield per plant (14.03 g), were recorded in T₉ (Jeevamrutha 20 % + Panchagavya 10 % + Vermiwash 20 %). Whereas, minimum fresh herbage yield per plant (18.95 g), dry herbage yield per plant (5.31 g), were recorded in T₁ (FYM 15 t/ha + NPK 75:75:50 kg/ha). The higher fresh and dry herbage yield obtained under the combined application of jeevamrutha, panchagavya and vermiwash could be attributed to the synergistic influence of these organic inputs on crop growth and biomass accumulation. Jeevamrutha enhanced microbial activity and nutrient mineralization, ensuring a continuous supply of essential nutrients throughout the crop growth period. Panchagavya being rich in naturally occurring plant growth regulators, vitamins and micronutrients promoted vigorous vegetative growth, increased leaf area and branching, thereby enhancing photosynthetic efficiency. Vermiwash supplied readily available nutrients, enzymes and bioactive compounds that improved chlorophyll synthesis, nutrient uptake and translocation of photosynthates towards the aerial plant parts. The combined effect of these organic formulations resulted in greater dry matter accumulation, increased biomass production and efficient partitioning of assimilates which ultimately contributed to higher fresh and dry herbage yield. Gowda *et al.* (2025) [14] in kalmegh.

Chlorophyll analysis

The maximum chlorophyll a (0.82 mg/g), chlorophyll b (0.36 mg/g) and total chlorophyll content (1.18 mg/g) were recorded in T₉ (Jeevamrutha 20 % + Panchagavya 10 % + Vermiwash 20 %). Whereas, the minimum chlorophyll a (0.25 mg/g), chlorophyll b (0.07 mg/g) and total chlorophyll content (0.32 mg/g) were recorded in T₁ (FYM 15 t/ha + NPK 75:75:50 kg/ha). The superior chlorophyll content observed under the combined application of jeevamrutha, panchagavya and vermiwash may be attributed to their synergistic influence on chlorophyll metabolism and the maintenance of photosynthetically active leaf tissues. Jeevamrutha creates a biologically active rhizosphere that enhances enzymatic activity and nutrient transformation, thereby improving the absorption of elements essential for chlorophyll synthesis. Panchagavya acts as a natural biostimulant by promoting cellular metabolism and enhancing the differentiation and functionality of chloroplasts, which favours increased pigment accumulation. Vermiwash, enriched with soluble organic compounds, enzymes and growth promoting metabolites, facilitates efficient translo-

cation of assimilates and protects the photosynthetic apparatus from oxidative stress. The combined application of these organic formulations sustained chlorophyll biosynthesis while minimizing pigment degradation, thereby maintaining higher concentrations of chlorophyll a, chlorophyll b and total chlorophyll throughout the crop growth period. Gowda *et al.* (2025) [14] in kalmegh

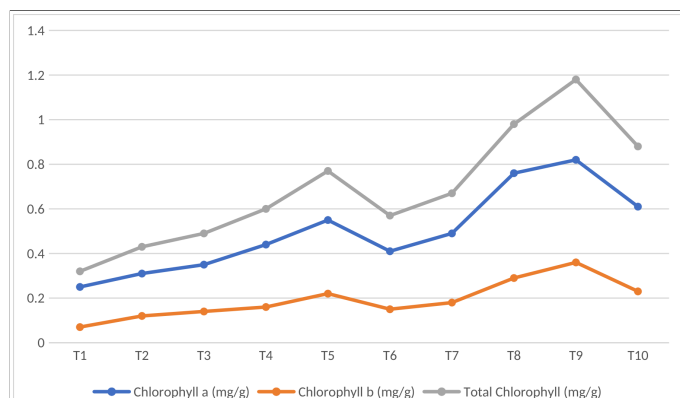


Figure 2. Effect of liquid organic manures on Chlorophyll content (mg/g) in kalmegh (*Andrographis paniculata* Burm. F Nees) at harvest stage.

Quality analysis

Andrographolide content

The highest andrographolide content (1.98 %) was recorded in T₉ (Jeevamrutha 20 % + Panchagavya 10 % + Vermiwash 20 %), while the lowest andrographolide content (0.85 %) was observed in T₁ (FYM 15 t/ha + NPK 75:75:50 kg/ha). The increased andrographolide content in T₉ may be attributed to the influence of integrated liquid organic manures on the plants secondary metabolic processes rather

than merely improving nutrient supply. Organic biostimulants such as jeevamrutha, panchagavya and vermiwash are known to enhance enzymatic activity and regulate metabolic pathways involved in the biosynthesis of terpenoids, of which andrographolide is a major diterpenoid lactone. The balanced availability of nutrients together with naturally occurring bioactive molecules and microbial metabolites creates favourable physiological conditions that divert a greater proportion of assimilates towards the synthesis of secondary metabolites after meeting the requirements for primary growth. In addition, enhanced root activity and improved nutrient use efficiency maintain sustained metabolic functioning throughout the crop growth period, leading to greater accumulation of andrographolide in the aerial parts of kalmegh at harvest. Gowda *et al.* (2025) [14] in kalmegh

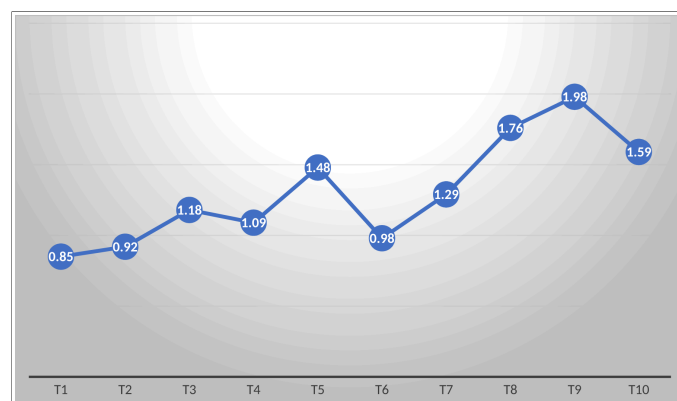


Figure 3. Effect of liquid organic manures on andrographolide content (%) in kalmegh (*Andrographis paniculata* Burm. F Nees) at harvest stage.

Microbial analysis

Table 2. Effect of liquid organic manures on general microflora in soil after harvest in Kalmegh (*Andrographis paniculata* Burm. F Nees)

Treatment details	At harvest		
	Fungi (10 ³ CFU/g)	Bacteria (10 ⁶ CFU/g)	Actinomycetes (10 ⁴ CFU/g)
T ₁	7.35	25.67	9.55
T ₂	10.33	38.63	10.45
T ₃	13.69	47.45	15.03
T ₄	12.05	45.63	13.35
T ₅	17.67	63.45	18.64
T ₆	11.67	43.58	12.67
T ₇	16.33	57.67	16.33
T ₈	21.67	86.87	26.33
T ₉	24.33	96.45	32.67
T ₁₀	18.00	71.36	22.24
S.Em ±	0.45	1.25	0.59
CD @ 5%	1.33	3.70	1.75

Note: T₁ (RDF) is common for all the treatments except T₁₀

The maximum fungal population was recorded in T₉ (Jeevamrutha 20 % + Panchagavya 10 % + Vermiwash 20 %), which recorded 24.33×10^3 CFU/g soil, whereas the minimum fungal population was observed in T₁ (RDF: FYM 15 t/ha + NPK 75:75:50 kg/ha) recording 7.35×10^3 CFU/g soil. The increased fungal population may be attributed to the continuous addition of labile organic carbon, cellulose, hemicellulose and other biodegradable substrates, which serve as primary energy sources for saprophytic fungi. Jeevamrutha and panchagavya also contain fungal propagules, vitamins, enzymes and organic acids that stimulate fungal metabolism and spore germination. Moreover, the decomposition of organic residues improves soil aggre-

gation and moisture status, creating a favourable microenvironment for fungal hyphal growth and colonization. The enhanced rhizosphere activity and increased root exudation under organic nutrition further supported fungal proliferation. These findings are in accordance with Patil *et al.* (2012) [20] in soybean, Kiran *et al.* (2015) [24] in field bean, Kumbhar *et al.* (2016) [13] in French bean, Lavanya *et al.* (2016) [25] in field bean, Devakumar *et al.* (2018) [26] in field bean, Gorabal (2020) [27] in groundnut and Tejaswini *et al.* (2021) [28] in tomato.

The maximum bacterial population was recorded in T₉ (Jeevamrutha 20 % + Panchagavya 10 % + Vermiwash 20 %), which registered 96.45×10^6 CFU/g soil, whereas the minimum bacterial population

was observed in T₁ (FYM 15 t/ha + NPK 75:75:50 kg/ha), recording 25.67×10^6 CFU/g soil. The higher bacterial population in T₉ could be due to the abundance of readily metabolizable carbon compounds, amino acids, carbohydrates and growth promoting substances supplied through jeevamrutha, panchagavya and vermiwash. These organic formulations act as microbial inoculants as well as nutrient sources, thereby accelerating bacterial multiplication and metabolic activity. The improvement in soil organic carbon and microbial biomass enhances nutrient mineralization and creates a biologically active rhizosphere, resulting in rapid bacterial colonization and sustained microbial activity. These findings are in accordance with Patil *et al.* (2012) [20] in soybean, Kiran *et al.* (2015) [24] in field bean, Kumbar *et al.* (2016) [13] in french bean, Lavanya *et al.* (2016) [25] in field bean, Devakumar *et al.* (2018) [26] in field bean, Gorabal (2020) [27] in groundnut and Tejaswini *et al.* (2021) [28] in tomato.

The maximum actinomycetes population was recorded in T₉ (Jeevamrutha 20 % + Panchagavya 10 % + Vermiwash 20 %), which registered 32.67×10^4 CFU/g soil, whereas the minimum actinomycetes population was observed in T₁ (FYM 15 t/ha + NPK 75:75:50 kg/ha), recording 9.55×10^4 CFU/g soil. The significantly higher actinomycetes population under T₉ may be attributed to the accumulation of stable organic matter and humified carbon fractions produced during decomposition of organic inputs. Actinomycetes are efficient decomposers of resistant organic compounds such as cellulose, chitin and lignin derivatives and their proliferation is favoured by increased soil organic matter, better aeration and near-neutral soil conditions created by liquid organic manures. In addition, enhanced microbial interactions and root derived carbon compounds in the rhizosphere provide a conducive environment for the growth and activity of actinomycetes, thereby increasing their population. These findings are in accordance with Patil *et al.* (2012) [20] in soybean, Kiran *et al.* (2015) [24] in field bean, Kumbar *et al.* (2016) [13] in french bean, Lavanya *et al.* (2016) [25] in field bean, Devakumar *et al.* (2018) [26] in field bean, Gorabal (2020) [27] in groundnut and Tejaswini *et al.* (2021) [28] in tomato.

Table 2. Effect of liquid organic manures on beneficial microflora in soil after harvest in Kalmegh (*Andrographis paniculata* Burm. F Nees)

Treatment details	At harvest		
	<i>Azotobacter</i> (CFU/g)	PSB (CFU/g)	KSB (CFU/g)
T ₁	11.44	7.22	4.22
T ₂	13.33	11.67	9.42
T ₃	15.33	16.22	13.22
T ₄	14.55	15.64	12.44
T ₅	17.88	19.56	16.55
T ₆	15.93	16.77	12.88
T ₇	16.44	17.22	14.22
T ₈	24.53	22.12	18.56
T ₉	27.33	23.44	19.84
T ₁₀	20.45	21.22	17.54
S.Em ±	0.48	0.49	0.51
CD @ 5%	1.43	1.47	1.51

Note: T₁ (RDF) is common for all the treatments except T₁₀. The maximum *Azotobacter* population (27.33 CFU/g), PSB (23.44 CFU/g) and KSB (19.84 CFU/g) was recorded in T₉ (Jeevamrutha 20 % + Panchagavya 10 % + Vermiwash 20 %), whereas the minimum *Azotobacter* population (11.44 CFU/g), PSB (7.22 CFU/g) and KSB (4.22 CFU/g) was recorded in T₁ (FYM 15 t/ha + NPK 75:75:50 kg/ha). The higher population of *Azotobacter*, PSB and KSB under T₉ may be attributed to the combined application of Jeevamrutha, Panchagavya and Vermiwash, which supplied a rich source of beneficial microorganisms, readily decomposable organic

substrates, amino acids, vitamins and growth-promoting substances. These organic formulations created a favourable rhizosphere environment by improving soil organic carbon, aeration and microbial activity, thereby promoting the multiplication and survival of free-living nitrogen-fixing bacteria such as *Azotobacter*. The continuous supply of organic nutrients also enhanced root exudation, providing additional energy sources for microbial growth. These findings are in accordance with Nileema and Srinivasa (2011) [29] in tomato, Kumbar *et al.* (2016) [13] in french bean, Lavanya *et al.* (2016) [25] in field bean, Boraiah *et al.* (2017) [30] in capsicum, Devakumar *et al.* (2018) [26] in field bean, Gorabal (2020) [27] in groundnut and Tejaswini *et al.* (2021) [28] in tomato, who reported increased populations of nitrogen-fixing microorganisms following the application of jeevamrutha, panchagavya and related organic formulations.

Conclusion

The results of the present study indicated that the combined application of (Jeevamrutha 20 % + Panchagavya 10 % + Vermiwash 20 %) (T₉) significantly improved the growth, foliage yield, quality and soil health in kalmegh. The treatment recorded higher growth attributes, chlorophyll content, fresh and dry herbage yield, andrographolide content, available soil nutrients and beneficial microbial populations compared to the other treatments. Based on the overall performance of growth, yield, quality and soil biological parameters observed in the present study, it was concluded that the combined application of (Jeevamrutha 20 % + Panchagavya 10 % + Vermiwash 20 %) can be recommended as an efficient and sustainable organic nutrient management practice for the cultivation of kalmegh under Malnad region of Karnataka.

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