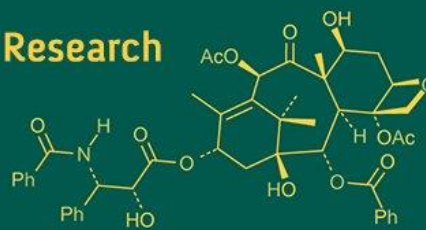


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(5): 362-366
www.biochemjournal.com
Received: 07-02-2026
Accepted: 10-03-2026

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Effect of conjunctive use of organic and inorganic fertilizers on the growth and yield performance of okra (*Abelmoschus esculentus* L.)

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i5Se.8384>

Abstract

The extensive reliance on synthetic chemical fertilizers has led to severe soil degradation, environmental pollution, and widespread nutrient deficiencies, necessitating a shift towards sustainable agricultural practices. This study, conducted during *Rabi*, 2023 season at PJTSAU, Hyderabad, evaluated the effects of Integrated Nutrient Management (INM) combining inorganic fertilizers with organic amendments like vermicompost, beejamrutha, and jeevamrutha on soil properties and the overall growth and yield of okra. Laboratory analyses revealed that these organic formulations are rich in essential macro-and micronutrients, plant growth-promoting substances (such as indole acetic acid), and beneficial microbiomes that fundamentally stimulate nutrient cycling. Field experiment demonstrated that INM treatment T₃ (50% Recommended Dose of Nitrogen [RDN] + 50% N via vermicompost) significantly maximized both vegetative growth and crop yield. T₃ produced the tallest plants, the highest dry matter accumulation (2522.99 kg ha⁻¹ at 90 days after sowing), and maximum fruit and stover yields (12.19 t ha⁻¹ and 2.57 t ha⁻¹, respectively). This represented a substantial 124.9% increase in fruit yield over the untreated control, performing comparably to 100% synthetic treatments but without the associated detrimental impacts on soil health. The findings conclude that the synergistic integration of chemical fertilizers which meet early growth demands coupled with organic solid and liquid microbial formulations, optimizes nutrient use efficiency, improves soil vitality, and provides disease protection. Ultimately, this conjunctive INM approach ensures highly productive and sustainable agricultural outcomes while meticulously preserving long-term ecosystem health.

Keywords: Integrated nutrient management, vermicompost, jeevamrutha, beejamrutha

Introduction

The widespread adoption of high-yielding crop varieties, heavily reliant on synthetic chemical fertilizers, has precipitated a significant departure from traditional organic farming practices, ultimately leading to severe soil degradation, environmental pollution, and widespread nutrient deficiencies. Although these chemical inputs initially boosted crop yields, their indiscriminate and unbalanced application has induced multi-nutrient deficiencies in both soils and crops, eroded the natural fertility of the land, reduced the economic returns per input, and caused profound destruction to soil biological health through the toxic accumulation of chemicals (Umesh *et al.*, 2025) [25]. To mitigate these escalating negative effects and ensure the long-term sustainability of agricultural productivity, it is imperative to adopt a holistic strategy that champions commercially and environmentally feasible organic methods, thereby elevating overall soil health, biodiversity, and inherent pest resistance (Singh *et al.*, 2025) [22]. Under these deteriorating conditions, the conjunctive use of organic and inorganic inputs under field conditions has emerged as a critical practice to restore soil vitality. Central to this sustainable transition is the incorporation of solid organic amendments like vermicompost, which serves as a potent source of the major and minor nutrients required for crop production, making it an exceptionally valuable resource, particularly in and around urban areas. Concurrently, the agricultural sector is witnessing the increasing importance of eco-friendly, cost-effective liquid organic formulations, such as jeevamrutha, beejamrutha, panchagavya, and vermiwash. These traditional fermented products are synthesized using easily accessible farm inputs—including cow dung, cow

urine, pulse or legume flour, jaggery, living soil, and local vegetation extracts—which collectively cultivate a rich reservoir of beneficial microorganisms (Kaur *et al.*, 2025) [6]. The profound efficacy of these liquid formulations stems not from adding macronutrients directly to the soil, but rather from their ability to fundamentally stimulate the development and activity of soil microbiomes (Umesh *et al.*, 2024) [26]. Enriched with macronutrients, micronutrients, essential amino acids, vitamins, and vital plant growth-promoting substances like indole acetic acid and gibberellic acid, these preparations facilitate efficient nutrient cycling, prevent soil-borne diseases, lessen pest infestations, and release crucial plant growth regulators. Ultimately, the strategic integration of these organic manures profoundly enhances the physical, chemical, and biological properties of the soil, increasing agricultural productivity and fertility while meticulously preserving natural resources for future generations.

Materials and Methods

This study took place at the College Farm, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, during the Rabi, 2023 season. The material and methods employed in the experiment are detailed below.

Soil pH was measured in a 1:2.5 soil: water suspension using the potentiometric method with a glass electrode paired with a reference electrode (Jackson, 1973) [5]. Electrical conductivity (EC) was assessed in a 1:2.5 soil: water suspension via conductivity bridge, with results reported in dS m^{-1} at 25 °C (Jackson, 1973) [5]. Organic carbon in finely ground samples was quantified using Walkley and Black's wet oxidation method (Jackson, 1973) [5] and expressed as a percentage. Total nitrogen was determined by the Kjeldahl method, total phosphorus by the vanadomolybdo phosphoric yellow color method, and total potassium in the diacid digest using a flame photometer (Piper, 1966) [15].

Samples were collected 24 hours and 12 days after preparation (DAP) of beejamrutha and jeevamrutha, respectively (Puja, 2021) [16]. Beejamrutha, jeevamrutha, and vermicompost samples underwent analysis for pH, EC, organic carbon, total N, P, and K, along with six microbial groups total bacteria, total fungi, total actinomycetes, *Pseudomonas*, *Bacillus*, and *Azospirillum* following methods by Martin (1950) [9], King *et al.* (1954) [7], Mossel *et al.* (1967) [10], and Dobereiner *et al.* (1976) [4].

Preparation of Liquid Organic Manures

Liquid organic formulations beejamrutha and jeevamrutha were prepared following protocols outlined by Puja (2021) [16].

Beejamrutha Preparation

One kilogram of fresh cow dung was tied in a muslin cloth bag and suspended at mid-depth in a 10 L bucket of water. Separately, 50 g of lime was dissolved in 1 L of water and left overnight. The next morning, the dung bag was squeezed three times in the same bucket. Then, 1 L of cow urine, 1 L of the prepared lime solution, and 100 g of soil were added. The mixture was thoroughly stirred and used immediately.

Jeevamrutha Preparation

Ten kilograms of cow dung were combined with 10 L of cow urine, 500 g of jaggery, 500 g of Bengal gram (*Cicer*

arietinum) flour, and 100 g of ant hill soil. The total volume was adjusted to 20 L with water and stirred vigorously. The bucket was covered with a gunny sack and placed in shade. The mixture was stirred clockwise for 1 min twice daily (morning and evening) for 12 days to promote fermentation. Beejamrutha was applied for seed treatment 24 h after preparation, while jeevamrutha was used for foliar spraying on the 12th day of post-preparation.

Vermicompost Sourcing

Vermicompost was sourced from the Vermicompost Unit at the College Farm, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad. It was produced using farm wastes rich in agricultural by-products, which contribute to its high organic matter content.

Laboratory Analyses

Physico-chemical properties (pH, EC, organic carbon, total N, P, K) and microbial populations (total bacteria, fungi, actinomycetes, *Pseudomonas*, *Bacillus*, *Azospirillum*) of beejamrutha, jeevamrutha, and vermicompost were analyzed as described in the preceding section.

Result and Discussion

Beejamrutha exhibited a pH of 8.14 and electrical conductivity (EC) of 2.81 dS m^{-1} . Organic carbon content was 0.63%, with total N, P, and K at 0.15%, 0.47%, and 0.75%, respectively. Jeevamrutha, On the 12th day post-preparation, jeevamrutha showed slightly acidic pH (5.53). Rameeza and Usha (2016) [19] noted similar low pH values, attributing them to organic acid production during early fermentation; alcohol formation in later stages likely raises pH, EC was 1.31 dS m^{-1} , reflecting a general upward trend in liquid formulations due to rising soluble salts over time (Chakraborty and Sarkar, 2019; Chu and Jennifer, 2018). Organic carbon stood at 0.46%, lower than beejamrutha, likely from microbial utilization as an energy source (Reddy and Menon, 2021) [20]. Total N, P, and K contents were 0.55%, 0.17%, and 0.14%, respectively. Reduced levels resulted from volatilization losses during fermentation and storage-induced biochemical shifts. Declines in N with jeevamrutha aging align with Rameeza and Usha (2016) [19] and Reddy and Menon (2021) [20], while drops in total P and K during storage corroborate and Radha and Rao (2014) [17]. The data on microbial population of prepared beejamrutha and jeevamrutha and vermicompost are presented in Table 1.

Total bacteria, total fungi, total actinomycetes, *Pseudomonas*, *Bacillus*, *Azospirillum* were enumerated in beejamrutha, jeevamrutha and vermicompost. The total microbial population decreased in the order of total bacteria ($39 \times 10^5 \text{ cfu/mL}$) > total actinomycetes ($13 \times 10^5 \text{ cfu/mL}$) > total fungi ($33 \times 10^4 \text{ cfu/mL}$). In among the bacterial population, the decrease in the order of population was; *Bacillus* ($20 \times 10^5 \text{ cfu/mL}$) > *Azospirillum* ($10 \times 10^5 \text{ cfu/mL}$) > *Pseudomonas* ($5 \times 10^5 \text{ cfu/mL}$) in beejamrutha.

The total microbial population decreased was in the order of total bacteria ($60.3 \times 10^5 \text{ cfu/mL}$) > total actinomycetes ($37 \times 10^5 \text{ cfu/mL}$) > total fungi ($29.5 \times 10^4 \text{ cfu/mL}$). In among the individual bacterial population, the decrease in the order of population was *Pseudomonas* ($25 \times 10^5 \text{ cfu/mL}$) > *Bacillus* ($18 \times 10^5 \text{ cfu/mL}$) > *Azospirillum* ($13.5 \times 10^5 \text{ cfu/mL}$) in jeevamrutha.

The rise in microbial populations in beejamrutha and jeevamrutha may be attributed to the addition of jaggery, pulse flour, ant hill soil and lime, which created favourable conditions for microbial growth. Sreenivasa *et al.*, (2009) [24]. Kulkarni and Gargelwar (2019) [8] reported a significant presence of naturally occurring beneficial microorganisms in jeevamrutha. Further, Somasundaram *et al.*, (2003) [21] observed that jeevamrutha not only enhances the microbial environment but also exhibits enzymatic properties, thereby improving conditions favourable for microbial growth. It has been shown by Devakumar *et al.* (2011) [3] that jeevamrutha promotes nitrogen-fixing bacteria in substrates such as farmyard manure (FYM) and compost. Additionally, the presence of substrates like cow dung, cow urine, gram flour and jaggery along with other plant growth-promoting substances like indole acetic acid, has been reported by Palekar (2006) [13], and Sreenivasa *et al.* (2010) [23]. Additionally, the handful of soil added during the preparation of jeevamrutha must have served as an initial inoculum of microorganisms such as bacteria, fungi, actinomycetes, nitrogen fixers and solubilizers (Radha and Rao, 2014) [17]. Rameeza and Usha (2016) [19] have reported an increase in the population of actinomycetes in jeevamrutha.

Response of okra to inorganic and organic (vermicompost, beejamrutha and jeevamrutha) on growth parameters

Integrated nutrient management (INM) significantly enhanced okra plant height at 30, 60, and 90 days after sowing (DAS), with the most rapid growth occurring between 30 and 60 DAS. Treatment T₃ (50% recommended dose of nitrogen [RDN] + 50% N via vermicompost) consistently yielded the tallest plants across all growth stages (25.79 cm, 76.12 cm, and 124.82 cm), performing comparably to other organically enriched treatments (T₈, T₅) and the 100% RDN treatment (T₂). Conversely, the untreated control (T₁) produced the shortest plants. Ultimately, T₃ increased plant height by 43.43%, 28.90%, and 32.81% over the control at the respective growth stages (Fig-1). This superior growth is directly attributed to the synergistic application of chemical fertilizers alongside organic amendments like vermicompost, beejamrutha, and jeevamrutha. These organic additions boost overall soil nutrient availability, supplying readily available nitrogen that is crucial for cell division, protein synthesis, and tissue development. These results are well-supported by previous agricultural research, which consistently confirms that combining inorganic fertilizers with organic manures optimally drives crop growth. Integrated Nutrient Management (INM) significantly maximized the dry matter production of okra at 30, 60, and 90 days after sowing (DAS), with the most rapid accumulation occurring between 30 and 60 DAS. Treatment T₃-combining 50% of the recommended dose of nitrogen (RDN) with 50% nitrogen derived from vermicompost produced the highest dry matter yields (258.17, 1523.83, and 2522.99 kg ha⁻¹), performing comparably to other integrated and fully inorganic treatments (T₈, T₅, and T₂). In contrast, the untreated control yielded the lowest dry matter across all stages. Consequently, T₃ achieved notable increases of 32.85%, 56.86%, and 28.87% over the control at 30, 60, and 90 DAS, respectively (Fig-2). Similar result was found by Puja *et al.* 2021 [16]. This substantial growth improvement is

driven by the synergistic application of organic and inorganic fertilizers (Naskar *et al.*, 2024) [11]. Organic amendments like vermicompost supply readily available nitrogen and promote rapid mineralization during early crop stages, while seed treatments and foliar sprays like beejamrutha and jeevamrutha ensure the continuous availability of essential nutrients (Nileema *et al.*, 2011) [12]. These findings align with extensive agricultural research demonstrating that combining chemical fertilizers with organic manures optimally stimulates plant height, branch development, and overall dry matter accumulation.

Response of okra to inorganic and organic (vermicompost, beejamrutha and jeevamrutha) on Yield parameters

Integrated Nutrient Management (INM) practices incorporating both organic and inorganic inputs significantly enhanced fruit and stover yields, with the highest results recorded in treatment T₃ (50% recommended dose of nitrogen [RDN] combined with 50% nitrogen derived from vermicompost). This treatment yielded 12.19 t ha⁻¹ of fruit and 2.57 t ha⁻¹ of stover, performing comparably to other integrated and fully inorganic treatments (T₈, T₅, and T₂), and vastly outperforming the untreated control, which yielded only 5.42 t ha⁻¹ of fruit and 1.99 t ha⁻¹ of stover. Consequently, T₃ achieved a substantial yield increase of 124.9% for fruit and 29.14% for stover over the control (Table-2). While applying 100% of the recommended dose of fertilizers (RDF) produced similarly high yields, it negatively impacted soil health; in contrast, combining inorganic fertilizers with organic amendments like vermicompost, beejamrutha, and jeevamrutha optimized yields while simultaneously improving overall soil vitality and reducing the chemical fertilizer burden (Sreenivasa *et al.*, 2009) [24]. This superior agronomic performance is directly linked to enhanced yield attributes—such as increased pod length, pod diameter, pod weight, and the number of pods per plant—which are driven by greater dry matter production, taller plants, and earlier flowering (Dobereiner *et al.*, 1976) [4]. The synergistic integration of chemical fertilizers (which provide readily available essential nutrients during the early growth stages) with organic manures and biofertilizers, such as phosphate-solubilizing bacteria, ensures a sustained and balanced nutrient supply throughout the entire crop cycle (Ram *et al.*, 2017) [18]. Furthermore, traditional liquid organic formulations like beejamrutha and jeevamrutha crafted from easily accessible farm inputs like cow dung, cow urine, legume flour, and jiggery enrich the soil with vital macro- and micronutrients, vitamins, essential amino acids, beneficial microorganisms, and plant growth-promoting substances such as indole acetic acid and gibberellic acid (King *et al.*, 1954) [7]. These organic additions create optimal soil conditions by enhancing nutrient mineralization, boosting soil enzyme and microbial activity, and improving overall nutrient use efficiency (Parvathi, 2017) [14]. Additionally, seed treatments with beejamrutha act as a protectant against seed- and soil-borne diseases while notably improving seed germination and seedling vigor. Concurrently, foliar and soil applications of jeevamrutha boost microbial loads and introduce growth hormones that facilitate the maximum uptake of both applied and native soil nutrients (Velmurugan *et al.*, 2025) [27]. Ultimately, this conjunctive INM approach systematically upgrades the

physical, chemical, and biological properties of the soil, ensuring highly productive and sustainable agricultural

outcomes without compromising long-term ecosystem health.

Table 1: Microbial properties of beejamrutha, jeevamrutha and vermicompost at the time of their preparation

Microbial characters	Beejamrutha	Jeevamrutha	Vermicompost
a) Total bacteria ($\times 10^5$ cfu/mL)	39	60.3	85.5
b) Total fungi ($\times 10^4$ cfu/mL)	33	29.5	23
c) Total actinomycetes ($\times 10^5$ cfu/mL)	13	37	16
d) <i>Pseudomonas</i> ($\times 10^5$ cfu/mL)	5	25	32
e) <i>Bacillus</i> ($\times 10^5$ cfu/mL)	20	18	26.5
f) <i>Azospirillum</i> ($\times 10^5$ cfu/mL)	10	13.5	14.7

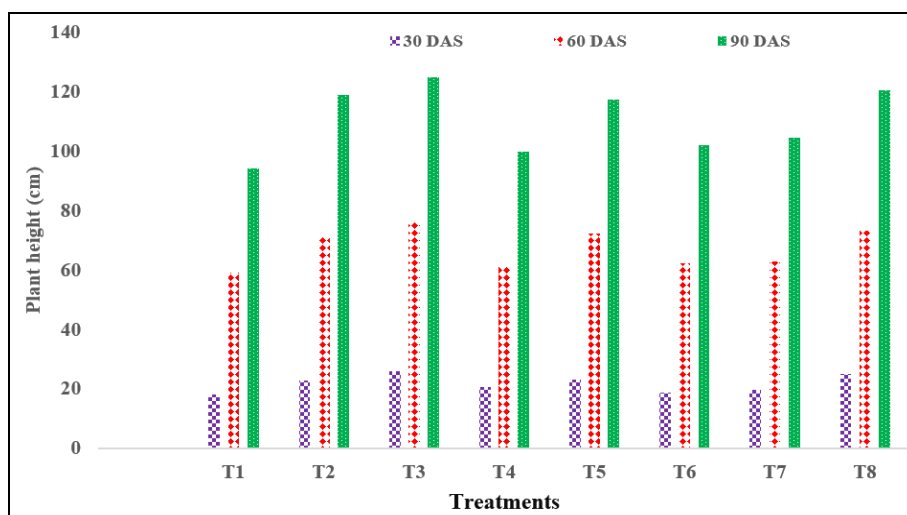


Fig 1: Effect of INM on the plant height of Okra Crop.

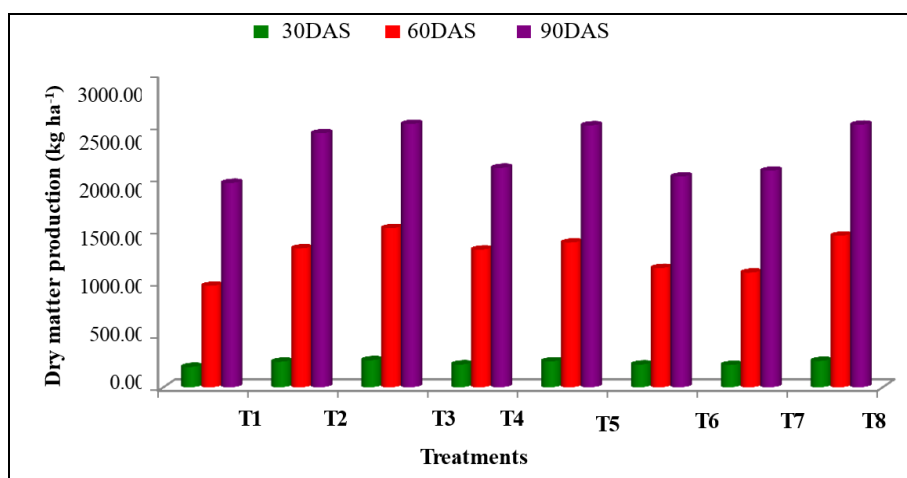


Fig 2: Effect of INM on the Dry matter (Kg) of Okra Crop.

Table 2: Effect of integrated nutrient management on dry matter production in okra at 30, 60, 90 DAS and fruit and Stover yield

Treatments	30 DAS (kg ha ⁻¹)	60 DAS (kg ha ⁻¹)	90 DAS (kg ha ⁻¹)	Fruit yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)
T ₁ Absolute Control (NPK at 0:0:0)	194.32	971.44	1957.67	5.42	1.99
T ₂ 100% RDN (150 kg ha ⁻¹)	243.42	1329.88	2433.55	11.61	2.34
T ₃ 50% RDN + 50% N through vermicompost	258.17	1523.83	2522.99	12.19	2.57
T ₄ 50% RDN + 1 spray of jeevamrutha at 40 DAS	217.40	1318.61	2102.30	9.95	2.09
T ₅ 50% RDN + 25% N through vermicompost + seed treatment with beejamrutha + 1 spray of jeevamrutha at 40 DAS	246.79	1386.16	2509.16	11.72	2.42
T ₆ 50% RDN + phosphate solubilizing bacteria + seed treatment with beejamrutha	216.81	1142.03	2018.43	8.41	2.16
T ₇ 50% RDN alone	212.61	1098.17	2074.40	6.43	2.15
T ₈ 100% N through vermicompost	251.40	1451.62	2515.40	11.95	2.49
SEm±	13.15	65.79	116.59	0.67	0.12
C.D (P = 0.05%)	39.89	199.57	353.64	2.03	0.38
CV (%)	9.90	8.92	8.91	11.94	9.47

Conclusion

The findings of this study demonstrate that Integrated Nutrient Management (INM) is a highly effective, sustainable approach for okra cultivation. The conjunctive application of 50% of the recommended dose of nitrogen (RDN) alongside 50% nitrogen sourced from vermicompost (T3), further supplemented by seed treatment with beejamrutha and foliar application of jeevamrutha emerged as the superior agronomic strategy. This specific combination significantly maximized vegetative growth, yielding the tallest plants and the highest dry matter accumulation (2522.99 kg ha⁻¹) across all growth stages. Furthermore, it delivered the maximum fruit (12.19 t ha⁻¹) and stover (2.57 t ha⁻¹) yields, representing a remarkable 124.9% increase in fruit production over the untreated control. While the sole application of 100% synthetic fertilizers produced comparable yields, the integrated approach offers the critical advantage of preserving and enhancing the soil ecosystem. By synergizing the rapid nutrient availability of chemical fertilizers with the sustained nutrient release, enhanced microbial activity, and growth-promoting substances provided by organic amendments, this INM strategy optimizes overall nutrient use efficiency. Ultimately, integrating vermicompost, beejamrutha, and jeevamrutha reduces the chemical fertilizer burden on the soil, protects the crop from seed-borne and soil-borne diseases, and provides an economically viable and ecologically sustainable framework for long-term agricultural productivity.

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